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# **Linux Userspace-api Documentation**

***Release 6.8.0***

**The kernel development community**

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While much of the kernel's user-space API is documented elsewhere (particularly in the [man-pages](#) project), some user-space information can also be found in the kernel tree itself. This manual is intended to be the place where this information is gathered.



## NO NEW PRIVILEGES FLAG

The execve system call can grant a newly-started program privileges that its parent did not have. The most obvious examples are setuid/setgid programs and file capabilities. To prevent the parent program from gaining these privileges as well, the kernel and user code must be careful to prevent the parent from doing anything that could subvert the child. For example:

- The dynamic loader handles LD\_\* environment variables differently if a program is setuid.
- chroot is disallowed to unprivileged processes, since it would allow /etc/passwd to be replaced from the point of view of a process that inherited chroot.
- The exec code has special handling for ptrace.

These are all ad-hoc fixes. The `no_new_privs` bit (since Linux 3.5) is a new, generic mechanism to make it safe for a process to modify its execution environment in a manner that persists across execve. Any task can set `no_new_privs`. Once the bit is set, it is inherited across fork, clone, and execve and cannot be unset. With `no_new_privs` set, `execve()` promises not to grant the privilege to do anything that could not have been done without the `execve` call. For example, the setuid and setgid bits will no longer change the uid or gid; file capabilities will not add to the permitted set, and LSMs will not relax constraints after execve.

To set `no_new_privs`, use:

```
prctl(PR_SET_NO_NEW_PRIVS, 1, 0, 0, 0);
```

Be careful, though: LSMs might also not tighten constraints on exec in `no_new_privs` mode. (This means that setting up a general-purpose service launcher to set `no_new_privs` before execing daemons may interfere with LSM-based sandboxing.)

Note that `no_new_privs` does not prevent privilege changes that do not involve `execve()`. An appropriately privileged task can still call `setuid(2)` and receive `SCM_RIGHTS` datagrams.

There are two main use cases for `no_new_privs` so far:

- Filters installed for the seccomp mode 2 sandbox persist across execve and can change the behavior of newly-executed programs. Unprivileged users are therefore only allowed to install such filters if `no_new_privs` is set.
- By itself, `no_new_privs` can be used to reduce the attack surface available to an unprivileged user. If everything running with a given uid has `no_new_privs` set, then that uid will be unable to escalate its privileges by directly attacking setuid, setgid, and fcap-using binaries; it will need to compromise something without the `no_new_privs` bit set first.

In the future, other potentially dangerous kernel features could become available to unprivileged tasks if `no_new_privs` is set. In principle, several options to `unshare(2)` and `clone(2)`

would be safe when `no_new_privs` is set, and `no_new_privs + chroot` is considerably less dangerous than `chroot` by itself.

## **SECCOMP BPF (SECURE COMPUTING WITH FILTERS)**

### **2.1 Introduction**

A large number of system calls are exposed to every userland process with many of them going unused for the entire lifetime of the process. As system calls change and mature, bugs are found and eradicated. A certain subset of userland applications benefit by having a reduced set of available system calls. The resulting set reduces the total kernel surface exposed to the application. System call filtering is meant for use with those applications.

Seccomp filtering provides a means for a process to specify a filter for incoming system calls. The filter is expressed as a Berkeley Packet Filter (BPF) program, as with socket filters, except that the data operated on is related to the system call being made: system call number and the system call arguments. This allows for expressive filtering of system calls using a filter program language with a long history of being exposed to userland and a straightforward data set.

Additionally, BPF makes it impossible for users of seccomp to fall prey to time-of-check-time-of-use (TOCTOU) attacks that are common in system call interposition frameworks. BPF programs may not dereference pointers which constrains all filters to solely evaluating the system call arguments directly.

### **2.2 What it isn't**

System call filtering isn't a sandbox. It provides a clearly defined mechanism for minimizing the exposed kernel surface. It is meant to be a tool for sandbox developers to use. Beyond that, policy for logical behavior and information flow should be managed with a combination of other system hardening techniques and, potentially, an LSM of your choosing. Expressive, dynamic filters provide further options down this path (avoiding pathological sizes or selecting which of the multiplexed system calls in `socketcall()` is allowed, for instance) which could be construed, incorrectly, as a more complete sandboxing solution.

## 2.3 Usage

An additional seccomp mode is added and is enabled using the same prctl(2) call as the strict seccomp. If the architecture has `CONFIG_HAVE_ARCH_SECCOMP_FILTER`, then filters may be added as below:

### **PR\_SET\_SECCOMP:**

Now takes an additional argument which specifies a new filter using a BPF program. The BPF program will be executed over struct seccomp\_data reflecting the system call number, arguments, and other metadata. The BPF program must then return one of the acceptable values to inform the kernel which action should be taken.

Usage:

```
prctl(PR_SET_SECCOMP, SECCOMP_MODE_FILTER, prog);
```

The 'prog' argument is a pointer to a struct sock\_fprog which will contain the filter program. If the program is invalid, the call will return -1 and set errno to EINVAL.

If fork/clone and execve are allowed by @prog, any child processes will be constrained to the same filters and system call ABI as the parent.

Prior to use, the task must call `prctl(PR_SET_NO_NEW_PRIVS, 1)` or run with `CAP_SYS_ADMIN` privileges in its namespace. If these are not true, -EACCES will be returned. This requirement ensures that filter programs cannot be applied to child processes with greater privileges than the task that installed them.

Additionally, if `prctl(2)` is allowed by the attached filter, additional filters may be layered on which will increase evaluation time, but allow for further decreasing the attack surface during execution of a process.

The above call returns 0 on success and non-zero on error.

## 2.4 Return values

A seccomp filter may return any of the following values. If multiple filters exist, the return value for the evaluation of a given system call will always use the highest precedent value. (For example, `SECCOMP_RET_KILL_PROCESS` will always take precedence.)

In precedence order, they are:

### **SECCOMP\_RET\_KILL\_PROCESS:**

Results in the entire process exiting immediately without executing the system call. The exit status of the task (`status & 0x7f`) will be SIGSYS, not SIGKILL.

### **SECCOMP\_RET\_KILL\_THREAD:**

Results in the task exiting immediately without executing the system call. The exit status of the task (`status & 0x7f`) will be SIGSYS, not SIGKILL.

### **SECCOMP\_RET\_TRAP:**

Results in the kernel sending a SIGSYS signal to the triggering task without executing the system call. `siginfo->si_call_addr` will show the address of the system call instruction, and `siginfo->si_syscall` and `siginfo->si_arch` will indicate which syscall was attempted. The program counter will be as though the syscall happened (i.e. it will not point to the syscall instruction). The return value register will contain an arch- dependent

value -- if resuming execution, set it to something sensible. (The architecture dependency is because replacing it with -ENOSYS could overwrite some useful information.)

The SECCOMP\_RET\_DATA portion of the return value will be passed as `si_errno`.

SIGSYS triggered by seccomp will have a `si_code` of `SYS_SECCOMP`.

#### **SECCOMP\_RET\_ERRNO:**

Results in the lower 16-bits of the return value being passed to userland as the `errno` without executing the system call.

#### **SECCOMP\_RET\_USER\_NOTIF:**

Results in a `struct seccomp_notif` message sent on the userspace notification fd, if it is attached, or -ENOSYS if it is not. See below on discussion of how to handle user notifications.

#### **SECCOMP\_RET\_TRACE:**

When returned, this value will cause the kernel to attempt to notify a `ptrace()`-based tracer prior to executing the system call. If there is no tracer present, -ENOSYS is returned to userland and the system call is not executed.

A tracer will be notified if it requests `PTRACE_O_TRACESECCOMP` using `ptrace(PTRACE_SETOPTIONS)`. The tracer will be notified of a `PTRACE_EVENT_SECCOMP` and the `SECCOMP_RET_DATA` portion of the BPF program return value will be available to the tracer via `PTRACE_GETEVENTMSG`.

The tracer can skip the system call by changing the syscall number to -1. Alternatively, the tracer can change the system call requested by changing the system call to a valid syscall number. If the tracer asks to skip the system call, then the system call will appear to return the value that the tracer puts in the return value register.

The seccomp check will not be run again after the tracer is notified. (This means that seccomp-based sandboxes MUST NOT allow use of `ptrace`, even of other sandboxed processes, without extreme care; ptracers can use this mechanism to escape.)

#### **SECCOMP\_RET\_LOG:**

Results in the system call being executed after it is logged. This should be used by application developers to learn which syscalls their application needs without having to iterate through multiple test and development cycles to build the list.

This action will only be logged if "log" is present in the `actions_logged` sysctl string.

#### **SECCOMP\_RET\_ALLOW:**

Results in the system call being executed.

If multiple filters exist, the return value for the evaluation of a given system call will always use the highest precedent value.

Precedence is only determined using the `SECCOMP_RET_ACTION` mask. When multiple filters return values of the same precedence, only the `SECCOMP_RET_DATA` from the most recently installed filter will be returned.

## 2.5 Pitfalls

The biggest pitfall to avoid during use is filtering on system call number without checking the architecture value. Why? On any architecture that supports multiple system call invocation conventions, the system call numbers may vary based on the specific invocation. If the numbers in the different calling conventions overlap, then checks in the filters may be abused. Always check the arch value!

## 2.6 Example

The `samples/seccomp/` directory contains both an x86-specific example and a more generic example of a higher level macro interface for BPF program generation.

## 2.7 Userspace Notification

The `SECCOMP_RET_USER_NOTIF` return code lets seccomp filters pass a particular syscall to userspace to be handled. This may be useful for applications like container managers, which wish to intercept particular syscalls (`mount()`, `finit_module()`, etc.) and change their behavior.

To acquire a notification FD, use the `SECCOMP_FILTER_FLAG_NEW_LISTENER` argument to the `seccomp()` syscall:

```
fd = seccomp(SECCOMP_SET_MODE_FILTER, SECCOMP_FILTER_FLAG_NEW_LISTENER, &prog);
```

which (on success) will return a listener fd for the filter, which can then be passed around via `SCM_RIGHTS` or similar. Note that filter fds correspond to a particular filter, and not a particular task. So if this task then forks, notifications from both tasks will appear on the same filter fd. Reads and writes to/from a filter fd are also synchronized, so a filter fd can safely have many readers.

The interface for a seccomp notification fd consists of two structures:

```
struct seccomp_notif_sizes {
    __u16 seccomp_notif;
    __u16 seccomp_notif_resp;
    __u16 seccomp_data;
};

struct seccomp_notif {
    __u64 id;
    __u32 pid;
    __u32 flags;
    struct seccomp_data data;
};

struct seccomp_notif_resp {
    __u64 id;
    __s64 val;
```

```

__s32 error;
__u32 flags;
};
```

The `struct seccomp_notif_sizes` structure can be used to determine the size of the various structures used in seccomp notifications. The size of `struct seccomp_data` may change in the future, so code should use:

```
struct seccomp_notif_sizes sizes;
seccomp(SECCOMP_GET_NOTIF_SIZES, 0, &sizes);
```

to determine the size of the various structures to allocate. See `samples/seccomp/user-trap.c` for an example.

Users can read via `ioctl(SECCOMP_IOCTL_NOTIF_RECV)` (or `poll()`) on a seccomp notification fd to receive a `struct seccomp_notif`, which contains five members: the input length of the structure, a unique-per-filter id, the pid of the task which triggered this request (which may be 0 if the task is in a pid ns not visible from the listener's pid namespace). The notification also contains the data passed to seccomp, and a filters flag. The structure should be zeroed out prior to calling the ioctl.

Userspace can then make a decision based on this information about what to do, and `ioctl(SECCOMP_IOCTL_NOTIF_SEND)` a response, indicating what should be returned to userspace. The `id` member of `struct seccomp_notif_resp` should be the same `id` as in `struct seccomp_notif`.

Userspace can also add file descriptors to the notifying process via `ioctl(SECCOMP_IOCTL_NOTIF_ADDFD)`. The `id` member of `struct seccomp_notif_addfd` should be the same `id` as in `struct seccomp_notif`. The `newfd_flags` flag may be used to set flags like `O_CLOEXEC` on the file descriptor in the notifying process. If the supervisor wants to inject the file descriptor with a specific number, the `SECCOMP_ADDFD_FLAG_SETFD` flag can be used, and set the `newfd` member to the specific number to use. If that file descriptor is already open in the notifying process it will be replaced. The supervisor can also add an FD, and respond atomically by using the `SECCOMP_ADDFD_FLAG_SEND` flag and the return value will be the injected file descriptor number.

The notifying process can be preempted, resulting in the notification being aborted. This can be problematic when trying to take actions on behalf of the notifying process that are long-running and typically retryable (mounting a filesystem). Alternatively, at filter installation time, the `SECCOMP_FILTER_FLAG_WAIT_KILLABLE_RECV` flag can be set. This flag makes it such that when a user notification is received by the supervisor, the notifying process will ignore non-fatal signals until the response is sent. Signals that are sent prior to the notification being received by userspace are handled normally.

It is worth noting that `struct seccomp_data` contains the values of register arguments to the syscall, but does not contain pointers to memory. The task's memory is accessible to suitably privileged traces via `ptrace()` or `/proc/pid/mem`. However, care should be taken to avoid the TOCTOU mentioned above in this document: all arguments being read from the tracee's memory should be read into the tracer's memory before any policy decisions are made. This allows for an atomic decision on syscall arguments.

## 2.8 Sysctls

Seccomp's sysctl files can be found in the `/proc/sys/kernel/seccomp/` directory. Here's a description of each file in that directory:

### **actions\_avail:**

A read-only ordered list of seccomp return values (refer to the `SECCOMP_RET_*` macros above) in string form. The ordering, from left-to-right, is the least permissive return value to the most permissive return value.

The list represents the set of seccomp return values supported by the kernel. A userspace program may use this list to determine if the actions found in the `seccomp.h`, when the program was built, differs from the set of actions actually supported in the current running kernel.

### **actions\_logged:**

A read-write ordered list of seccomp return values (refer to the `SECCOMP_RET_*` macros above) that are allowed to be logged. Writes to the file do not need to be in ordered form but reads from the file will be ordered in the same way as the `actions_avail` sysctl.

The `allow` string is not accepted in the `actions_logged` sysctl as it is not possible to log `SECCOMP_RET_ALLOW` actions. Attempting to write `allow` to the sysctl will result in an `EINVAL` being returned.

## 2.9 Adding architecture support

See `arch/Kconfig` for the authoritative requirements. In general, if an architecture supports both `ptrace_event` and `seccomp`, it will be able to support seccomp filter with minor fixup: `SIGSYS` support and seccomp return value checking. Then it must just add `CONFIG_HAVE_ARCH_SECCOMP_FILTER` to its arch-specific `Kconfig`.

## 2.10 Caveats

The vDSO can cause some system calls to run entirely in userspace, leading to surprises when you run programs on different machines that fall back to real syscalls. To minimize these surprises on x86, make sure you test with `/sys/devices/system/clocksource/clocksource0/current_clocksource` set to something like `acpi_pm`.

On x86-64, vsyscall emulation is enabled by default. (vsyscalls are legacy variants on vDSO calls.) Currently, emulated vsyscalls will honor seccomp, with a few oddities:

- A return value of `SECCOMP_RET_TRAP` will set a `si_call_addr` pointing to the vsyscall entry for the given call and not the address after the 'syscall' instruction. Any code which wants to restart the call should be aware that (a) a ret instruction has been emulated and (b) trying to resume the syscall will again trigger the standard vsyscall emulation security checks, making resuming the syscall mostly pointless.
- A return value of `SECCOMP_RET_TRACE` will signal the tracer as usual, but the syscall may not be changed to another system call using the `orig_rax` register. It may only be changed to -1 order to skip the currently emulated call. Any other change MAY terminate the process. The rip value seen by the tracer will be the syscall entry address; this is different from

normal behavior. The tracer MUST NOT modify rip or rsp. (Do not rely on other changes terminating the process. They might work. For example, on some kernels, choosing a syscall that only exists in future kernels will be correctly emulated (by returning -ENOSYS).

To detect this quirky behavior, check for `addr & ~0x0C00 == 0xFFFFFFFFF600000`. (For `SECCOMP_RET_TRACE`, use `rip`. For `SECCOMP_RET_TRAP`, use `siginfo->si_call_addr`.) Do not check any other condition: future kernels may improve vsyscall emulation and current kernels in `vsyscall=native` mode will behave differently, but the instructions at `0xF...F600{0,4,8,C}00` will not be system calls in these cases.

Note that modern systems are unlikely to use vsyscalls at all -- they are a legacy feature and they are considerably slower than standard syscalls. New code will use the vDSO, and vDSO-issued system calls are indistinguishable from normal system calls.



## LANDLOCK: UNPRIVILEGED ACCESS CONTROL

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### Date

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The goal of Landlock is to enable to restrict ambient rights (e.g. global filesystem or network access) for a set of processes. Because Landlock is a stackable LSM, it makes possible to create safe security sandboxes as new security layers in addition to the existing system-wide access-controls. This kind of sandbox is expected to help mitigate the security impact of bugs or unexpected/malicious behaviors in user space applications. Landlock empowers any process, including unprivileged ones, to securely restrict themselves.

We can quickly make sure that Landlock is enabled in the running system by looking for "landlock: Up and running" in kernel logs (as root): `dmesg | grep landlock || journalctl -kg landlock`. Developers can also easily check for Landlock support with a *related system call*. If Landlock is not currently supported, we need to *configure the kernel appropriately*.

### 3.1 Landlock rules

A Landlock rule describes an action on an object which the process intends to perform. A set of rules is aggregated in a ruleset, which can then restrict the thread enforcing it, and its future children.

The two existing types of rules are:

#### Filesystem rules

For these rules, the object is a file hierarchy, and the related filesystem actions are defined with *filesystem access rights*.

#### Network rules (since ABI v4)

For these rules, the object is a TCP port, and the related actions are defined with *network access rights*.

### 3.1.1 Defining and enforcing a security policy

We first need to define the ruleset that will contain our rules.

For this example, the ruleset will contain rules that only allow filesystem read actions and establish a specific TCP connection. Filesystem write actions and other TCP actions will be denied.

The ruleset then needs to handle both these kinds of actions. This is required for backward and forward compatibility (i.e. the kernel and user space may not know each other's supported restrictions), hence the need to be explicit about the denied-by-default access rights.

```
struct landlock_ruleset_attr ruleset_attr = {
    .handled_access_fs =
        LANDLOCK_ACCESS_FS_EXECUTE |
        LANDLOCK_ACCESS_FS_WRITE_FILE |
        LANDLOCK_ACCESS_FS_READ_FILE |
        LANDLOCK_ACCESS_FS_READ_DIR |
        LANDLOCK_ACCESS_FS_REMOVE_DIR |
        LANDLOCK_ACCESS_FS_REMOVE_FILE |
        LANDLOCK_ACCESS_FS_MAKE_CHAR |
        LANDLOCK_ACCESS_FS_MAKE_DIR |
        LANDLOCK_ACCESS_FS_MAKE_REG |
        LANDLOCK_ACCESS_FS_MAKE_SOCK |
        LANDLOCK_ACCESS_FS_MAKE_FIFO |
        LANDLOCK_ACCESS_FS_MAKE_BLOCK |
        LANDLOCK_ACCESS_FS_MAKE_SYM |
        LANDLOCK_ACCESS_FS_REFER |
        LANDLOCK_ACCESS_FS_TRUNCATE,
    .handled_access_net =
        LANDLOCK_ACCESS_NET_BIND_TCP |
        LANDLOCK_ACCESS_NET_CONNECT_TCP,
};
```

Because we may not know on which kernel version an application will be executed, it is safer to follow a best-effort security approach. Indeed, we should try to protect users as much as possible whatever the kernel they are using. To avoid binary enforcement (i.e. either all security features or none), we can leverage a dedicated Landlock command to get the current version of the Landlock ABI and adapt the handled accesses. Let's check if we should remove access rights which are only supported in higher versions of the ABI.

```
int abi;

abi = landlock_create_ruleset(NULL, 0, LANDLOCK_CREATE_RULESET_VERSION);
if (abi < 0) {
    /* Degrades gracefully if Landlock is not handled. */
    perror("The running kernel does not enable to use Landlock");
    return 0;
}
switch (abi) {
case 1:
    /* Removes LANDLOCK_ACCESS_FS_REFER for ABI < 2 */
    ruleset_attr.handled_access_fs &= ~LANDLOCK_ACCESS_FS_REFER;
```

```

__attribute__((fallthrough));
case 2:
/* Removes LANDLOCK_ACCESS_FS_TRUNCATE for ABI < 3 */
ruleset_attr.handled_access_fs &= ~LANDLOCK_ACCESS_FS_TRUNCATE;
__attribute__((fallthrough));
case 3:
/* Removes network support for ABI < 4 */
ruleset_attr.handled_access_net &=
~(LANDLOCK_ACCESS_NET_BIND_TCP |
LANDLOCK_ACCESS_NET_CONNECT_TCP);
}

```

This enables to create an inclusive ruleset that will contain our rules.

```

int ruleset_fd;

ruleset_fd = landlock_create_ruleset(&ruleset_attr, sizeof(ruleset_attr), 0);
if (ruleset_fd < 0) {
    perror("Failed to create a ruleset");
    return 1;
}

```

We can now add a new rule to this ruleset thanks to the returned file descriptor referring to this ruleset. The rule will only allow reading the file hierarchy `/usr`. Without another rule, write actions would then be denied by the ruleset. To add `/usr` to the ruleset, we open it with the `0_PATH` flag and fill the `&struct landlock_path_beneath_attr` with this file descriptor.

```

int err;
struct landlock_path_beneath_attr path_beneath = {
    .allowed_access =
        LANDLOCK_ACCESS_FS_EXECUTE |
        LANDLOCK_ACCESS_FS_READ_FILE |
        LANDLOCK_ACCESS_FS_READ_DIR,
};

path_beneath.parent_fd = open("/usr", 0_PATH | 0_CLOEXEC);
if (path_beneath.parent_fd < 0) {
    perror("Failed to open file");
    close(ruleset_fd);
    return 1;
}
err = landlock_add_rule(ruleset_fd, LANDLOCK_RULE_PATH_BENEATH,
                        &path_beneath, 0);
close(path_beneath.parent_fd);
if (err) {
    perror("Failed to update ruleset");
    close(ruleset_fd);
    return 1;
}

```

It may also be required to create rules following the same logic as explained for the ruleset

creation, by filtering access rights according to the Landlock ABI version. In this example, this is not required because all of the requested `allowed_access` rights are already available in ABI 1.

For network access-control, we can add a set of rules that allow to use a port number for a specific action: HTTPS connections.

```
struct landlock_net_port_attr net_port = {
    .allowed_access = LANDLOCK_ACCESS_NET_CONNECT_TCP,
    .port = 443,
};

err = landlock_add_rule(ruleset_fd, LANDLOCK_RULE_NET_PORT,
                           &net_port, 0);
```

The next step is to restrict the current thread from gaining more privileges (e.g. through a SUID binary). We now have a ruleset with the first rule allowing read access to `/usr` while denying all other handled accesses for the filesystem, and a second rule allowing HTTPS connections.

```
if (prctl(PR_SET_NO_NEW_PRIVS, 1, 0, 0, 0)) {
    perror("Failed to restrict privileges");
    close(ruleset_fd);
    return 1;
}
```

The current thread is now ready to sandbox itself with the ruleset.

```
if (landlock_restrict_self(ruleset_fd, 0)) {
    perror("Failed to enforce ruleset");
    close(ruleset_fd);
    return 1;
}
close(ruleset_fd);
```

If the `landlock_restrict_self` system call succeeds, the current thread is now restricted and this policy will be enforced on all its subsequently created children as well. Once a thread is landlocked, there is no way to remove its security policy; only adding more restrictions is allowed. These threads are now in a new Landlock domain, merge of their parent one (if any) with the new ruleset.

Full working code can be found in [samples/landlock/sandboxer.c](#).

### 3.1.2 Good practices

It is recommended setting access rights to file hierarchy leaves as much as possible. For instance, it is better to be able to have `~/doc/` as a read-only hierarchy and `~/tmp/` as a read-write hierarchy, compared to `~/` as a read-only hierarchy and `~/tmp/` as a read-write hierarchy. Following this good practice leads to self-sufficient hierarchies that do not depend on their location (i.e. parent directories). This is particularly relevant when we want to allow linking or renaming. Indeed, having consistent access rights per directory enables to change the location of such directory without relying on the destination directory access rights (except those that are required for this operation, see `LANDLOCK_ACCESS_FS_REFER` documentation). Having

self-sufficient hierarchies also helps to tighten the required access rights to the minimal set of data. This also helps avoid sinkhole directories, i.e. directories where data can be linked to but not linked from. However, this depends on data organization, which might not be controlled by developers. In this case, granting read-write access to `~/tmp/`, instead of write-only access, would potentially allow to move `~/tmp/` to a non-readable directory and still keep the ability to list the content of `~/tmp/`.

### 3.1.3 Layers of file path access rights

Each time a thread enforces a ruleset on itself, it updates its Landlock domain with a new layer of policy. Indeed, this complementary policy is stacked with the potentially other rulesets already restricting this thread. A sandboxed thread can then safely add more constraints to itself with a new enforced ruleset.

One policy layer grants access to a file path if at least one of its rules encountered on the path grants the access. A sandboxed thread can only access a file path if all its enforced policy layers grant the access as well as all the other system access controls (e.g. filesystem DAC, other LSM policies, etc.).

### 3.1.4 Bind mounts and OverlayFS

Landlock enables to restrict access to file hierarchies, which means that these access rights can be propagated with bind mounts (cf. Documentation/filesystems/sharedsubtree.rst) but not with Documentation/filesystems/overlayfs.rst.

A bind mount mirrors a source file hierarchy to a destination. The destination hierarchy is then composed of the exact same files, on which Landlock rules can be tied, either via the source or the destination path. These rules restrict access when they are encountered on a path, which means that they can restrict access to multiple file hierarchies at the same time, whether these hierarchies are the result of bind mounts or not.

An OverlayFS mount point consists of upper and lower layers. These layers are combined in a merge directory, result of the mount point. This merge hierarchy may include files from the upper and lower layers, but modifications performed on the merge hierarchy only reflects on the upper layer. From a Landlock policy point of view, each OverlayFS layers and merge hierarchies are standalone and contains their own set of files and directories, which is different from bind mounts. A policy restricting an OverlayFS layer will not restrict the resulted merged hierarchy, and vice versa. Landlock users should then only think about file hierarchies they want to allow access to, regardless of the underlying filesystem.

### 3.1.5 Inheritance

Every new thread resulting from a `clone(2)` inherits Landlock domain restrictions from its parent. This is similar to the seccomp inheritance (cf. *Seccomp BPF (SECure COMPUTing with filters)*) or any other LSM dealing with task's `credentials(7)`. For instance, one process's thread may apply Landlock rules to itself, but they will not be automatically applied to other sibling threads (unlike POSIX thread credential changes, cf. `nptl(7)`).

When a thread sandboxes itself, we have the guarantee that the related security policy will stay enforced on all this thread's descendants. This allows creating standalone and modular security

policies per application, which will automatically be composed between themselves according to their runtime parent policies.

### 3.1.6 Ptrace restrictions

A sandboxed process has less privileges than a non-sandboxed process and must then be subject to additional restrictions when manipulating another process. To be allowed to use *ptrace(2)* and related syscalls on a target process, a sandboxed process should have a subset of the target process rules, which means the tracee must be in a sub-domain of the tracer.

### 3.1.7 Truncating files

The operations covered by `LANDLOCK_ACCESS_FS_WRITE_FILE` and `LANDLOCK_ACCESS_FS_TRUNCATE` both change the contents of a file and sometimes overlap in non-intuitive ways. It is recommended to always specify both of these together.

A particularly surprising example is *creat(2)*. The name suggests that this system call requires the rights to create and write files. However, it also requires the truncate right if an existing file under the same name is already present.

It should also be noted that truncating files does not require the `LANDLOCK_ACCESS_FS_WRITE_FILE` right. Apart from the *truncate(2)* system call, this can also be done through *open(2)* with the flags `O_RDONLY | O_TRUNC`.

When opening a file, the availability of the `LANDLOCK_ACCESS_FS_TRUNCATE` right is associated with the newly created file descriptor and will be used for subsequent truncation attempts using *ftruncate(2)*. The behavior is similar to opening a file for reading or writing, where permissions are checked during *open(2)*, but not during the subsequent *read(2)* and *write(2)* calls.

As a consequence, it is possible to have multiple open file descriptors for the same file, where one grants the right to truncate the file and the other does not. It is also possible to pass such file descriptors between processes, keeping their Landlock properties, even when these processes do not have an enforced Landlock ruleset.

## 3.2 Compatibility

### 3.2.1 Backward and forward compatibility

Landlock is designed to be compatible with past and future versions of the kernel. This is achieved thanks to the system call attributes and the associated bitflags, particularly the ruleset's `handled_access_fs`. Making handled access right explicit enables the kernel and user space to have a clear contract with each other. This is required to make sure sandboxing will not get stricter with a system update, which could break applications.

Developers can subscribe to the [Landlock mailing list](#) to knowingly update and test their applications with the latest available features. In the interest of users, and because they may use different kernel versions, it is strongly encouraged to follow a best-effort security approach by checking the Landlock ABI version at runtime and only enforcing the supported features.

### 3.2.2 Landlock ABI versions

The Landlock ABI version can be read with the `sys_landlock_create_ruleset()` system call:

```
int abi;

abi = landlock_create_ruleset(NULL, 0, LANDLOCK_CREATE_RULESET_VERSION);
if (abi < 0) {
    switch (errno) {
    case ENOSYS:
        printf("Landlock is not supported by the current kernel.\n");
        break;
    case EOPNOTSUPP:
        printf("Landlock is currently disabled.\n");
        break;
    }
    return 0;
}
if (abi >= 2) {
    printf("Landlock supports LANDLOCK_ACCESS_FS_REFER.\n");
}
```

The following kernel interfaces are implicitly supported by the first ABI version. Features only supported from a specific version are explicitly marked as such.

## 3.3 Kernel interface

### 3.3.1 Access rights

A set of actions on kernel objects may be defined by an attribute (e.g. `struct landlock_path_beneath_attr`) including a bitmask of access.

#### Filesystem flags

These flags enable to restrict a sandboxed process to a set of actions on files and directories. Files or directories opened before the sandboxing are not subject to these restrictions.

A file can only receive these access rights:

- `LANDLOCK_ACCESS_FS_EXECUTE`: Execute a file.
- `LANDLOCK_ACCESS_FS_WRITE_FILE`: Open a file with write access. Note that you might additionally need the `LANDLOCK_ACCESS_FS_TRUNCATE` right in order to overwrite files with `open(2)` using `O_TRUNC` or `creat(2)`.
- `LANDLOCK_ACCESS_FS_READ_FILE`: Open a file with read access.
- `LANDLOCK_ACCESS_FS_TRUNCATE`: Truncate a file with `truncate(2)`, `ftruncate(2)`, `creat(2)`, or `open(2)` with `O_TRUNC`. Whether an opened file can be truncated with `ftruncate(2)` is determined during `open(2)`, in the same way as read and write permissions are checked during `open(2)` using `LANDLOCK_ACCESS_FS_READ_FILE` and

`LANDLOCK_ACCESS_FS_WRITE_FILE`. This access right is available since the third version of the Landlock ABI.

A directory can receive access rights related to files or directories. The following access right is applied to the directory itself, and the directories beneath it:

- `LANDLOCK_ACCESS_FS_READ_DIR`: Open a directory or list its content.

However, the following access rights only apply to the content of a directory, not the directory itself:

- `LANDLOCK_ACCESS_FS_REMOVE_DIR`: Remove an empty directory or rename one.
- `LANDLOCK_ACCESS_FS_REMOVE_FILE`: Unlink (or rename) a file.
- `LANDLOCK_ACCESS_FS_MAKE_CHAR`: Create (or rename or link) a character device.
- `LANDLOCK_ACCESS_FS_MAKE_DIR`: Create (or rename) a directory.
- `LANDLOCK_ACCESS_FS_MAKE_REG`: Create (or rename or link) a regular file.
- `LANDLOCK_ACCESS_FS_MAKE_SOCK`: Create (or rename or link) a UNIX domain socket.
- `LANDLOCK_ACCESS_FS_MAKE_FIFO`: Create (or rename or link) a named pipe.
- `LANDLOCK_ACCESS_FS_MAKE_BLOCK`: Create (or rename or link) a block device.
- `LANDLOCK_ACCESS_FS_MAKE_SYM`: Create (or rename or link) a symbolic link.
- `LANDLOCK_ACCESS_FS_REFER`: Link or rename a file from or to a different directory (i.e. reparent a file hierarchy).

This access right is available since the second version of the Landlock ABI.

This is the only access right which is denied by default by any ruleset, even if the right is not specified as handled at ruleset creation time. The only way to make a ruleset grant this right is to explicitly allow it for a specific directory by adding a matching rule to the ruleset.

In particular, when using the first Landlock ABI version, Landlock will always deny attempts to reparent files between different directories.

In addition to the source and destination directories having the `LANDLOCK_ACCESS_FS_REFER` access right, the attempted link or rename operation must meet the following constraints:

- The reparented file may not gain more access rights in the destination directory than it previously had in the source directory. If this is attempted, the operation results in an `EXDEV` error.
- When linking or renaming, the `LANDLOCK_ACCESS_FS_MAKE_*` right for the respective file type must be granted for the destination directory. Otherwise, the operation results in an `EACCES` error.
- When renaming, the `LANDLOCK_ACCESS_FS_REMOVE_*` right for the respective file type must be granted for the source directory. Otherwise, the operation results in an `EACCES` error.

If multiple requirements are not met, the `EACCES` error code takes precedence over `EXDEV`.

**Warning:** It is currently not possible to restrict some file-related actions accessible through these syscall families: `chdir(2)`, `stat(2)`, `flock(2)`, `chmod(2)`, `chown(2)`, `setxattr(2)`, `utime(2)`, `ioctl(2)`, `fcntl(2)`, `access(2)`. Future Landlock evolutions will enable to restrict them.

## Network flags

These flags enable to restrict a sandboxed process to a set of network actions. This is supported since the Landlock ABI version 4.

TCP sockets with allowed actions:

- `LANDLOCK_ACCESS_NET_BIND_TCP`: Bind a TCP socket to a local port.
- `LANDLOCK_ACCESS_NET_CONNECT_TCP`: Connect an active TCP socket to a remote port.

### 3.3.2 Creating a new ruleset

```
long sys_landlock_create_ruleset(const struct landlock_ruleset_attr __user *const attr,  
                                const size_t size, const __u32 flags)
```

Create a new ruleset

#### Parameters

`const struct landlock_ruleset_attr __user *const attr`

Pointer to a `struct landlock_ruleset_attr` identifying the scope of the new ruleset.

`const size_t size`

Size of the pointed `struct landlock_ruleset_attr` (needed for backward and forward compatibility).

`const __u32 flags`

Supported value: `LANDLOCK_CREATE_RULESET_VERSION`.

#### Description

This system call enables to create a new Landlock ruleset, and returns the related file descriptor on success.

If `flags` is `LANDLOCK_CREATE_RULESET_VERSION` and `attr` is NULL and `size` is 0, then the returned value is the highest supported Landlock ABI version (starting at 1).

Possible returned errors are:

- `EOPNOTSUPP`: Landlock is supported by the kernel but disabled at boot time;
- `EINVAL`: unknown `flags`, or unknown access, or too small `size`;
- `E2BIG` or `EFAULT`: `attr` or `size` inconsistencies;
- `ENOMSG`: empty `landlock_ruleset_attr.handled_access_fs`.

`struct landlock_ruleset_attr`

Ruleset definition

#### Definition:

```
struct landlock_ruleset_attr {  
    __u64 handled_access_fs;  
    __u64 handled_access_net;  
};
```

## Members

### **handled\_access\_fs**

Bitmask of actions (cf. *Filesystem flags*) that is handled by this ruleset and should then be forbidden if no rule explicitly allow them: it is a deny-by-default list that should contain as much Landlock access rights as possible. Indeed, all Landlock filesystem access rights that are not part of handled\_access\_fs are allowed. This is needed for backward compatibility reasons. One exception is the LANDLOCK\_ACCESS\_FS\_REFER access right, which is always implicitly handled, but must still be explicitly handled to add new rules with this access right.

### **handled\_access\_net**

Bitmask of actions (cf. *Network flags*) that is handled by this ruleset and should then be forbidden if no rule explicitly allow them.

## Description

Argument of `sys_landlock_create_ruleset()`. This structure can grow in future versions.

### 3.3.3 Extending a ruleset

```
long sys_landlock_add_rule(const int ruleset_fd, const enum landlock_rule_type rule_type,  
                           const void __user *const rule_attr, const __u32 flags)
```

Add a new rule to a ruleset

## Parameters

### **const int ruleset\_fd**

File descriptor tied to the ruleset that should be extended with the new rule.

### **const enum landlock\_rule\_type rule\_type**

Identify the structure type pointed to by **rule\_attr**: LANDLOCK\_RULE\_PATH\_BENEATH or LANDLOCK\_RULE\_NET\_PORT.

### **const void \_\_user \*const rule\_attr**

Pointer to a rule (only of type `struct landlock_path_beneath_attr` for now).

### **const \_\_u32 flags**

Must be 0.

## Description

This system call enables to define a new rule and add it to an existing ruleset.

Possible returned errors are:

- EOPNOTSUPP: Landlock is supported by the kernel but disabled at boot time;
- EAFNOSUPPORT: **rule\_type** is LANDLOCK\_RULE\_NET\_PORT but TCP/IP is not supported by the running kernel;

- EINVAL: **flags** is not 0, or inconsistent access in the rule (i.e. `landlock_path_beneath_attr.allowed_access` or `landlock_net_port_attr.allowed_access` is not a subset of the ruleset handled accesses), or `landlock_net_port_attr.port` is greater than 65535;
- ENOMSG: Empty accesses (e.g. `landlock_path_beneath_attr.allowed_access`);
- EBADF: **ruleset\_fd** is not a file descriptor for the current thread, or a member of **rule\_attr** is not a file descriptor as expected;
- EBADFD: **ruleset\_fd** is not a ruleset file descriptor, or a member of **rule\_attr** is not the expected file descriptor type;
- EPERM: **ruleset\_fd** has no write access to the underlying ruleset;
- EFAULT: **rule\_attr** inconsistency.

## enum `landlock_rule_type`

Landlock rule type

## Constants

### `LANDLOCK_RULE_PATH_BENEATH`

Type of a `struct landlock_path_beneath_attr`.

### `LANDLOCK_RULE_NET_PORT`

Type of a `struct landlock_net_port_attr`.

## Description

Argument of `sys_landlock_add_rule()`.

## struct `landlock_path_beneath_attr`

Path hierarchy definition

### Definition:

```
struct landlock_path_beneath_attr {
    __u64 allowed_access;
    __s32 parent_fd;
};
```

## Members

### `allowed_access`

Bitmask of allowed actions for this file hierarchy (cf. *Filesystem flags*).

### `parent_fd`

File descriptor, preferably opened with `O_PATH`, which identifies the parent directory of a file hierarchy, or just a file.

## Description

Argument of `sys_landlock_add_rule()`.

## struct `landlock_net_port_attr`

Network port definition

### Definition:

```
struct landlock_net_port_attr {  
    __u64 allowed_access;  
    __u64 port;  
};
```

### Members

#### **allowed\_access**

Bitmask of allowed access network for a port (cf. *Network flags*).

#### **port**

Network port in host endianness.

It should be noted that port 0 passed to *bind(2)* will bind to an available port from a specific port range. This can be configured thanks to the /proc/sys/net/ipv4/ip\_local\_port\_range sysctl (also used for IPv6). A Landlock rule with port 0 and the LANDLOCK\_ACCESS\_NET\_BIND\_TCP right means that requesting to bind on port 0 is allowed and it will automatically translate to binding on the related port range.

### Description

Argument of *sys\_landlock\_add\_rule()*.

## 3.3.4 Enforcing a ruleset

```
long sys_landlock_restrict_self(const int ruleset_fd, const __u32 flags)
```

Enforce a ruleset on the calling thread

### Parameters

#### **const int ruleset\_fd**

File descriptor tied to the ruleset to merge with the target.

#### **const \_\_u32 flags**

Must be 0.

### Description

This system call enables to enforce a Landlock ruleset on the current thread. Enforcing a ruleset requires that the task has CAP\_SYS\_ADMIN in its namespace or is running with no\_new\_privs. This avoids scenarios where unprivileged tasks can affect the behavior of privileged children.

Possible returned errors are:

- EOPNOTSUPP: Landlock is supported by the kernel but disabled at boot time;
- EINVAL: **flags** is not 0.
- EBADF: **ruleset\_fd** is not a file descriptor for the current thread;
- EBADFD: **ruleset\_fd** is not a ruleset file descriptor;
- EPERM: **ruleset\_fd** has no read access to the underlying ruleset, or the current thread is not running with no\_new\_privs, or it doesn't have CAP\_SYS\_ADMIN in its namespace.
- E2BIG: The maximum number of stacked rulesets is reached for the current thread.

## 3.4 Current limitations

### 3.4.1 Filesystem topology modification

Threads sandboxed with filesystem restrictions cannot modify filesystem topology, whether via `mount(2)` or `pivot_root(2)`. However, `chroot(2)` calls are not denied.

### 3.4.2 Special filesystems

Access to regular files and directories can be restricted by Landlock, according to the handled accesses of a ruleset. However, files that do not come from a user-visible filesystem (e.g. pipe, socket), but can still be accessed through `/proc/<pid>/fd/*`, cannot currently be explicitly restricted. Likewise, some special kernel filesystems such as nsfs, which can be accessed through `/proc/<pid>/ns/*`, cannot currently be explicitly restricted. However, thanks to the [ptrace restrictions](#), access to such sensitive `/proc` files are automatically restricted according to domain hierarchies. Future Landlock evolutions could still enable to explicitly restrict such paths with dedicated ruleset flags.

### 3.4.3 Ruleset layers

There is a limit of 16 layers of stacked rulesets. This can be an issue for a task willing to enforce a new ruleset in complement to its 16 inherited rulesets. Once this limit is reached, `sys_landlock_restrict_self()` returns E2BIG. It is then strongly suggested to carefully build rulesets once in the life of a thread, especially for applications able to launch other applications that may also want to sandbox themselves (e.g. shells, container managers, etc.).

### 3.4.4 Memory usage

Kernel memory allocated to create rulesets is accounted and can be restricted by the Documentation/admin-guide/cgroup-v1/memory.rst.

## 3.5 Previous limitations

### 3.5.1 File renaming and linking (ABI < 2)

Because Landlock targets unprivileged access controls, it needs to properly handle composition of rules. Such property also implies rules nesting. Properly handling multiple layers of rulesets, each one of them able to restrict access to files, also implies inheritance of the ruleset restrictions from a parent to its hierarchy. Because files are identified and restricted by their hierarchy, moving or linking a file from one directory to another implies propagation of the hierarchy constraints, or restriction of these actions according to the potentially lost constraints. To protect against privilege escalations through renaming or linking, and for the sake of simplicity, Landlock previously limited linking and renaming to the same directory. Starting with the Landlock ABI version 2, it is now possible to securely control renaming and linking thanks to the new `LANDLOCK_ACCESS_FS_REFER` access right.

### 3.5.2 File truncation (ABI < 3)

File truncation could not be denied before the third Landlock ABI, so it is always allowed when using a kernel that only supports the first or second ABI.

Starting with the Landlock ABI version 3, it is now possible to securely control truncation thanks to the new `LANDLOCK_ACCESS_FS_TRUNCATE` access right.

### 3.5.3 Network support (ABI < 4)

Starting with the Landlock ABI version 4, it is now possible to restrict TCP bind and connect actions to only a set of allowed ports thanks to the new `LANDLOCK_ACCESS_NET_BIND_TCP` and `LANDLOCK_ACCESS_NET_CONNECT_TCP` access rights.

## 3.6 Kernel support

Landlock was first introduced in Linux 5.13 but it must be configured at build time with `CONFIG_SECURITY_LANDLOCK=y`. Landlock must also be enabled at boot time as the other security modules. The list of security modules enabled by default is set with `CONFIG LSM`. The kernel configuration should then contains `CONFIG LSM=landlock, [...]` with [...] as the list of other potentially useful security modules for the running system (see the `CONFIG LSM` help).

If the running kernel does not have `landlock` in `CONFIG LSM`, then we can still enable it by adding `lsm=landlock, [...]` to `Documentation/admin-guide/kernel-parameters.rst` thanks to the bootloader configuration.

To be able to explicitly allow TCP operations (e.g., adding a network rule with `LANDLOCK_ACCESS_NET_BIND_TCP`), the kernel must support TCP (`CONFIG_INET=y`). Otherwise, `sys_landlock_add_rule()` returns an `EAFNOSUPPORT` error, which can safely be ignored because this kind of TCP operation is already not possible.

## 3.7 Questions and answers

### 3.7.1 What about user space sandbox managers?

Using user space process to enforce restrictions on kernel resources can lead to race conditions or inconsistent evaluations (i.e. Incorrect mirroring of the OS code and state).

### 3.7.2 What about namespaces and containers?

Namespaces can help create sandboxes but they are not designed for access-control and then miss useful features for such use case (e.g. no fine-grained restrictions). Moreover, their complexity can lead to security issues, especially when untrusted processes can manipulate them (cf. [Controlling access to user namespaces](#)).

## 3.8 Additional documentation

- Documentation/security/landlock.rst
- <https://landlock.io>



## **UNSHARE SYSTEM CALL**

This document describes the new system call, unshare(). The document provides an overview of the feature, why it is needed, how it can be used, its interface specification, design, implementation and how it can be tested.

### **4.1 Change Log**

version 0.1 Initial document, Janak Desai ([janak@us.ibm.com](mailto:janak@us.ibm.com)), Jan 11, 2006

### **4.2 Contents**

- 1) Overview
- 2) Benefits
- 3) Cost
- 4) Requirements
- 5) Functional Specification
- 6) High Level Design
- 7) Low Level Design
- 8) Test Specification
- 9) Future Work

### **4.3 1) Overview**

Most legacy operating system kernels support an abstraction of threads as multiple execution contexts within a process. These kernels provide special resources and mechanisms to maintain these "threads". The Linux kernel, in a clever and simple manner, does not make distinction between processes and "threads". The kernel allows processes to share resources and thus they can achieve legacy "threads" behavior without requiring additional data structures and mechanisms in the kernel. The power of implementing threads in this manner comes not only from its simplicity but also from allowing application programmers to work outside the confinement of all-or-nothing shared resources of legacy threads. On Linux, at the time of thread

creation using the clone system call, applications can selectively choose which resources to share between threads.

unshare() system call adds a primitive to the Linux thread model that allows threads to selectively 'unshare' any resources that were being shared at the time of their creation. unshare() was conceptualized by Al Viro in the August of 2000, on the Linux-Kernel mailing list, as part of the discussion on POSIX threads on Linux. unshare() augments the usefulness of Linux threads for applications that would like to control shared resources without creating a new process. unshare() is a natural addition to the set of available primitives on Linux that implement the concept of process/thread as a virtual machine.

## 4.4 2) Benefits

unshare() would be useful to large application frameworks such as PAM where creating a new process to control sharing/unsharing of process resources is not possible. Since namespaces are shared by default when creating a new process using fork or clone, unshare() can benefit even non-threaded applications if they have a need to disassociate from default shared namespace. The following lists two use-cases where unshare() can be used.

### 4.4.1 2.1 Per-security context namespaces

unshare() can be used to implement polyinstantiated directories using the kernel's per-process namespace mechanism. Polyinstantiated directories, such as per-user and/or per-security context instance of /tmp, /var/tmp or per-security context instance of a user's home directory, isolate user processes when working with these directories. Using unshare(), a PAM module can easily setup a private namespace for a user at login. Polyinstantiated directories are required for Common Criteria certification with Labeled System Protection Profile, however, with the availability of shared-tree feature in the Linux kernel, even regular Linux systems can benefit from setting up private namespaces at login and polyinstantiating /tmp, /var/tmp and other directories deemed appropriate by system administrators.

### 4.4.2 2.2 unsharing of virtual memory and/or open files

Consider a client/server application where the server is processing client requests by creating processes that share resources such as virtual memory and open files. Without unshare(), the server has to decide what needs to be shared at the time of creating the process which services the request. unshare() allows the server an ability to disassociate parts of the context during the servicing of the request. For large and complex middleware application frameworks, this ability to unshare() after the process was created can be very useful.

## 4.5 3) Cost

In order to not duplicate code and to handle the fact that unshare() works on an active task (as opposed to clone/fork working on a newly allocated inactive task) unshare() had to make minor reorganizational changes to copy\_\* functions utilized by clone/fork system call. There is a cost associated with altering existing, well tested and stable code to implement a new feature that may not get exercised extensively in the beginning. However, with proper design and code review of the changes and creation of an unshare() test for the LTP the benefits of this new feature can exceed its cost.

## 4.6 4) Requirements

unshare() reverses sharing that was done using clone(2) system call, so unshare() should have a similar interface as clone(2). That is, since flags in clone(int flags, void \*stack) specifies what should be shared, similar flags in unshare(int flags) should specify what should be unshared. Unfortunately, this may appear to invert the meaning of the flags from the way they are used in clone(2). However, there was no easy solution that was less confusing and that allowed incremental context unsharing in future without an ABI change.

unshare() interface should accommodate possible future addition of new context flags without requiring a rebuild of old applications. If and when new context flags are added, unshare() design should allow incremental unsharing of those resources on an as needed basis.

## 4.7 5) Functional Specification

### NAME

unshare - disassociate parts of the process execution context

### SYNOPSIS

```
#include <sched.h>
int unshare(int flags);
```

### DESCRIPTION

unshare() allows a process to disassociate parts of its execution context that are currently being shared with other processes. Part of execution context, such as the namespace, is shared by default when a new process is created using fork(2), while other parts, such as the virtual memory, open file descriptors, etc, may be shared by explicit request to share them when creating a process using clone(2).

The main use of unshare() is to allow a process to control its shared execution context without creating a new process.

The flags argument specifies one or bitwise-or'ed of several of the following constants.

#### **CLONE\_FS**

If CLONE\_FS is set, file system information of the caller is disassociated from the shared file system information.

#### **CLONE\_FILES**

If CLONE\_FILES is set, the file descriptor table of the caller is disassociated from the shared file descriptor table.

**CLONE\_NEWNS**

If CLONE\_NEWNS is set, the namespace of the caller is disassociated from the shared namespace.

**CLONE\_VM**

If CLONE\_VM is set, the virtual memory of the caller is disassociated from the shared virtual memory.

**RETURN VALUE**

On success, zero returned. On failure, -1 is returned and errno is

**ERRORS**

**EPERM CLONE\_NEWNS was specified by a non-root process (process without CAP\_SYS\_ADMIN).**

**ENOMEM Cannot allocate sufficient memory to copy parts of caller's context that need to be unshared.**

**EINVAL** Invalid flag was specified as an argument.

**CONFORMING TO**

The unshare() call is Linux-specific and should not be used in programs intended to be portable.

**SEE ALSO**

clone(2), fork(2)

## 4.8 6) High Level Design

Depending on the flags argument, the unshare() system call allocates appropriate process context structures, populates it with values from the current shared version, associates newly duplicated structures with the current task structure and releases corresponding shared versions. Helper functions of clone (copy\_\*) could not be used directly by unshare() because of the following two reasons.

- 1) clone operates on a newly allocated not-yet-active task structure, whereas unshare() operates on the current active task. Therefore unshare() has to take appropriate task\_lock() before associating newly duplicated context structures
- 2) unshare() has to allocate and duplicate all context structures that are being unshared, before associating them with the current task and releasing older shared structures. Failure to do so will create race conditions and/or oops when trying to backout due to an error. Consider the case of unsharing both virtual memory and namespace. After successfully unsharing vm, if the system call encounters an error while allocating new namespace structure, the error return code will have to reverse the unsharing of vm. As part of the reversal the system call will have to go back to older, shared, vm structure, which may not exist anymore.

Therefore code from copy\_\* functions that allocated and duplicated current context structure was moved into new dup\_\* functions. Now, copy\_\* functions call dup\_\* functions to allocate and duplicate appropriate context structures and then associate them with the task structure that is being constructed. unshare() system call on the other hand performs the following:

- 1) Check flags to force missing, but implied, flags

- 2) For each context structure, call the corresponding unshare() helper function to allocate and duplicate a new context structure, if the appropriate bit is set in the flags argument.
- 3) If there is no error in allocation and duplication and there are new context structures then lock the current task structure, associate new context structures with the current task structure, and release the lock on the current task structure.
- 4) Appropriately release older, shared, context structures.

## 4.9 7) Low Level Design

Implementation of unshare() can be grouped in the following 4 different items:

- a) Reorganization of existing copy\_\* functions
- b) unshare() system call service function
- c) unshare() helper functions for each different process context
- d) Registration of system call number for different architectures

### 4.9.1 7.1) Reorganization of copy\_\* functions

Each copy function such as copy\_mm, copy\_namespace, copy\_files, etc, had roughly two components. The first component allocated and duplicated the appropriate structure and the second component linked it to the task structure passed in as an argument to the copy function. The first component was split into its own function. These dup\_\* functions allocated and duplicated the appropriate context structure. The reorganized copy\_\* functions invoked their corresponding dup\_\* functions and then linked the newly duplicated structures to the task structure with which the copy function was called.

### 4.9.2 7.2) unshare() system call service function

- Check flags Force implied flags. If CLONE\_THREAD is set force CLONE\_VM. If CLONE\_VM is set, force CLONE\_SIGHAND. If CLONE\_SIGHAND is set and signals are also being shared, force CLONE\_THREAD. If CLONE\_NEWNS is set, force CLONE\_FS.
- For each context flag, invoke the corresponding unshare\_\* helper routine with flags passed into the system call and a reference to pointer pointing the new unshared structure
- If any new structures are created by unshare\_\* helper functions, take the task\_lock() on the current task, modify appropriate context pointers, and release the task lock.
- For all newly unshared structures, release the corresponding older, shared, structures.

#### **4.9.3 7.3) unshare\_\* helper functions**

For `unshare_*` helpers corresponding to `CLONE_SYSVSEM`, `CLONE_SIGHAND`, and `CLONE_THREAD`, return `-EINVAL` since they are not implemented yet. For others, check the flag value to see if the unsharing is required for that structure. If it is, invoke the corresponding `dup_*` function to allocate and duplicate the structure and return a pointer to it.

#### **4.9.4 7.4) Finally**

Appropriately modify architecture specific code to register the new system call.

### **4.10 8) Test Specification**

The test for `unshare()` should test the following:

- 1) Valid flags: Test to check that clone flags for signal and signal handlers, for which unsharing is not implemented yet, return `-EINVAL`.
- 2) Missing/implied flags: Test to make sure that if unsharing namespace without specifying unsharing of filesystem, correctly unshares both namespace and filesystem information.
- 3) For each of the four (namespace, filesystem, files and vm) supported unsharing, verify that the system call correctly unshares the appropriate structure. Verify that unsharing them individually as well as in combination with each other works as expected.
- 4) Concurrent execution: Use shared memory segments and futex on an address in the shm segment to synchronize execution of about 10 threads. Have a couple of threads execute `execve`, a couple `_exit` and the rest `unshare` with different combination of flags. Verify that unsharing is performed as expected and that there are no oops or hangs.

### **4.11 9) Future Work**

The current implementation of `unshare()` does not allow unsharing of signals and signal handlers. Signals are complex to begin with and to unshare signals and/or signal handlers of a currently running process is even more complex. If in the future there is a specific need to allow unsharing of signals and/or signal handlers, it can be incrementally added to `unshare()` without affecting legacy applications using `unshare()`.

## SPECULATION CONTROL

Quite some CPUs have speculation-related misfeatures which are in fact vulnerabilities causing data leaks in various forms even across privilege domains.

The kernel provides mitigation for such vulnerabilities in various forms. Some of these mitigations are compile-time configurable and some can be supplied on the kernel command line.

There is also a class of mitigations which are very expensive, but they can be restricted to a certain set of processes or tasks in controlled environments. The mechanism to control these mitigations is via *prctl(2)*.

There are two prctl options which are related to this:

- PR\_GET\_SPECULATION\_CTRL
- PR\_SET\_SPECULATION\_CTRL

### 5.1 PR\_GET\_SPECULATION\_CTRL

PR\_GET\_SPECULATION\_CTRL returns the state of the speculation misfeature which is selected with arg2 of prctl(2). The return value uses bits 0-3 with the following meaning:

Bit	Define	Description
0	PR_SPEC_PRCTL	Mitigation can be controlled per task by PR_SET_SPECULATION_CTRL.
1	PR_SPEC_ENABLE	The speculation feature is enabled, mitigation is disabled.
2	PR_SPEC_DISABLE	The speculation feature is disabled, mitigation is enabled.
3	PR_SPEC_FORCE_DISABLE	Same as PR_SPEC_DISABLE, but cannot be undone. A subsequent prctl(..., PR_SPEC_ENABLE) will fail.
4	PR_SPEC_DISABLE_NOEXEC	Same as PR_SPEC_DISABLE, but the state will be cleared on execve(2).

If all bits are 0 the CPU is not affected by the speculation misfeature.

If PR\_SPEC\_PRCTL is set, then the per-task control of the mitigation is available. If not set, prctl(PR\_SET\_SPECULATION\_CTRL) for the speculation misfeature will fail.

## 5.2 PR\_SET\_SPECULATION\_CTRL

`PR_SET_SPECULATION_CTRL` allows to control the speculation misfeature, which is selected by `arg2` of `prctl(2)` per task. `arg3` is used to hand in the control value, i.e. either `PR_SPEC_ENABLE` or `PR_SPEC_DISABLE` or `PR_SPEC_FORCE_DISABLE`.

## 5.3 Common error codes

Value	Meaning
<code>EINVAL</code>	The <code>prctl</code> is not implemented by the architecture or unused <code>prctl(2)</code> arguments are not 0.
<code>ENODEV</code>	<code>arg2</code> is selecting a not supported speculation misfeature.

## 5.4 PR\_SET\_SPECULATION\_CTRL error codes

Value	Meaning
0	Success
<code>ERANGE</code>	<code>arg3</code> is incorrect, i.e. it's neither <code>PR_SPEC_ENABLE</code> nor <code>PR_SPEC_DISABLE</code> nor <code>PR_SPEC_FORCE_DISABLE</code> .
<code>ENXIO</code>	Control of the selected speculation misfeature is not possible. See <code>PR_GET_SPECULATION_CTRL</code> .
<code>EPERM</code>	Speculation was disabled with <code>PR_SPEC_FORCE_DISABLE</code> and caller tried to enable it again.

## 5.5 Speculation misfeature controls

- `PR_SPEC_STORE_BYPASS`: Speculative Store Bypass

### Invocations:

- `prctl(PR_GET_SPECULATION_CTRL, PR_SPEC_STORE_BYPASS, 0, 0, 0);`
- `prctl(PR_SET_SPECULATION_CTRL, PR_SPEC_STORE_BYPASS, PR_SPEC_ENABLE, 0, 0);`
- `prctl(PR_SET_SPECULATION_CTRL, PR_SPEC_STORE_BYPASS, PR_SPEC_DISABLE, 0, 0);`
- `prctl(PR_SET_SPECULATION_CTRL, PR_SPEC_STORE_BYPASS, PR_SPEC_FORCE_DISABLE, 0, 0);`
- `prctl(PR_SET_SPECULATION_CTRL, PR_SPEC_STORE_BYPASS, PR_SPEC_DISABLE_NOEXEC, 0, 0);`

- **`PR_SPEC_INDIR_BRANCH`: Indirect Branch Speculation in User Processes**  
(Mitigate Spectre V2 style attacks against user processes)

### Invocations:

- `prctl(PR_GET_SPECULATION_CTRL, PR_SPEC_INDIRECT_BRANCH, 0, 0, 0);`
  - `prctl(PR_SET_SPECULATION_CTRL, PR_SPEC_INDIRECT_BRANCH, PR_SPEC_ENABLE, 0, 0);`
  - `prctl(PR_SET_SPECULATION_CTRL, PR_SPEC_INDIRECT_BRANCH, PR_SPEC_DISABLE, 0, 0);`
  - `prctl(PR_SET_SPECULATION_CTRL, PR_SPEC_INDIRECT_BRANCH, PR_SPEC_FORCE_DISABLE, 0, 0);`
- **PR\_SPEC\_L1D\_FLUSH: Flush L1D Cache on context switch out of the task**  
(works only when tasks run on non SMT cores)

**Invocations:**

- `prctl(PR_GET_SPECULATION_CTRL, PR_SPEC_L1D_FLUSH, 0, 0, 0);`
- `prctl(PR_SET_SPECULATION_CTRL, PR_SPEC_L1D_FLUSH, PR_SPEC_ENABLE, 0, 0);`
- `prctl(PR_SET_SPECULATION_CTRL, PR_SPEC_L1D_FLUSH, PR_SPEC_DISABLE, 0, 0);`



## **OPENCAPI (OPEN COHERENT ACCELERATOR PROCESSOR INTERFACE)**

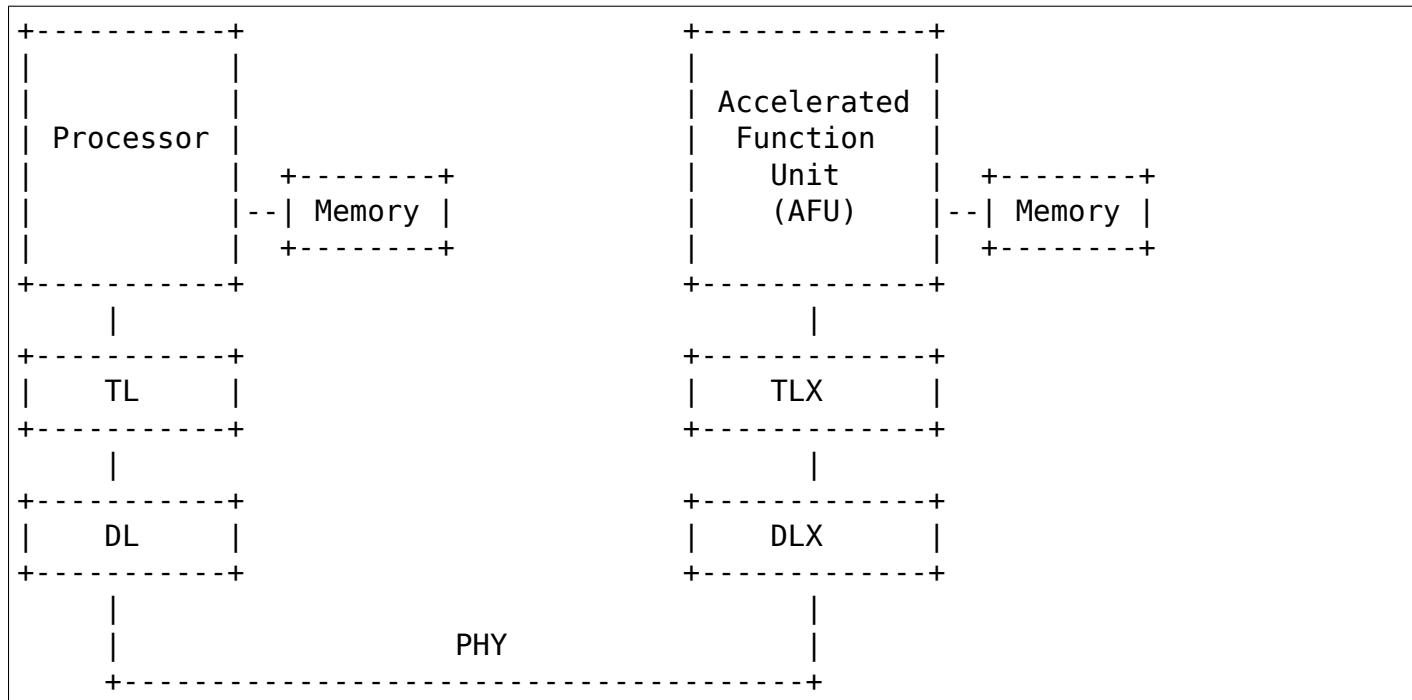
OpenCAPI is an interface between processors and accelerators. It aims at being low-latency and high-bandwidth. The specification is developed by the [OpenCAPI Consortium](#).

It allows an accelerator (which could be an FPGA, ASICs, ...) to access the host memory coherently, using virtual addresses. An OpenCAPI device can also host its own memory, that can be accessed from the host.

OpenCAPI is known in linux as 'ocxl', as the open, processor-agnostic evolution of 'cxl' (the driver for the IBM CAPI interface for powerpc), which was named that way to avoid confusion with the ISDN CAPI subsystem.

### **6.1 High-level view**

OpenCAPI defines a Data Link Layer (DL) and Transaction Layer (TL), to be implemented on top of a physical link. Any processor or device implementing the DL and TL can start sharing memory.



## 6.2 Device discovery

OpenCAPI relies on a PCI-like configuration space, implemented on the device. So the host can discover AFUs by querying the config space.

OpenCAPI devices in Linux are treated like PCI devices (with a few caveats). The firmware is expected to abstract the hardware as if it was a PCI link. A lot of the existing PCI infrastructure is reused: devices are scanned and BARs are assigned during the standard PCI enumeration. Commands like 'lspci' can therefore be used to see what devices are available.

The configuration space defines the AFU(s) that can be found on the physical adapter, such as its name, how many memory contexts it can work with, the size of its MMIO areas, ...

## 6.3 MMIO

OpenCAPI defines two MMIO areas for each AFU:

- the global MMIO area, with registers pertinent to the whole AFU.
- a per-process MMIO area, which has a fixed size for each context.

## 6.4 AFU interrupts

OpenCAPI includes the possibility for an AFU to send an interrupt to a host process. It is done through a 'intrp\_req' defined in the Transaction Layer, specifying a 64-bit object handle which defines the interrupt.

The driver allows a process to allocate an interrupt and obtain its 64-bit object handle, that can be passed to the AFU.

## 6.5 char devices

The driver creates one char device per AFU found on the physical device. A physical device may have multiple functions and each function can have multiple AFUs. At the time of this writing though, it has only been tested with devices exporting only one AFU.

Char devices can be found in /dev/ocxl/ and are named as: /dev/ocxl/<AFU name>.<location>.<index>

where <AFU name> is a max 20-character long name, as found in the config space of the AFU. <location> is added by the driver and can help distinguish devices when a system has more than one instance of the same OpenCAPI device. <index> is also to help distinguish AFUs in the unlikely case where a device carries multiple copies of the same AFU.

## 6.6 Sysfs class

An ocxl class is added for the devices representing the AFUs. See `/sys/class/ocxl`. The layout is described in Documentation/ABI/testing/sysfs-class-ocxl

## 6.7 User API

### 6.7.1 open

Based on the AFU definition found in the config space, an AFU may support working with more than one memory context, in which case the associated char device may be opened multiple times by different processes.

### 6.7.2 ioctl

`OCXL_IOCTL_ATTACH`:

Attach the memory context of the calling process to the AFU so that the AFU can access its memory.

`OCXL_IOCTL_IRQ_ALLOC`:

Allocate an AFU interrupt and return an identifier.

`OCXL_IOCTL_IRQ_FREE`:

Free a previously allocated AFU interrupt.

`OCXL_IOCTL_IRQ_SET_FD`:

Associate an event fd to an AFU interrupt so that the user process can be notified when the AFU sends an interrupt.

`OCXL_IOCTL_GET_METADATA`:

Obtains configuration information from the card, such at the size of MMIO areas, the AFU version, and the PASID for the current context.

`OCXL_IOCTL_ENABLE_P9_WAIT`:

Allows the AFU to wake a userspace thread executing 'wait'. Returns information to userspace to allow it to configure the AFU. Note that this is only available on POWER9.

`OCXL_IOCTL_GET_FEATURES`:

Reports on which CPU features that affect OpenCAPI are usable from userspace.

### **6.7.3 mmap**

A process can mmap the per-process MMIO area for interactions with the AFU.

## EXCHANGING PIXEL BUFFERS

As originally designed, the Linux graphics subsystem had extremely limited support for sharing pixel-buffer allocations between processes, devices, and subsystems. Modern systems require extensive integration between all three classes; this document details how applications and kernel subsystems should approach this sharing for two-dimensional image data.

It is written with reference to the DRM subsystem for GPU and display devices, V4L2 for media devices, and also to Vulkan, EGL and Wayland, for userspace support, however any other subsystems should also follow this design and advice.

### 7.1 Glossary of terms

**image:**

Conceptually a two-dimensional array of pixels. The pixels may be stored in one or more memory buffers. Has width and height in pixels, pixel format and modifier (implicit or explicit).

**row:**

A span along a single y-axis value, e.g. from co-ordinates (0,100) to (200,100).

**scanline:**

Synonym for row.

**column:**

A span along a single x-axis value, e.g. from co-ordinates (100,0) to (100,100).

**memory buffer:**

A piece of memory for storing (parts of) pixel data. Has stride and size in bytes and at least one handle in some API. May contain one or more planes.

**plane:**

A two-dimensional array of some or all of an image's color and alpha channel values.

**pixel:**

A picture element. Has a single color value which is defined by one or more color channels values, e.g. R, G and B, or Y, Cb and Cr. May also have an alpha value as an additional channel.

**pixel data:**

Bytes or bits that represent some or all of the color/alpha channel values of a pixel or an image. The data for one pixel may be spread over several planes or memory buffers depending on format and modifier.

**color value:**

A tuple of numbers, representing a color. Each element in the tuple is a color channel value.

**color channel:**

One of the dimensions in a color model. For example, RGB model has channels R, G, and B. Alpha channel is sometimes counted as a color channel as well.

**pixel format:**

A description of how pixel data represents the pixel's color and alpha values.

**modifier:**

A description of how pixel data is laid out in memory buffers.

**alpha:**

A value that denotes the color coverage in a pixel. Sometimes used for translucency instead.

**stride:**

A value that denotes the relationship between pixel-location co-ordinates and byte-offset values. Typically used as the byte offset between two pixels at the start of vertically-consecutive tiling blocks. For linear layouts, the byte offset between two vertically-adjacent pixels. For non-linear formats the stride must be computed in a consistent way, which usually is done as-if the layout was linear.

**pitch:**

Synonym for stride.

## 7.2 Formats and modifiers

Each buffer must have an underlying format. This format describes the color values provided for each pixel. Although each subsystem has its own format descriptions (e.g. V4L2 and fbdev), the `DRM_FORMAT_*` tokens should be reused wherever possible, as they are the standard descriptions used for interchange. These tokens are described in the `drm_fourcc.h` file, which is a part of DRM's uAPI.

Each `DRM_FORMAT_*` token describes the translation between a pixel co-ordinate in an image, and the color values for that pixel contained within its memory buffers. The number and type of color channels are described: whether they are RGB or YUV, integer or floating-point, the size of each channel and their locations within the pixel memory, and the relationship between color planes.

For example, `DRM_FORMAT_ARGB8888` describes a format in which each pixel has a single 32-bit value in memory. Alpha, red, green, and blue, color channels are available at 8-bit precision per channel, ordered respectively from most to least significant bits in little-endian storage. `DRM_FORMAT_*` is not affected by either CPU or device endianness; the byte pattern in memory is always as described in the format definition, which is usually little-endian.

As a more complex example, `DRM_FORMAT_NV12` describes a format in which luma and chroma YUV samples are stored in separate planes, where the chroma plane is stored at half the resolution in both dimensions (i.e. one U/V chroma sample is stored for each 2x2 pixel grouping).

Format modifiers describe a translation mechanism between these per-pixel memory samples, and the actual memory storage for the buffer. The most straightforward modifier is `DRM_FORMAT_MOD_LINEAR`, describing a scheme in which each plane is laid out row-sequentially,

from the top-left to the bottom-right corner. This is considered the baseline interchange format, and most convenient for CPU access.

Modern hardware employs much more sophisticated access mechanisms, typically making use of tiled access and possibly also compression. For example, the `DRM_FORMAT_MOD_VIVANTE_TILED` modifier describes memory storage where pixels are stored in 4x4 blocks arranged in row-major ordering, i.e. the first tile in a plane stores pixels (0,0) to (3,3) inclusive, and the second tile in a plane stores pixels (4,0) to (7,3) inclusive.

Some modifiers may modify the number of planes required for an image; for example, the `I915_FORMAT_MOD_Y_TILED_CCS` modifier adds a second plane to RGB formats in which it stores data about the status of every tile, notably including whether the tile is fully populated with pixel data, or can be expanded from a single solid color.

These extended layouts are highly vendor-specific, and even specific to particular generations or configurations of devices per-vendor. For this reason, support of modifiers must be explicitly enumerated and negotiated by all users in order to ensure a compatible and optimal pipeline, as discussed below.

## 7.3 Dimensions and size

Each pixel buffer must be accompanied by logical pixel dimensions. This refers to the number of unique samples which can be extracted from, or stored to, the underlying memory storage. For example, even though a 1920x1080 `DRM_FORMAT_NV12` buffer has a luma plane containing 1920x1080 samples for the Y component, and 960x540 samples for the U and V components, the overall buffer is still described as having dimensions of 1920x1080.

The in-memory storage of a buffer is not guaranteed to begin immediately at the base address of the underlying memory, nor is it guaranteed that the memory storage is tightly clipped to either dimension.

Each plane must therefore be described with an `offset` in bytes, which will be added to the base address of the memory storage before performing any per-pixel calculations. This may be used to combine multiple planes into a single memory buffer; for example, `DRM_FORMAT_NV12` may be stored in a single memory buffer where the luma plane's storage begins immediately at the start of the buffer with an offset of 0, and the chroma plane's storage follows within the same buffer beginning from the byte offset for that plane.

Each plane must also have a `stride` in bytes, expressing the offset in memory between two contiguous row. For example, a `DRM_FORMAT_MOD_LINEAR` buffer with dimensions of 1000x1000 may have been allocated as if it were 1024x1000, in order to allow for aligned access patterns. In this case, the buffer will still be described with a width of 1000, however the stride will be  $1024 * \text{bpp}$ , indicating that there are 24 pixels at the positive extreme of the x axis whose values are not significant.

Buffers may also be padded further in the y dimension, simply by allocating a larger area than would ordinarily be required. For example, many media decoders are not able to natively output buffers of height 1080, but instead require an effective height of 1088 pixels. In this case, the buffer continues to be described as having a height of 1080, with the memory allocation for each buffer being increased to account for the extra padding.

## 7.4 Enumeration

Every user of pixel buffers must be able to enumerate a set of supported formats and modifiers, described together. Within KMS, this is achieved with the `IN_FORMATS` property on each DRM plane, listing the supported DRM formats, and the modifiers supported for each format. In userspace, this is supported through the `EGL_EXT_image_dma_buf_import_modifiers` extension entrypoints for EGL, the `VK_EXT_image_drm_format_modifier` extension for Vulkan, and the `zwp_linux_dmabuf_v1` extension for Wayland.

Each of these interfaces allows users to query a set of supported format+modifier combinations.

## 7.5 Negotiation

It is the responsibility of userspace to negotiate an acceptable format+modifier combination for its usage. This is performed through a simple intersection of lists. For example, if a user wants to use Vulkan to render an image to be displayed on a KMS plane, it must:

- query KMS for the `IN_FORMATS` property for the given plane
- query Vulkan for the supported formats for its physical device, making sure to pass the `VkImageUsageFlagBits` and `VkImageCreateFlagBits` corresponding to the intended rendering use
- intersect these formats to determine the most appropriate one
- for this format, intersect the lists of supported modifiers for both KMS and Vulkan, to obtain a final list of acceptable modifiers for that format

This intersection must be performed for all usages. For example, if the user also wishes to encode the image to a video stream, it must query the media API it intends to use for encoding for the set of modifiers it supports, and additionally intersect against this list.

If the intersection of all lists is an empty list, it is not possible to share buffers in this way, and an alternate strategy must be considered (e.g. using CPU access routines to copy data between the different uses, with the corresponding performance cost).

The resulting modifier list is unsorted; the order is not significant.

## 7.6 Allocation

Once userspace has determined an appropriate format, and corresponding list of acceptable modifiers, it must allocate the buffer. As there is no universal buffer-allocation interface available at either kernel or userspace level, the client makes an arbitrary choice of allocation interface such as Vulkan, GBM, or a media API.

Each allocation request must take, at a minimum: the pixel format, a list of acceptable modifiers, and the buffer's width and height. Each API may extend this set of properties in different ways, such as allowing allocation in more than two dimensions, intended usage patterns, etc.

The component which allocates the buffer will make an arbitrary choice of what it considers the 'best' modifier within the acceptable list for the requested allocation, any padding required, and further properties of the underlying memory buffers such as whether they are stored in system or device-specific memory, whether or not they are physically contiguous, and their cache mode.

These properties of the memory buffer are not visible to userspace, however the `dma-heaps` API is an effort to address this.

After allocation, the client must query the allocator to determine the actual modifier selected for the buffer, as well as the per-plane offset and stride. Allocators are not permitted to vary the format in use, to select a modifier not provided within the acceptable list, nor to vary the pixel dimensions other than the padding expressed through offset, stride, and size.

Communicating additional constraints, such as alignment of stride or offset, placement within a particular memory area, etc, is out of scope of `dma-buf`, and is not solved by format and modifier tokens.

## 7.7 Import

To use a buffer within a different context, device, or subsystem, the user passes these parameters (format, modifier, width, height, and per-plane offset and stride) to an importing API.

Each memory buffer is referred to by a buffer handle, which may be unique or duplicated within an image. For example, a `DRM_FORMAT_NV12` buffer may have the luma and chroma buffers combined into a single memory buffer by use of the per-plane offset parameters, or they may be completely separate allocations in memory. For this reason, each import and allocation API must provide a separate handle for each plane.

Each kernel subsystem has its own types and interfaces for buffer management. DRM uses GEM buffer objects (BOs), V4L2 has its own references, etc. These types are not portable between contexts, processes, devices, or subsystems.

To address this, `dma-buf` handles are used as the universal interchange for buffers. Subsystem-specific operations are used to export native buffer handles to a `dma-buf` file descriptor, and to import those file descriptors into a native buffer handle. `dma-buf` file descriptors can be transferred between contexts, processes, devices, and subsystems.

For example, a Wayland media player may use V4L2 to decode a video frame into a `DRM_FORMAT_NV12` buffer. This will result in two memory planes (luma and chroma) being dequeued by the user from V4L2. These planes are then exported to one `dma-buf` file descriptor per plane, these descriptors are then sent along with the metadata (format, modifier, width, height, per-plane offset and stride) to the Wayland server. The Wayland server will then import these file descriptors as an EGLImage for use through EGL/OpenGL (ES), a VkImage for use through Vulkan, or a KMS framebuffer object; each of these import operations will take the same metadata and convert the `dma-buf` file descriptors into their native buffer handles.

Having a non-empty intersection of supported modifiers does not guarantee that import will succeed into all consumers; they may have constraints beyond those implied by modifiers which must be satisfied.

## 7.8 Implicit modifiers

The concept of modifiers post-dates all of the subsystems mentioned above. As such, it has been retrofitted into all of these APIs, and in order to ensure backwards compatibility, support is needed for drivers and userspace which do not (yet) support modifiers.

As an example, GBM is used to allocate buffers to be shared between EGL for rendering and KMS for display. It has two entrypoints for allocating buffers: `gbm_bo_create` which only takes the format, width, height, and a usage token, and `gbm_bo_create_with_modifiers` which extends this with a list of modifiers.

In the latter case, the allocation is as discussed above, being provided with a list of acceptable modifiers that the implementation can choose from (or fail if it is not possible to allocate within those constraints). In the former case where modifiers are not provided, the GBM implementation must make its own choice as to what is likely to be the 'best' layout. Such a choice is entirely implementation-specific: some will internally use tiled layouts which are not CPU-accessible if the implementation decides that is a good idea through whatever heuristic. It is the implementation's responsibility to ensure that this choice is appropriate.

To support this case where the layout is not known because there is no awareness of modifiers, a special `DRM_FORMAT_MOD_INVALID` token has been defined. This pseudo-modifier declares that the layout is not known, and that the driver should use its own logic to determine what the underlying layout may be.

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**Note:** `DRM_FORMAT_MOD_INVALID` is a non-zero value. The modifier value zero is `DRM_FORMAT_MOD_LINEAR`, which is an explicit guarantee that the image has the linear layout. Care and attention should be taken to ensure that zero as a default value is not mixed up with either no modifier or the linear modifier. Also note that in some APIs the invalid modifier value is specified with an out-of-band flag, like in `DRM_IOCTL_MODE_ADDFB2`.

---

### There are four cases where this token may be used:

- during enumeration, an interface may return `DRM_FORMAT_MOD_INVALID`, either as the sole member of a modifier list to declare that explicit modifiers are not supported, or as part of a larger list to declare that implicit modifiers may be used
- during allocation, a user may supply `DRM_FORMAT_MOD_INVALID`, either as the sole member of a modifier list (equivalent to not supplying a modifier list at all) to declare that explicit modifiers are not supported and must not be used, or as part of a larger list to declare that an allocation using implicit modifiers is acceptable
- in a post-allocation query, an implementation may return `DRM_FORMAT_MOD_INVALID` as the modifier of the allocated buffer to declare that the underlying layout is implementation-defined and that an explicit modifier description is not available; per the above rules, this may only be returned when the user has included `DRM_FORMAT_MOD_INVALID` as part of the list of acceptable modifiers, or not provided a list
- when importing a buffer, the user may supply `DRM_FORMAT_MOD_INVALID` as the buffer modifier (or not supply a modifier) to indicate that the modifier is unknown for whatever reason; this is only acceptable when the buffer has not been allocated with an explicit modifier

It follows from this that for any single buffer, the complete chain of operations formed by the producer and all the consumers must be either fully implicit or fully explicit. For example, if a user wishes to allocate a buffer for use between GPU, display, and media, but the media API does not support modifiers, then the user **must not** allocate the buffer with explicit modifiers and attempt to import the buffer into the media API with no modifier, but either perform the allocation using implicit modifiers, or allocate the buffer for media use separately and copy between the two buffers.

As one exception to the above, allocations may be 'upgraded' from implicit to explicit modifiers. For example, if the buffer is allocated with `gbm_bo_create` (taking no modifiers), the user may then query the modifier with `gbm_bo_get_modifier` and then use this modifier as an explicit modifier token if a valid modifier is returned.

When allocating buffers for exchange between different users and modifiers are not available, implementations are strongly encouraged to use `DRM_FORMAT_MOD_LINEAR` for their allocation, as this is the universal baseline for exchange. However, it is not guaranteed that this will result in the correct interpretation of buffer content, as implicit modifier operation may still be subject to driver-specific heuristics.

Any new users - userspace programs and protocols, kernel subsystems, etc - wishing to exchange buffers must offer interoperability through dma-buf file descriptors for memory planes, DRM format tokens to describe the format, DRM format modifiers to describe the layout in memory, at least width and height for dimensions, and at least offset and stride for each memory plane.



## EBPF USERSPACE API

eBPF is a kernel mechanism to provide a sandboxed runtime environment in the Linux kernel for runtime extension and instrumentation without changing kernel source code or loading kernel modules. eBPF programs can be attached to various kernel subsystems, including networking, tracing and Linux security modules (LSM).

For internal kernel documentation on eBPF, see Documentation/bpf/index.rst.

### 8.1 eBPF Syscall

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The primary info for the bpf syscall is available in the [man-pages](#) for bpf(2).

#### 8.1.1 bpf() subcommand reference

The operation to be performed by the **bpf()** system call is determined by the *cmd* argument. Each operation takes an accompanying argument, provided via *attr*, which is a pointer to a union of type *bpf\_attr* (see below). The *size* argument is the size of the union pointed to by *attr*.

##### BPF\_MAP\_CREATE

###### Description

Create a map and return a file descriptor that refers to the map. The close-on-exec file descriptor flag (see **fcntl(2)**) is automatically enabled for the new file descriptor.

Applying **close(2)** to the file descriptor returned by **BPF\_MAP\_CREATE** will delete the map (but see NOTES).

###### Return

A new file descriptor (a nonnegative integer), or -1 if an error occurred (in which case, *errno* is set appropriately).

##### BPF\_MAP\_LOOKUP\_ELEM

###### Description

Look up an element with a given *key* in the map referred to by the file descriptor *map\_fd*.

The *flags* argument may be specified as one of the following:

**BPF\_F\_LOCK**

Look up the value of a spin-locked map without returning the lock. This must be specified if the elements contain a spinlock.

**Return**

Returns zero on success. On error, -1 is returned and *errno* is set appropriately.

**BPF\_MAP\_UPDATE\_ELEM****Description**

Create or update an element (key/value pair) in a specified map.

The *flags* argument should be specified as one of the following:

**BPF\_ANY**

Create a new element or update an existing element.

**BPF\_NOEXIST**

Create a new element only if it did not exist.

**BPF\_EXIST**

Update an existing element.

**BPF\_F\_LOCK**

Update a spin\_lock-ed map element.

**Return**

Returns zero on success. On error, -1 is returned and *errno* is set appropriately.

May set *errno* to **EINVAL**, **EPERM**, **ENOMEM**, **E2BIG**, **EEXIST**, or **ENOENT**.

**E2BIG**

The number of elements in the map reached the *max\_entries* limit specified at map creation time.

**EEXIST**

If *flags* specifies **BPF\_NOEXIST** and the element with *key* already exists in the map.

**ENOENT**

If *flags* specifies **BPF\_EXIST** and the element with *key* does not exist in the map.

**BPF\_MAP\_DELETE\_ELEM****Description**

Look up and delete an element by key in a specified map.

**Return**

Returns zero on success. On error, -1 is returned and *errno* is set appropriately.

**BPF\_MAP\_GET\_NEXT\_KEY****Description**

Look up an element by key in a specified map and return the key of the next element. Can be used to iterate over all elements in the map.

**Return**

Returns zero on success. On error, -1 is returned and *errno* is set appropriately.

The following cases can be used to iterate over all elements of the map:

- If *key* is not found, the operation returns zero and sets the *next\_key* pointer to the key of the first element.
- If *key* is found, the operation returns zero and sets the *next\_key* pointer to the key of the next element.
- If *key* is the last element, returns -1 and *errno* is set to **ENOENT**.

May set *errno* to **ENOMEM**, **EFAULT**, **EPERM**, or **EINVAL** on error.

## BPF\_PROG\_LOAD

### Description

Verify and load an eBPF program, returning a new file descriptor associated with the program.

Applying **close(2)** to the file descriptor returned by **BPF\_PROG\_LOAD** will unload the eBPF program (but see NOTES).

The close-on-exec file descriptor flag (see **fctl(2)**) is automatically enabled for the new file descriptor.

### Return

A new file descriptor (a nonnegative integer), or -1 if an error occurred (in which case, *errno* is set appropriately).

## BPF\_OBJ\_PIN

### Description

Pin an eBPF program or map referred by the specified *bpf\_fd* to the provided *pathname* on the filesystem.

The *pathname* argument must not contain a dot (".".).

On success, *pathname* retains a reference to the eBPF object, preventing deallocation of the object when the original *bpf\_fd* is closed. This allow the eBPF object to live beyond **close(bpf\_fd)**, and hence the lifetime of the parent process.

Applying **unlink(2)** or similar calls to the *pathname* unpins the object from the filesystem, removing the reference. If no other file descriptors or filesystem nodes refer to the same object, it will be deallocated (see NOTES).

The filesystem type for the parent directory of *pathname* must be **BPF\_FS\_MAGIC**.

### Return

Returns zero on success. On error, -1 is returned and *errno* is set appropriately.

## BPF\_OBJ\_GET

### Description

Open a file descriptor for the eBPF object pinned to the specified *pathname*.

### Return

A new file descriptor (a nonnegative integer), or -1 if an error occurred (in which case, *errno* is set appropriately).

## BPF\_PROG\_ATTACH

### Description

Attach an eBPF program to a *target\_fd* at the specified *attach\_type* hook.

The *attach\_type* specifies the eBPF attachment point to attach the program to, and must be one of *bpf\_attach\_type* (see below).

The *attach\_bpf\_fd* must be a valid file descriptor for a loaded eBPF program of a cgroup, flow dissector, LIRC, sockmap or sock\_ops type corresponding to the specified *attach\_type*.

The *target\_fd* must be a valid file descriptor for a kernel object which depends on the attach type of *attach\_bpf\_fd*:

**BPF\_PROG\_TYPE\_CGROUP\_DEVICE**, **BPF\_PROG\_TYPE\_CGROUP\_SKB**,  
**BPF\_PROG\_TYPE\_CGROUP\_SOCK**, **BPF\_PROG\_TYPE\_CGROUP\_SOCK\_ADDR**,  
**BPF\_PROG\_TYPE\_CGROUP SOCKOPT**, **BPF\_PROG\_TYPE\_CGROUP\_SYSCTL**,  
**BPF\_PROG\_TYPE\_SOCK\_OPS**

Control Group v2 hierarchy with the eBPF controller enabled. Requires the kernel to be compiled with **CONFIG\_CGROUP\_BPF**.

### **BPF\_PROG\_TYPE\_FLOW\_DISSECTOR**

Network namespace (eg /proc/self/ns/net).

### **BPF\_PROG\_TYPE\_LIRC\_MODE2**

LIRC device path (eg /dev/lircN). Requires the kernel to be compiled with **CONFIG\_BPF\_LIRC\_MODE2**.

### **BPF\_PROG\_TYPE\_SK\_SKB**, **BPF\_PROG\_TYPE\_SK\_MSG**

eBPF map of socket type (eg **BPF\_MAP\_TYPE\_SOCKHASH**).

#### **Return**

Returns zero on success. On error, -1 is returned and *errno* is set appropriately.

## **BPF\_PROG\_DETACH**

#### **Description**

Detach the eBPF program associated with the *target\_fd* at the hook specified by *attach\_type*. The program must have been previously attached using **BPF\_PROG\_ATTACH**.

#### **Return**

Returns zero on success. On error, -1 is returned and *errno* is set appropriately.

## **BPF\_PROG\_TEST\_RUN**

#### **Description**

Run the eBPF program associated with the *prog\_fd* a *repeat* number of times against a provided program context *ctx\_in* and data *data\_in*, and return the modified program context *ctx\_out*, *data\_out* (for example, packet data), result of the execution *retval*, and *duration* of the test run.

The sizes of the buffers provided as input and output parameters *ctx\_in*, *ctx\_out*, *data\_in*, and *data\_out* must be provided in the corresponding variables *ctx\_size\_in*, *ctx\_size\_out*, *data\_size\_in*, and/or *data\_size\_out*. If any of these parameters are not provided (ie set to NULL), the corresponding size field must be zero.

Some program types have particular requirements:

### **BPF\_PROG\_TYPE\_SK\_LOOKUP**

*data\_in* and *data\_out* must be NULL.

**BPF\_PROG\_TYPE\_RAW\_TRACEPOINT, BPF\_PROG\_TYPE\_RAW\_TRACEPOINT\_WRITABLE**

*ctx\_out*, *data\_in* and *data\_out* must be NULL. *repeat* must be zero.

BPF\_PROG\_RUN is an alias for BPF\_PROG\_TEST\_RUN.

**Return**

Returns zero on success. On error, -1 is returned and *errno* is set appropriately.

**ENOSPC**

Either *data\_size\_out* or *ctx\_size\_out* is too small.

**ENOTSUPP**

This command is not supported by the program type of the program referred to by *prog\_fd*.

**BPF\_PROG\_GET\_NEXT\_ID****Description**

Fetch the next eBPF program currently loaded into the kernel.

Looks for the eBPF program with an id greater than *start\_id* and updates *next\_id* on success. If no other eBPF programs remain with ids higher than *start\_id*, returns -1 and sets *errno* to **ENOENT**.

**Return**

Returns zero on success. On error, or when no id remains, -1 is returned and *errno* is set appropriately.

**BPF\_MAP\_GET\_NEXT\_ID****Description**

Fetch the next eBPF map currently loaded into the kernel.

Looks for the eBPF map with an id greater than *start\_id* and updates *next\_id* on success. If no other eBPF maps remain with ids higher than *start\_id*, returns -1 and sets *errno* to **ENOENT**.

**Return**

Returns zero on success. On error, or when no id remains, -1 is returned and *errno* is set appropriately.

**BPF\_PROG\_GET\_FD\_BY\_ID****Description**

Open a file descriptor for the eBPF program corresponding to *prog\_id*.

**Return**

A new file descriptor (a nonnegative integer), or -1 if an error occurred (in which case, *errno* is set appropriately).

**BPF\_MAP\_GET\_FD\_BY\_ID****Description**

Open a file descriptor for the eBPF map corresponding to *map\_id*.

**Return**

A new file descriptor (a nonnegative integer), or -1 if an error occurred (in which case, *errno* is set appropriately).

**BPF\_OBJ\_GET\_INFO\_BY\_FD**

**Description**

Obtain information about the eBPF object corresponding to *bpf\_fd*.

Populates up to *info\_len* bytes of *info*, which will be in one of the following formats depending on the eBPF object type of *bpf\_fd*:

- **struct bpf\_prog\_info**
- **struct bpf\_map\_info**
- **struct bpf\_btf\_info**
- **struct bpf\_link\_info**

**Return**

Returns zero on success. On error, -1 is returned and *errno* is set appropriately.

**BPF\_PROG\_QUERY****Description**

Obtain information about eBPF programs associated with the specified *attach\_type* hook.

The *target\_fd* must be a valid file descriptor for a kernel object which depends on the attach type of *attach\_bpf\_fd*:

**BPF\_PROG\_TYPE\_CGROUP\_DEVICE**,           **BPF\_PROG\_TYPE\_CGROUP\_SKB**,  
**BPF\_PROG\_TYPE\_CGROUP SOCK**,   **BPF\_PROG\_TYPE\_CGROUP SOCK\_ADDR**,  
**BPF\_PROG\_TYPE\_CGROUP\_SOCKOPT**,   **BPF\_PROG\_TYPE\_CGROUP\_SYSCTL**,  
**BPF\_PROG\_TYPE\_SOCK\_OPS**

Control Group v2 hierarchy with the eBPF controller enabled. Requires the kernel to be compiled with **CONFIG\_CGROUP\_BPF**.

**BPF\_PROG\_TYPE\_FLOW\_DISSECTOR**

Network namespace (eg /proc/self/ns/net).

**BPF\_PROG\_TYPE\_LIRC\_MODE2**

LIRC device path (eg /dev/lircN). Requires the kernel to be compiled with **CONFIG\_BPF\_LIRC\_MODE2**.

**BPF\_PROG\_QUERY** always fetches the number of programs attached and the *attach\_flags* which were used to attach those programs. Additionally, if *prog\_ids* is nonzero and the number of attached programs is less than *prog\_cnt*, populates *prog\_ids* with the eBPF program ids of the programs attached at *target\_fd*.

The following flags may alter the result:

**BPF\_F\_QUERY\_EFFECTIVE**

Only return information regarding programs which are currently effective at the specified *target\_fd*.

**Return**

Returns zero on success. On error, -1 is returned and *errno* is set appropriately.

**BPF\_RAW\_TRACEPOINT\_OPEN****Description**

Attach an eBPF program to a tracepoint *name* to access kernel internal arguments of the tracepoint in their raw form.

The *prog\_fd* must be a valid file descriptor associated with a loaded eBPF program of type **BPF\_PROG\_TYPE\_RAW\_TRACEPOINT**.

No ABI guarantees are made about the content of tracepoint arguments exposed to the corresponding eBPF program.

Applying **close(2)** to the file descriptor returned by **BPF\_RAW\_TRACEPOINT\_OPEN** will delete the map (but see NOTES).

### Return

A new file descriptor (a nonnegative integer), or -1 if an error occurred (in which case, *errno* is set appropriately).

## **BPF\_BTF\_LOAD**

### Description

Verify and load BPF Type Format (BTF) metadata into the kernel, returning a new file descriptor associated with the metadata. BTF is described in more detail at <https://www.kernel.org/doc/html/latest/bpf/btf.html>.

The *btf* parameter must point to valid memory providing *btf\_size* bytes of BTF binary metadata.

The returned file descriptor can be passed to other **bpf()** subcommands such as **BPF\_PROG\_LOAD** or **BPF\_MAP\_CREATE** to associate the BTF with those objects.

Similar to **BPF\_PROG\_LOAD**, **BPF\_BTF\_LOAD** has optional parameters to specify a *btf\_log\_buf*, *btf\_log\_size* and *btf\_log\_level* which allow the kernel to return freeform log output regarding the BTF verification process.

### Return

A new file descriptor (a nonnegative integer), or -1 if an error occurred (in which case, *errno* is set appropriately).

## **BPF\_BTF\_GET\_FD\_BY\_ID**

### Description

Open a file descriptor for the BPF Type Format (BTF) corresponding to *btf\_id*.

### Return

A new file descriptor (a nonnegative integer), or -1 if an error occurred (in which case, *errno* is set appropriately).

## **BPF\_TASK\_FD\_QUERY**

### Description

Obtain information about eBPF programs associated with the target process identified by *pid* and *fd*.

If the *pid* and *fd* are associated with a tracepoint, kprobe or uprobe perf event, then the *prog\_id* and *fd\_type* will be populated with the eBPF program id and file descriptor type of type **bpf\_task\_fd\_type**. If associated with a kprobe or uprobe, the *probe\_offset* and *probe\_addr* will also be populated. Optionally, if *buf* is provided, then up to *buf\_len* bytes of *buf* will be populated with the name of the tracepoint, kprobe or uprobe.

The resulting *prog\_id* may be introspected in deeper detail using **BPF\_PROG\_GET\_FD\_BY\_ID** and **BPF\_OBJ\_GET\_INFO\_BY\_FD**.

### Return

Returns zero on success. On error, -1 is returned and *errno* is set appropriately.

## BPF\_MAP\_LOOKUP\_AND\_DELETE\_ELEM

### Description

Look up an element with the given *key* in the map referred to by the file descriptor *fd*, and if found, delete the element.

For **BPF\_MAP\_TYPE\_QUEUE** and **BPF\_MAP\_TYPE\_STACK** map types, the *flags* argument needs to be set to 0, but for other map types, it may be specified as:

### BPF\_F\_LOCK

Look up and delete the value of a spin-locked map without returning the lock. This must be specified if the elements contain a spinlock.

The **BPF\_MAP\_TYPE\_QUEUE** and **BPF\_MAP\_TYPE\_STACK** map types implement this command as a "pop" operation, deleting the top element rather than one corresponding to *key*. The *key* and *key\_len* parameters should be zeroed when issuing this operation for these map types.

This command is only valid for the following map types: \*  
**BPF\_MAP\_TYPE\_QUEUE** \* **BPF\_MAP\_TYPE\_STACK** \* **BPF\_MAP\_TYPE\_HASH**  
\* **BPF\_MAP\_TYPE\_PERCPU\_HASH** \* **BPF\_MAP\_TYPE\_LRU\_HASH** \*  
**BPF\_MAP\_TYPE\_LRU\_PERCPU\_HASH**

### Return

Returns zero on success. On error, -1 is returned and *errno* is set appropriately.

## BPF\_MAP\_FREEZE

### Description

Freeze the permissions of the specified map.

Write permissions may be frozen by passing zero *flags*. Upon success, no future syscall invocations may alter the map state of *map\_fd*. Write operations from eBPF programs are still possible for a frozen map.

Not supported for maps of type **BPF\_MAP\_TYPE\_STRUCT\_OPS**.

### Return

Returns zero on success. On error, -1 is returned and *errno* is set appropriately.

## BPF\_BTF\_GET\_NEXT\_ID

### Description

Fetch the next BPF Type Format (BTF) object currently loaded into the kernel.

Looks for the BTF object with an id greater than *start\_id* and updates *next\_id* on success. If no other BTF objects remain with ids higher than *start\_id*, returns -1 and sets *errno* to **ENOENT**.

### Return

Returns zero on success. On error, or when no id remains, -1 is returned and *errno* is set appropriately.

## BPF\_MAP\_LOOKUP\_BATCH

### Description

Iterate and fetch multiple elements in a map.

Two opaque values are used to manage batch operations, *in\_batch* and *out\_batch*. Initially, *in\_batch* must be set to NULL to begin the batched operation. After each sub-

sequent **BPF\_MAP\_LOOKUP\_BATCH**, the caller should pass the resultant *out\_batch* as the *in\_batch* for the next operation to continue iteration from the current point.

The *keys* and *values* are output parameters which must point to memory large enough to hold *count* items based on the key and value size of the map *map\_fd*. The *keys* buffer must be of *key\_size \* count*. The *values* buffer must be of *value\_size \* count*.

The *elem\_flags* argument may be specified as one of the following:

#### **BPF\_F\_LOCK**

Look up the value of a spin-locked map without returning the lock. This must be specified if the elements contain a spinlock.

On success, *count* elements from the map are copied into the user buffer, with the keys copied into *keys* and the values copied into the corresponding indices in *values*.

If an error is returned and *errno* is not **EFAULT**, *count* is set to the number of successfully processed elements.

#### **Return**

Returns zero on success. On error, -1 is returned and *errno* is set appropriately.

May set *errno* to **ENOSPC** to indicate that *keys* or *values* is too small to dump an entire bucket during iteration of a hash-based map type.

### **BPF\_MAP\_LOOKUP\_AND\_DELETE\_BATCH**

#### **Description**

Iterate and delete all elements in a map.

This operation has the same behavior as **BPF\_MAP\_LOOKUP\_BATCH** with two exceptions:

- Every element that is successfully returned is also deleted from the map. This is at least *count* elements. Note that *count* is both an input and an output parameter.
- Upon returning with *errno* set to **EFAULT**, up to *count* elements may be deleted without returning the keys and values of the deleted elements.

#### **Return**

Returns zero on success. On error, -1 is returned and *errno* is set appropriately.

### **BPF\_MAP\_UPDATE\_BATCH**

#### **Description**

Update multiple elements in a map by *key*.

The *keys* and *values* are input parameters which must point to memory large enough to hold *count* items based on the key and value size of the map *map\_fd*. The *keys* buffer must be of *key\_size \* count*. The *values* buffer must be of *value\_size \* count*.

Each element specified in *keys* is sequentially updated to the value in the corresponding index in *values*. The *in\_batch* and *out\_batch* parameters are ignored and should be zeroed.

The *elem\_flags* argument should be specified as one of the following:

#### **BPF\_ANY**

Create new elements or update a existing elements.

**BPF\_NOEXIST**

Create new elements only if they do not exist.

**BPF\_EXIST**

Update existing elements.

**BPF\_F\_LOCK**

Update spin\_lock-ed map elements. This must be specified if the map value contains a spinlock.

On success, *count* elements from the map are updated.

If an error is returned and *errno* is not **EFAULT**, *count* is set to the number of successfully processed elements.

**Return**

Returns zero on success. On error, -1 is returned and *errno* is set appropriately.

May set *errno* to **EINVAL**, **EPERM**, **ENOMEM**, or **E2BIG**. **E2BIG** indicates that the number of elements in the map reached the *max\_entries* limit specified at map creation time.

May set *errno* to one of the following error codes under specific circumstances:

**EEXIST**

If *flags* specifies **BPF\_NOEXIST** and the element with *key* already exists in the map.

**ENOENT**

If *flags* specifies **BPF\_EXIST** and the element with *key* does not exist in the map.

**BPF\_MAP\_DELETE\_BATCH****Description**

Delete multiple elements in a map by *key*.

The *keys* parameter is an input parameter which must point to memory large enough to hold *count* items based on the key size of the map *map\_fd*, that is, *key\_size* \* *count*.

Each element specified in *keys* is sequentially deleted. The *in\_batch*, *out\_batch*, and *values* parameters are ignored and should be zeroed.

The *elem\_flags* argument may be specified as one of the following:

**BPF\_F\_LOCK**

Look up the value of a spin-locked map without returning the lock. This must be specified if the elements contain a spinlock.

On success, *count* elements from the map are updated.

If an error is returned and *errno* is not **EFAULT**, *count* is set to the number of successfully processed elements. If *errno* is **EFAULT**, up to *count* elements may be deleted.

**Return**

Returns zero on success. On error, -1 is returned and *errno* is set appropriately.

**BPF\_LINK\_CREATE**

**Description**

Attach an eBPF program to a *target\_fd* at the specified *attach\_type* hook and return a file descriptor handle for managing the link.

**Return**

A new file descriptor (a nonnegative integer), or -1 if an error occurred (in which case, *errno* is set appropriately).

**BPF\_LINK\_UPDATE****Description**

Update the eBPF program in the specified *link\_fd* to *new\_prog\_fd*.

**Return**

Returns zero on success. On error, -1 is returned and *errno* is set appropriately.

**BPF\_LINK\_GET\_FD\_BY\_ID****Description**

Open a file descriptor for the eBPF Link corresponding to *link\_id*.

**Return**

A new file descriptor (a nonnegative integer), or -1 if an error occurred (in which case, *errno* is set appropriately).

**BPF\_LINK\_GET\_NEXT\_ID****Description**

Fetch the next eBPF link currently loaded into the kernel.

Looks for the eBPF link with an id greater than *start\_id* and updates *next\_id* on success. If no other eBPF links remain with ids higher than *start\_id*, returns -1 and sets *errno* to **ENOENT**.

**Return**

Returns zero on success. On error, or when no id remains, -1 is returned and *errno* is set appropriately.

**BPF\_ENABLE\_STATS****Description**

Enable eBPF runtime statistics gathering.

Runtime statistics gathering for the eBPF runtime is disabled by default to minimize the corresponding performance overhead. This command enables statistics globally.

Multiple programs may independently enable statistics. After gathering the desired statistics, eBPF runtime statistics may be disabled again by calling **close(2)** for the file descriptor returned by this function. Statistics will only be disabled system-wide when all outstanding file descriptors returned by prior calls for this subcommand are closed.

**Return**

A new file descriptor (a nonnegative integer), or -1 if an error occurred (in which case, *errno* is set appropriately).

**BPF\_ITER\_CREATE****Description**

Create an iterator on top of the specified *link\_fd* (as previously created using

**BPF\_LINK\_CREATE**) and return a file descriptor that can be used to trigger the iteration.

If the resulting file descriptor is pinned to the filesystem using **BPF\_OBJ\_PIN**, then subsequent **read(2)** syscalls for that path will trigger the iterator to read kernel state using the eBPF program attached to *link\_fd*.

**Return**

A new file descriptor (a nonnegative integer), or -1 if an error occurred (in which case, *errno* is set appropriately).

**BPF\_LINK\_DETACH****Description**

Forcefully detach the specified *link\_fd* from its corresponding attachment point.

**Return**

Returns zero on success. On error, -1 is returned and *errno* is set appropriately.

**BPF\_PROG\_BIND\_MAP****Description**

Bind a map to the lifetime of an eBPF program.

The map identified by *map\_fd* is bound to the program identified by *prog\_fd* and only released when *prog\_fd* is released. This may be used in cases where metadata should be associated with a program which otherwise does not contain any references to the map (for example, embedded in the eBPF program instructions).

**Return**

Returns zero on success. On error, -1 is returned and *errno* is set appropriately.

**NOTES**

eBPF objects (maps and programs) can be shared between processes.

- After **fork(2)**, the child inherits file descriptors referring to the same eBPF objects.
- File descriptors referring to eBPF objects can be transferred over **unix(7)** domain sockets.
- File descriptors referring to eBPF objects can be duplicated in the usual way, using **dup(2)** and similar calls.
- File descriptors referring to eBPF objects can be pinned to the filesystem using the **BPF\_OBJ\_PIN** command of **bpf(2)**.

An eBPF object is deallocated only after all file descriptors referring to the object have been closed and no references remain pinned to the filesystem or attached (for example, bound to a program or device).

## LINUX-SPECIFIC ELF IDIOSYNCRASIES

### 9.1 Definitions

"First" program header is the one with the smallest offset in the file: `e_phoff`.

"Last" program header is the one with the biggest offset in the file: `e_phoff + (e_phnum - 1) * sizeof(Elf_Phdr)`.

### 9.2 PT\_INTERP

First PT\_INTERP program header is used to locate the filename of ELF interpreter. Other PT\_INTERP headers are ignored (since Linux 2.4.11).

### 9.3 PT\_GNU\_STACK

Last PT\_GNU\_STACK program header defines userspace stack executability (since Linux 2.6.6). Other PT\_GNU\_STACK headers are ignored.

### 9.4 PT\_GNU\_PROPERTY

ELF interpreter's last PT\_GNU\_PROPERTY program header is used (since Linux 5.8). If interpreter doesn't have one, then the last PT\_GNU\_PROPERTY program header of an executable is used. Other PT\_GNU\_PROPERTY headers are ignored.



## IOCTLS

### 10.1 ioctl Numbers

19 October 1999

Michael Elizabeth Chastain <[mec@shout.net](mailto:mec@shout.net)>

If you are adding new ioctl's to the kernel, you should use the \_IO macros defined in <linux/ioctl.h>:

_IO	an	ioctl with no parameters
_IOW	an	ioctl with write parameters (copy_from_user)
_IOR	an	ioctl with read parameters (copy_to_user)
_IOWR	an	ioctl with both write and read parameters.

'Write' and 'read' are from the user's point of view, just like the system calls 'write' and 'read'. For example, a SET\_FOO ioctl would be \_IOW, although the kernel would actually read data from user space; a GET\_FOO ioctl would be \_IOR, although the kernel would actually write data to user space.

The first argument to \_IO, \_IOW, \_IOR, or \_IOWR is an identifying letter or number from the table below. Because of the large number of drivers, many drivers share a partial letter with other drivers.

If you are writing a driver for a new device and need a letter, pick an unused block with enough room for expansion: 32 to 256 ioctl commands. You can register the block by patching this file and submitting the patch to Linus Torvalds. Or you can e-mail me at <[mec@shout.net](mailto:mec@shout.net)> and I'll register one for you.

The second argument to \_IO, \_IOW, \_IOR, or \_IOWR is a sequence number to distinguish ioctls from each other. The third argument to \_IOW, \_IOR, or \_IOWR is the type of the data going into the kernel or coming out of the kernel (e.g. 'int' or 'struct foo'). NOTE! Do NOT use sizeof(arg) as the third argument as this results in your ioctl thinking it passes an argument of type size\_t.

Some devices use their major number as the identifier; this is OK, as long as it is unique. Some devices are irregular and don't follow any convention at all.

Following this convention is good because:

- (1) Keeping the ioctl's globally unique helps error checking: if a program calls an ioctl on the wrong device, it will get an error rather than some unexpected behaviour.
- (2) The 'strace' build procedure automatically finds ioctl numbers defined with \_IO, \_IOW, \_IOR, or \_IOWR.

- (3) 'strace' can decode numbers back into useful names when the numbers are unique.
- (4) People looking for ioctls can grep for them more easily when this convention is used to define the ioctl numbers.
- (5) When following the convention, the driver code can use generic code to copy the parameters between user and kernel space.

This table lists ioctls visible from user land for Linux/x86. It contains most drivers up to 2.6.31, but I know I am missing some. There has been no attempt to list non-X86 architectures or ioctls from drivers/staging/.

Code	Seq# (hex)	Include File	
0x00	00-1F	linux/fs.h	C
0x00	00-1F	scsi/scsi_ioctl.h	C
0x00	00-1F	linux/fb.h	C
0x00	00-1F	linux/wavefront.h	C
0x02	all	linux/fd.h	
0x03	all	linux/hdreg.h	
0x04	D2-DC	linux/umsdos_fs.h	I
0x06	all	linux/lp.h	
0x09	all	linux/raid/md_u.h	
0x10	00-0F	drivers/char/s390/vmcp.h	
0x10	10-1F	arch/s390/include/uapi/sclp_ctl.h	
0x10	20-2F	arch/s390/include/uapi/asm/hypfs.h	
0x12	all	linux/fs.h linux/blkpg.h	
0x1b	all		
0x20	all	drivers/cdrom/cm206.h	
0x22	all	scsi/sg.h	
0x3E	00-0F	linux/counter.h	<
'!'	00-1F	uapi/linux/seccomp.h	
'#'	00-3F		I
'\$'	00-0F	linux/perf_counter.h, linux/perf_event.h	S
'%'	00-0F	include/uapi/linux/stm.h	
'&'	00-07	drivers/firewire/nosy-user.h	
'1'	00-1F	linux/timepps.h	F
'2'	01-04	linux/i2o.h	
'3'	00-0F	drivers/s390/char/raw3270.h	C
'3'	00-1F	linux/suspend_ioctl.h, kernel/power/user.c	C
'8'	all		S
';'	64-7F	linux/vfio.h	
'.'	80-FF	linux/iommufd.h	
'='	00-3f	uapi/linux/ptp_clock.h	<
'@'	00-0F	linux/radeonfb.h	C
'@'	00-0F	drivers/video/aty/aty128fb.c	C
'A'	00-1F	linux/apm_bios.h	C
'A'	00-0F	linux/agpgart.h, drivers/char/agp/compat_ioctl.h	C
'A'	00-7F	sound/asound.h	C
'B'	00-1F	linux/cciss_ioctl.h	C
'B'	00-0F	include/linux/pmu.h	C

Table 1 – continu

Code	Seq# (hex)	Include File
'B'	C0-FF	advanced_bbus
'B'	00-0F	xen/xenbus_dev.h
'C'	all	linux/soundcard.h
'C'	01-2F	linux/capi.h
'C'	F0-FF	drivers/net/wan/cosa.h
'D'	all	arch/s390/include/asm/dasd.h
'D'	40-5F	drivers/scsi/dpt/dtpi_ioctl.h
'D'	05	drivers/scsi/pmcraid.h
'E'	all	linux/input.h
'E'	00-0F	xen/evtchn.h
'F'	all	linux/fb.h
'F'	01-02	drivers/scsi/pmcraid.h
'F'	20	drivers/video/fsl-diu-fb.h
'F'	20	linux/ivtvfb.h
'F'	20	linux/matroxfb.h
'F'	20	drivers/video/aty/atyfb_base.c
'F'	00-0F	video/da8xx-fb.h
'F'	80-8F	linux/arcfb.h
'F'	DD	video/sstfb.h
'G'	00-3F	drivers/misc/sgi-gru/grulib.h
'G'	00-0F	xen/gntalloc.h, xen/gntdev.h
'H'	00-7F	linux/hiddev.h
'H'	00-0F	linux/hidraw.h
'H'	01	linux/mei.h
'H'	02	linux/mei.h
'H'	03	linux/mei.h
'H'	00-0F	sound/asound.h
'H'	20-40	sound/asound_fm.h
'H'	80-8F	sound/sfnt_info.h
'H'	10-8F	sound/emu10k1.h
'H'	10-1F	sound/sb16_csp.h
'H'	10-1F	sound/hda_hwdep.h
'H'	40-4F	sound/hdspm.h
'H'	40-4F	sound/hdsp.h
'H'	90	sound/usb/usx2y/usb_stream.h
'H'	00-0F	uapi/misc/habanalabs.h
'H'	A0	uapi/linux/usb/cdc-wdm.h
'H'	C0-F0	net/bluetooth/hci.h
'H'	C0-DF	net/bluetooth/hidp/hidp.h
'H'	C0-DF	net/bluetooth/cmtp/cmtp.h
'H'	C0-DF	net/bluetooth/bnep/bnep.h
'H'	F1	linux/hid-roccat.h
'H'	F8-FA	sound/firewire.h
'T'	all	linux/isdn.h
'T'	00-0F	drivers/isdn/divert/isdn_divert.h
'T'	40-4F	linux/mISDNif.h
'K'	all	linux/kd.h

Table 1 – continu

Code	Seq# (hex)	Include File
'L'	00-1F	linux/loop.h
'L'	10-1F	drivers/scsi/mpt3sas/mpt3sas_ctl.h
'L'	E0-FF	linux/ppdd.h
'M'	all	linux/soundcard.h
'M'	01-16 and	mtd/mtd-abi.h drivers/mtd/mtdchar.c
'M'	01-03	drivers/scsi/megaraid/megaraid_sas.h
'M'	00-0F	drivers/video/fsl-diu-fb.h
'N'	00-1F	drivers/usb/scanner.h
'N'	40-7F	drivers/block/nvme.c
'O'	00-06	mtd/ubi-user.h
'P'	all	linux/soundcard.h
'P'	60-6F	sound/sscape_ioctl.h
'P'	00-0F	drivers/usb/class/usblp.c
'P'	01-09	drivers/misc/pci_endpoint_test.c
'P'	00-0F	xen/privcmd.h
'P'	00-05	linux/tps6594_p fsm.h
'Q'	all	linux/soundcard.h
'R'	00-1F	linux/random.h
'R'	01	linux/rfkill.h
'R'	C0-DF	net/bluetooth/rfcomm.h
'R'	E0	uapi/linux/fsl_mc.h
'S'	all	linux/cdrom.h
'S'	80-81	scsi/scsi_ioctl.h
'S'	82-FF	scsi/scsi.h
'S'	00-7F	sound/asequencer.h
'T'	all	linux/soundcard.h
'T'	00-AF	sound/asound.h
'T'	all	arch/x86/include/asm/ioctls.h
'T'	C0-DF	linux/if_tun.h
'U'	all	sound/asound.h
'U'	00-CF	linux/uinput.h
'U'	00-EF	linux/usbdevice_fs.h
'U'	C0-CF	drivers/bluetooth/hci_uart.h
'V'	all	linux/vt.h
'V'	all	linux/videodev2.h
'V'	C0	linux/ivtvfb.h
'V'	C0	linux/ivtv.h
'V'	C0	media/si4713.h
'W'	00-1F	linux/watchdog.h
'W'	00-1F	linux/wanrouter.h
'W'	00-3F	sound/asound.h
'W'	40-5F	drivers/pci/switch/switchtec.c
'W'	60-61	linux/watch_queue.h
'X'	all	fs/xfs/xfs_fs.h, fs/xfs/linux-2.6/xfs_ioctl32.h, include/linux/falloc.h, linux/fs.h,
'X'	all	fs/ocfs2/ocfs_fs.h
'X'	01	linux/pktcdvd.h
'Z'	14-15	drivers/message/fusion/mptctl.h

Table 1 – continu

Code	Seq# (hex)	Include File
'T'	00-3F	linux/usb/tmc.h
'a'	all	linux/atm*.h, linux/sonet.h
'a'	00-0F	drivers/crypto/qat/qat_common/adf_cfg_common.h
'b'	00-FF	
'b'	00-0F	linux/dma-buf.h
'c'	00-7F	linux/comstats.h
'c'	00-7F	linux/coda.h
'c'	00-1F	linux/chio.h
'c'	80-9F	arch/s390/include/asm/chsc.h
'c'	A0-AF	arch/x86/include/asm/msr.h conflict!
'd'	00-FF	linux/char/drm/drm.h
'd'	02-40	pcmcia/ds.h
'd'	F0-FF	linux/digi1.h
'e'	all	linux/digi1.h
'f'	00-1F	linux/ext2_fs.h
'f'	00-1F	linux/ext3_fs.h
'f'	00-0F	fs/jfs/jfs_dinode.h
'f'	00-0F	fs/ext4/ext4.h
'f'	00-0F	linux/fs.h
'f'	00-0F	fs/ocfs2/ocfs2_fs.h
'f'	13-27	linux/fscrypt.h
'f'	81-8F	linux/fsverity.h
'g'	00-0F	linux/usb/gadgetfs.h
'g'	20-2F	linux/usb/g_printer.h
'h'	00-7F	
'h'	00-1F	linux/hpet.h
'h'	80-8F	fs/hfsplus/ioctl.c
'i'	00-3F	linux/i2o-dev.h
'i'	0B-1F	linux/ipmi.h
'i'	80-8F	linux/i8k.h
'i'	90-9F	linux/iio/*.h
'j'	00-3F	linux/joystick.h
'k'	00-0F	linux/spi/spidev.h
'k'	00-05	video/kyro.h
'k'	10-17	linux/hsi/hsi_char.h
'l'	00-3F	linux/tcfs_fs.h
'l'	40-7F	linux/udf_fs_i.h
'm'	00-09	linux/mmtimer.h
'm'	all	linux/mtio.h
'm'	all	linux/soundcard.h
'm'	all	linux/synclink.h
'm'	00-19	drivers/message/fusion/mptctl.h
'm'	00	drivers/scsi/megaraid/megaraid_ioctl.h
'n'	00-7F	linux/ncp_fs.h and fs/ncpfs/ioctl.c
'n'	80-8F	uapi/linux/nilfs2_api.h
'n'	E0-FF	linux/matroxfb.h
'o'	00-1F	fs/ocfs2/ocfs2_fs.h

Table 1 – continu

Code	Seq# (hex)	Include File	
'o'	00-03	mtd/ubi-user.h	C
'o'	40-41	mtd/ubi-user.h	C
'o'	01-A1	linux/dvb/*.h	I
'p'	00-0F	linux/phantom.h	C
'p'	00-1F	linux/rtc.h	C
'p'	40-7F	linux/nvram.h	
'p'	80-9F	linux/ppdev.h	u
'p'	A1-A5	linux/pps.h	I
'q'	00-1F	linux/serio.h	
'q'	80-FF	linux/telephony.h linux/ixjuser.h	I
'r'	00-1F	linux/msdos_fs.h and fs/fat/dir.c	
's'	all	linux/cdk.h	
't'	00-7F	linux/ppp-ioctl.h	
't'	80-8F	linux/isdn_ppp.h	
't'	90-91	linux/toshiba.h	t
'u'	00-1F	linux/smb_fs.h	g
'u'	20-3F	linux/uvcvideo.h	U
'u'	40-4f	linux/udmabuf.h	u
'v'	00-1F	linux/ext2_fs.h	C
'v'	00-1F	linux/fs.h	C
'v'	00-0F	linux/sonypi.h	C
'v'	00-0F	media/v4l2-subdev.h	C
'v'	20-27	arch/powerpc/include/uapi/asm/vas-api.h	V
'v'	C0-FF	linux/meye.h	C
'w'	all		C
'y'	00-1F		P
'z'	00-3F		C
'z'	40-7F		C
'z'	10-4F	drivers/s390/crypto/zcrypt_api.h	C
' '	00-7F	linux/media.h	
0x80	00-1F	linux/fb.h	
0x81	00-1F	linux/vduse.h	
0x89	00-06	arch/x86/include/asm/sockios.h	
0x89	0B-DF	linux/sockios.h	
0x89	E0-EF	linux/sockios.h	S
0x89	F0-FF	linux/sockios.h	S
0x8B	all	linux/wireless.h	
0x8C	00-3F		V
0x90	00	drivers/cdrom/sbpcd.h	
0x92	00-0F	drivers/usb/mon/mon_bin.c	
0x93	60-7F	linux/auto_fs.h	
0x94	all	fs/btrfs/ioctl.h and linux/fs.h	E
0x97	00-7F	fs/ceph/ioctl.h	C
0x99	00-0F		E
0xA0	all	linux/sdp/sdp.h	I
0xA1	0	linux/vtpm_proxy.h	T
0xA2	all	uapi/linux/acrn.h	A

Table 1 – continu

Code	Seq# (hex)	Include File	
0xA3	80-8F		C
0xA3	90-9F	linux/dtlk.h	F
0xA4	00-1F	uapi/linux/tee.h	C
0xA4	00-1F	uapi/asm/sgx.h	<
0xA5	01-05	linux/surface_aggregator/cdev.h	M
0xA5	20-2F	linux/surface_aggregator/dtx.h	M
0xAA	00-3F	linux/uapi/linux/userfaultfd.h	
0xAB	00-1F	linux/nbd.h	
0xAC	00-1F	linux/raw.h	
0xAD	00		N
0xAE	00-1F	linux/kvm.h	K
0xAE	40-FF	linux/kvm.h	K
0xAE	20-3F	linux/nitro_enclaves.h	M
0xAF	00-1F	linux/fsl_hypervisor.h	H
0xB0	all		F
0xB1	00-1F		F
0xB2	00	arch/powerpc/include/uapi/asm/papr-vpd.h	P
0xB2	01-02	arch/powerpc/include/uapi/asm/papr-sysparm.h	p
0xB3	00	linux/mmc/ioctl.h	
0xB4	00-0F	linux/gpio.h	<
0xB5	00-0F	uapi/linux/rpmsg.h	<
0xB6	all	linux/fpga-dfl.h	
0xB7	all	uapi/linux/remoteproc_cdev.h	<
0xB7	all	uapi/linux/nsfs.h	<
0xC0	00-0F	linux/usb/iowarrior.h	
0xCA	00-0F	uapi/misc/cxl.h	
0xCA	10-2F	uapi/misc/ocxl.h	
0xCA	80-BF	uapi/scsi/cxlflash_ioctl.h	
0xCB	00-1F		C
0xCC	00-0F	drivers/misc/ibmvmc.h	p
0xCD	01	linux/reiserfs_fs.h	
0xCE	01-02	uapi/linux/cxl_mem.h	C
0xCF	02	fs/smb/client/cifs_ioctl.h	
0xDB	00-0F	drivers/char/mwave/mwavepub.h	
0xDD	00-3F		Z
0xE5	00-3F	linux/fuse.h	
0xEC	00-01	drivers/platform/chrome/cros_ec_dev.h	C
0xEE	00-09	uapi/linux/pfrut.h	F
0xF3	00-3F	drivers/usb/misc/sisusbvga/sisusb.h	s
0xF6	all		I
0xF8	all	arch/x86/include/uapi/asm/amd_hsmp.h	A
0xFD	all	linux/dm-ioctl.h	
0xFE	all	linux/isst_if.h	

## 10.2 Decoding an IOCTL Magic Number

To decode a hex IOCTL code:

Most architectures use this generic format, but check include/ARCH/ioctl.h for specifics, e.g. powerpc uses 3 bits to encode read/write and 13 bits for size.

bits	meaning
31-30	00 - no parameters: uses _IO macro 10 - read: _IOR 01 - write: _IOW 11 - read/write: _IOWR
29-16	size of arguments
15-8	ascii character supposedly unique to each driver
7-0	function #

So for example 0x82187201 is a read with arg length of 0x218, character 'r' function 1. Grep-ping the source reveals this is:

```
#define VFAT_IOCTL_READDIR_BOTH           _IOR('r', 1, struct dirent [2])
```

## 10.3 Summary of CDROM ioctl calls

- Edward A. Falk <efalk@google.com>

November, 2004

This document attempts to describe the ioctl(2) calls supported by the CDROM layer. These are by-and-large implemented (as of Linux 2.6) in drivers/cdrom/cdrom.c and drivers/block/scsi\_ioctl.c

ioctl values are listed in <linux/cdrom.h>. As of this writing, they are as follows:

CDROMPAUSE	Pause Audio Operation
CDROMRESUME	Resume paused Audio Operation
CDROMPLAYMSF	Play Audio MSF (struct cdrom_msf)
CDROMPLAYTRKIND	Play Audio Track/index (struct cdrom_ti)
CDROMREADTOCHDR	Read TOC header (struct cdrom_tochdr)
CDROMREADTOCENTRY	Read TOC entry (struct cdrom_tocentry)
CDROMSTOP	Stop the cdrom drive
CDROMSTART	Start the cdrom drive
CDROMEJECT	Ejects the cdrom media
CDROMVOLCTRL	Control output volume (struct cdrom_volctrl)
CDROMSUBCHNL	Read subchannel data (struct cdrom_subchnl)
CDROMREADMODE2	Read CDROM mode 2 data (2336 Bytes) (struct cdrom_read)
CDROMREADMODE1	Read CDROM mode 1 data (2048 Bytes) (struct cdrom_read)
CDROMREADAUDIO	(struct cdrom_read_audio)
CDROMEJECT_SW	enable(1)/disable(0) auto-ejecting
CDROMMULTISESSION	Obtain the start-of-last-session address of multi session disks (
CDROM_GET_MCN	Obtain the "Universal Product Code" if available (struct cdrom

Table 2 – continued from previous page

CDROM_GET_UPC	Deprecated, use CDROM_GET_MCN instead.
CDROMRESET	hard-reset the drive
CDROMVOLREAD	Get the drive's volume setting (struct cdrom_volctrl)
CDROMREADRAW	read data in raw mode (2352 Bytes) (struct cdrom_read)
CDROMREADCOOKED	read data in cooked mode
CDROMSEEK	seek msf address
CDROMPLAYBLK	scsi-cd only, (struct cdrom_blk)
CDROMREADALL	read all 2646 bytes
CDROMGETSPINDOWN	return 4-bit spindown value
CDROMSETSPINDOWN	set 4-bit spindown value
CDROMCLOSETRAY	pendant of CDROMEJECT
CDROM_SET_OPTIONS	Set behavior options
CDROM_CLEAR_OPTIONS	Clear behavior options
CDROM_SELECT_SPEED	Set the CD-ROM speed
CDROM_SELECT_DISC	Select disc (for juke-boxes)
CDROM_MEDIA_CHANGED	Check is media changed
CDROM_TIMED_MEDIA_CHANGE	Check if media changed since given time (struct cdrom_timed_
CDROM_DRIVE_STATUS	Get tray position, etc.
CDROM_DISC_STATUS	Get disc type, etc.
CDROM_CHANGER_NSLOTS	Get number of slots
CDROM_LOCKDOOR	lock or unlock door
CDROM_DEBUG	Turn debug messages on/off
CDROM_GET_CAPABILITY	get capabilities
CDROMAUDIOPUFSIZ	set the audio buffer size
DVD_READ_STRUCT	Read structure
DVD_WRITE_STRUCT	Write structure
DVD_AUTH	Authentication
CDROM_SEND_PACKET	send a packet to the drive
CDROM_NEXT_WRITABLE	get next writable block
CDROM_LAST_WRITTEN	get last block written on disc

The information that follows was determined from reading kernel source code. It is likely that some corrections will be made over time.

---

#### General:

Unless otherwise specified, all ioctl calls return 0 on success and -1 with errno set to an appropriate value on error. (Some ioctls return non-negative data values.)

Unless otherwise specified, all ioctl calls return -1 and set errno to EFAULT on a failed attempt to copy data to or from user address space.

Individual drivers may return error codes not listed here.

Unless otherwise specified, all data structures and constants are defined in <linux/cdrom.h>

---

## CDROMPAUSE

Pause Audio Operation

usage:

```
ioctl(fd, CDROMPAUSE, 0);
```

**inputs:**

none

**outputs:**

none

**error return:**

- ENOSYS cd drive not audio-capable.

## CDROMRESUME

Resume paused Audio Operation

usage:

```
ioctl(fd, CDROMRESUME, 0);
```

**inputs:**

none

**outputs:**

none

**error return:**

- ENOSYS cd drive not audio-capable.

## CDROMPLAYMSF

Play Audio MSF

(struct cdrom\_msf)

usage:

```
struct cdrom_msf msf;  
  
ioctl(fd, CDROMPLAYMSF, &msf);
```

**inputs:**

cdrom\_msf structure, describing a segment of music to play

**outputs:**

none

**error return:**

- ENOSYS cd drive not audio-capable.

**notes:**

- MSF stands for minutes-seconds-frames
- LBA stands for logical block address

- Segment is described as start and end times, where each time is described as minutes:seconds:frames. A frame is 1/75 of a second.

**CDROMPLAYTRKIND**

Play Audio Track/index

(struct cdrom\_ti)

usage:

```
struct cdrom_ti ti;
ioctl(fd, CDROMPLAYTRKIND, &ti);
```

**inputs:**

cdrom\_ti structure, describing a segment of music to play

**outputs:**

none

**error return:**

- ENOSYS cd drive not audio-capable.

**notes:**

- Segment is described as start and end times, where each time is described as a track and an index.

**CDROMREADTOCHDR**

Read TOC header

(struct cdrom\_tochdr)

usage:

```
cdrom_tochdr header;
ioctl(fd, CDROMREADTOCHDR, &header);
```

**inputs:**

cdrom\_tochdr structure

**outputs:**

cdrom\_tochdr structure

**error return:**

- ENOSYS cd drive not audio-capable.

**CDROMREADTOCENTRY**

Read TOC entry

(struct cdrom\_tocentry)

usage:

```
struct cdrom_tocentry entry;
ioctl(fd, CDROMREADTOCENTRY, &entry);
```

**inputs:**

cdrom\_tocentry structure

**outputs:**

cdrom\_tocentry structure

**error return:**

- ENOSYS cd drive not audio-capable.
- EINVAL entry.cdte\_format not CDROM\_MSF or CDROM\_LBA
- EINVAL requested track out of bounds
- EIO I/O error reading TOC

**notes:**

- TOC stands for Table Of Contents
- MSF stands for minutes-seconds-frames
- LBA stands for logical block address

## CDROMSTOP

Stop the cdrom drive

usage:

```
ioctl(fd, CDROMSTOP, 0);
```

**inputs:**

none

**outputs:**

none

**error return:**

- ENOSYS cd drive not audio-capable.

**notes:**

- Exact interpretation of this ioctl depends on the device, but most seem to spin the drive down.

## CDROMSTART

Start the cdrom drive

usage:

```
ioctl(fd, CDROMSTART, 0);
```

**inputs:**

none

**outputs:**

none

**error return:**

- ENOSYS cd drive not audio-capable.

**notes:**

- Exact interpretation of this ioctl depends on the device, but most seem to spin the drive up and/or close the tray. Other devices ignore the ioctl completely.

**CDROMEJECT**

- Ejects the cdrom media

usage:

```
ioctl(fd, CDROMEJECT, 0);
```

**inputs:**

none

**outputs:**

none

**error returns:**

- ENOSYS cd drive not capable of ejecting
- EBUSY other processes are accessing drive, or door is locked

**notes:**

- See CDROM\_LOCKDOOR, below.

**CDROMCLOSETRAY**

pendant of CDROMEJECT

usage:

```
ioctl(fd, CDROMCLOSETRAY, 0);
```

**inputs:**

none

**outputs:**

none

**error returns:**

- ENOSYS cd drive not capable of closing the tray
- EBUSY other processes are accessing drive, or door is locked

**notes:**

- See CDROM\_LOCKDOOR, below.

**CDROMVOLCTRL**

Control output volume (struct cdrom\_volctrl)

usage:

```
struct cdrom_volctrl volume;
ioctl(fd, CDROMVOLCTRL, &volume);
```

**inputs:**

cdrom\_volctrl structure containing volumes for up to 4 channels.

**outputs:**

none

**error return:**

- ENOSYS cd drive not audio-capable.

**CDROMVOLREAD**

Get the drive's volume setting

(struct cdrom\_volctrl)

usage:

```
struct cdrom_volctrl volume;  
  
ioctl(fd, CDROMVOLREAD, &volume);
```

**inputs:**

none

**outputs:**

The current volume settings.

**error return:**

- ENOSYS cd drive not audio-capable.

**CDROMSUBCHNL**

Read subchannel data

(struct cdrom\_subchnl)

usage:

```
struct cdrom_subchnl q;  
  
ioctl(fd, CDROMSUBCHNL, &q);
```

**inputs:**

cdrom\_subchnl structure

**outputs:**

cdrom\_subchnl structure

**error return:**

- ENOSYS cd drive not audio-capable.
- EINVAL format not CDROM\_MSF or CDROM\_LBA

**notes:**

- Format is converted to CDROM\_MSF or CDROM\_LBA as per user request on return

**CDROMREADRAW**

read data in raw mode (2352 Bytes)

(struct cdrom\_read)

usage:

```
union {
    struct cdrom_msf msf;          /* input */
    char buffer[CD_FRAMESIZE_RAW]; /* return */
} arg;
ioctl(fd, CDROMREADRAW, &arg);
```

**inputs:**

cdrom\_msf structure indicating an address to read.

Only the start values are significant.

**outputs:**

Data written to address provided by user.

**error return:**

- EINVAL address less than 0, or msf less than 0:2:0
- ENOMEM out of memory

**notes:**

- As of 2.6.8.1, comments in <linux/cdrom.h> indicate that this ioctl accepts a cdrom\_read structure, but actual source code reads a cdrom\_msf structure and writes a buffer of data to the same address.
- MSF values are converted to LBA values via this formula:

```
lba = (((m * CD_SECS) + s) * CD_FRAMES + f) - CD_MSF_OFFSET;
```

## CDROMREADMODE1

Read CDROM mode 1 data (2048 Bytes)

(struct cdrom\_read)

**notes:**

Identical to CDROMREADRAW except that block size is CD\_FRAMESIZE (2048) bytes

## CDROMREADMODE2

Read CDROM mode 2 data (2336 Bytes)

(struct cdrom\_read)

**notes:**

Identical to CDROMREADRAW except that block size is CD\_FRAMESIZE\_RAW0 (2336) bytes

## CDROMREADAUDIO

(struct cdrom\_read\_audio)

usage:

```
struct cdrom_read_audio ra;
ioctl(fd, CDROMREADAUDIO, &ra);
```

**inputs:**

cdrom\_read\_audio structure containing read start point and length

**outputs:**

audio data, returned to buffer indicated by ra

**error return:**

- EINVAL format not CDROM\_MSF or CDROM\_LBA
- EINVAL nframes not in range [1 75]
- ENXIO drive has no queue (probably means invalid fd)
- ENOMEM out of memory

**CDROMEJECT\_SW**

enable(1)/disable(0) auto-ejecting

usage:

```
int val;  
  
ioctl(fd, CDROMEJECT_SW, val);
```

**inputs:**

Flag specifying auto-eject flag.

**outputs:**

none

**error return:**

- ENOSYS Drive is not capable of ejecting.
- EBUSY Door is locked

**CDROMMULTISESSION**

Obtain the start-of-last-session address of multi session disks

(struct cdrom\_multisession)

usage:

```
struct cdrom_multisession ms_info;  
  
ioctl(fd, CDROMMULTISESSION, &ms_info);
```

**inputs:**

cdrom\_multisession structure containing desired format.

**outputs:**

cdrom\_multisession structure is filled with last\_session information.

**error return:**

- EINVAL format not CDROM\_MSF or CDROM\_LBA

**CDROM\_GET\_MCN**

Obtain the "Universal Product Code" if available

(struct cdrom\_mcn)

usage:

```
struct cdrom_mcn mcn;
ioctl(fd, CDROM_GET_MCN, &mcn);
```

**inputs:**

none

**outputs:**

Universal Product Code

**error return:**

- ENOSYS Drive is not capable of reading MCN data.

**notes:**

- Source code comments state:

The following function is implemented, although very few audio discs give Universal Product Code information, which should just be the Medium Catalog Number on the box. Note, that the way the code is written on the CD is /not/ uniform across all discs!

**CDROM\_GET\_UPC**

CDROM\_GET\_MCN (deprecated)

Not implemented, as of 2.6.8.1

**CDROMRESET**

hard-reset the drive

usage:

```
ioctl(fd, CDROMRESET, 0);
```

**inputs:**

none

**outputs:**

none

**error return:**

- EACCES Access denied: requires CAP\_SYS\_ADMIN
- ENOSYS Drive is not capable of resetting.

**CDROMREADCOOKED**

read data in cooked mode

usage:

```
u8 buffer[CD_FRAMESIZE]  
  
ioctl(fd, CDROMREADCOOKED, buffer);
```

**inputs:**

none

**outputs:**

2048 bytes of data, "cooked" mode.

**notes:**

Not implemented on all drives.

### CDROMREADALL

read all 2646 bytes

Same as CDROMREADCOOKED, but reads 2646 bytes.

### CDROMSEEK

seek msf address

usage:

```
struct cdrom_msf msf;  
  
ioctl(fd, CDROMSEEK, &msf);
```

**inputs:**

MSF address to seek to.

**outputs:**

none

### CDROMPLAYBLK

scsi-cd only

(struct cdrom\_blk)

usage:

```
struct cdrom_blk blk;  
  
ioctl(fd, CDROMPLAYBLK, &blk);
```

**inputs:**

Region to play

**outputs:**

none

### CDROMGETSPINDOWN

Obsolete, was ide-cd only

usage:

```
char spindown;  
  
ioctl(fd, CDROMGETSPINDOWN, &spindown);
```

**inputs:**

none

**outputs:**

The value of the current 4-bit spindown value.

**CDROMSETSPINDOWN**

Obsolete, was ide-cd only

usage:

```
char spindown
ioctl(fd, CDROMSETSPINDOWN, &spindown);
```

**inputs:**

4-bit value used to control spindown (TODO: more detail here)

**outputs:**

none

**CDROM\_SET\_OPTIONS**

Set behavior options

usage:

```
int options;
ioctl(fd, CDROM_SET_OPTIONS, options);
```

**inputs:**

New values for drive options. The logical 'or' of:

CDO_AUTO_CLOSE	close tray on first open(2)
CDO_AUTO_EJECT	open tray on last release
CDO_USE_FFLAGS	use O_NONBLOCK information on open
CDO_LOCK	lock tray on open files
CDO_CHECK_TYPE	check type on open for data

**outputs:**

Returns the resulting options settings in the ioctl return value. Returns -1 on error.

**error return:**

- ENOSYS selected option(s) not supported by drive.

**CDROM\_CLEAR\_OPTIONS**

Clear behavior options

Same as CDROM\_SET\_OPTIONS, except that selected options are turned off.

**CDROM\_SELECT\_SPEED**

Set the CD-ROM speed

usage:

```
int speed;  
  
ioctl(fd, CDROM_SELECT_SPEED, speed);
```

**inputs:**

New drive speed.

**outputs:**

none

**error return:**

- ENOSYS speed selection not supported by drive.

### **CDROM\_SELECT\_DISC**

Select disc (for juke-boxes)

usage:

```
int disk;  
  
ioctl(fd, CDROM_SELECT_DISC, disk);
```

**inputs:**

Disk to load into drive.

**outputs:**

none

**error return:**

- EINVAL Disk number beyond capacity of drive

### **CDROM\_MEDIA\_CHANGED**

Check is media changed

usage:

```
int slot;  
  
ioctl(fd, CDROM_MEDIA_CHANGED, slot);
```

**inputs:**

Slot number to be tested, always zero except for jukeboxes.

May also be special values CDSL\_NONE or CDSL\_CURRENT

**outputs:**

Ioctl return value is 0 or 1 depending on whether the media has been changed, or -1 on error.

**error returns:**

- ENOSYS Drive can't detect media change
- EINVAL Slot number beyond capacity of drive
- ENOMEM Out of memory

**CDROM\_DRIVE\_STATUS**

Get tray position, etc.

usage:

```
int slot;
ioctl(fd, CDROM_DRIVE_STATUS, slot);
```

**inputs:**

Slot number to be tested, always zero except for jukeboxes.

May also be special values CDSL\_NONE or CDSL\_CURRENT

**outputs:**

Ioctl return value will be one of the following values

from <linux/cdrom.h>:

CDS_NO_INFO	Information not available.
CDS_NO_DISC	
CDS_TRAY_OPEN	
CDS_DRIVE_NOT_READY	
CDS_DISC_OK	
-1	error

**error returns:**

- ENOSYS Drive can't detect drive status
- EINVAL Slot number beyond capacity of drive
- ENOMEM Out of memory

**CDROM\_DISC\_STATUS**

Get disc type, etc.

usage:

```
ioctl(fd, CDROM_DISC_STATUS, 0);
```

**inputs:**

none

**outputs:**

Ioctl return value will be one of the following values

from <linux/cdrom.h>:

- CDS\_NO\_INFO
- CDS\_AUDIO
- CDS\_MIXED
- CDS\_XA\_2\_2
- CDS\_XA\_2\_1

- CDS\_DATA\_1

**error returns:**

none at present

**notes:**

- Source code comments state:

Ok, this is where problems start. The current interface for the CDROM\_DISC\_STATUS ioctl is flawed. It makes the false assumption that CDs are all CDS\_DATA\_1 or all CDS\_AUDIO, etc. Unfortunately, while this is often the case, it is also very common for CDs to have some tracks with data, and some tracks with audio. Just because I feel like it, I declare the following to be the best way to cope. If the CD has ANY data tracks on it, it will be returned as a data CD. If it has any XA tracks, I will return it as that. Now I could simplify this interface by combining these returns with the above, but this more clearly demonstrates the problem with the current interface. Too bad this wasn't designed to use bitmasks... -Erik

Well, now we have the option CDS\_MIXED: a mixed-type CD. User level programmers might feel the ioctl is not very useful.

---david

### CDROM\_CHANGER\_NSLOTS

Get number of slots

usage:

```
ioctl(fd, CDROM_CHANGER_NSLOTS, 0);
```

**inputs:**

none

**outputs:**

The ioctl return value will be the number of slots in a CD changer. Typically 1 for non-multi-disk devices.

**error returns:**

none

### CDROM\_LOCKDOOR

lock or unlock door

usage:

```
int lock;  
  
ioctl(fd, CDROM_LOCKDOOR, lock);
```

**inputs:**

Door lock flag, 1=lock, 0=unlock

**outputs:**

none

**error returns:**

- EDRIVE\_CANT\_DO\_THIS

Door lock function not supported.

- EBUSY

Attempt to unlock when multiple users have the drive open and not CAP\_SYS\_ADMIN

**notes:**

As of 2.6.8.1, the lock flag is a global lock, meaning that all CD drives will be locked or unlocked together. This is probably a bug.

The EDRIVE\_CANT\_DO\_THIS value is defined in <linux/cdrom.h> and is currently (2.6.8.1) the same as EOPNOTSUPP

**CDROM\_DEBUG**

Turn debug messages on/off

usage:

```
int debug;

ioctl(fd, CDROM_DEBUG, debug);
```

**inputs:**

Cdrom debug flag, 0=disable, 1=enable

**outputs:**

The ioctl return value will be the new debug flag.

**error return:**

- EACCES Access denied: requires CAP\_SYS\_ADMIN

**CDROM\_GET\_CAPABILITY**

get capabilities

usage:

```
ioctl(fd, CDROM_GET_CAPABILITY, 0);
```

**inputs:**

none

**outputs:**

The ioctl return value is the current device capability flags. See CDC\_CLOSE\_TRAY, CDC\_OPEN\_TRAY, etc.

**CDROMAUDIOBUFSIZ**

set the audio buffer size

usage:

```
int arg;
ioctl(fd, CDROMAUDIOBUFSIZ, val);
```

**inputs:**

New audio buffer size

**outputs:**

The ioctl return value is the new audio buffer size, or -1 on error.

**error return:**

- ENOSYS Not supported by this driver.

**notes:**

Not supported by all drivers.

DVD\_READ\_STRUCT Read structure

usage:

```
dvd_struct s;
ioctl(fd, DVD_READ_STRUCT, &s);
```

**inputs:**

dvd\_struct structure, containing:

type	specifies the information desired, one of DVD_STRUCT_PHYSICAL, DVD_STRUCT_COPYRIGHT, DVD_STRUCT_DISCKEY, DVD_STRUCT_BCA, DVD_STRUCT_MANUFACT
physical.layer_num	desired layer, indexed from 0
copyright.layer_num	desired layer, indexed from 0
disckey.agid	

**outputs:**

dvd\_struct structure, containing:

physical	for type == DVD_STRUCT_PHYSICAL
copyright	for type == DVD_STRUCT_COPYRIGHT
disckey.value	for type == DVD_STRUCT_DISCKEY
bca.{len,value}	for type == DVD_STRUCT_BCA
manufact.{len,valu}	for type == DVD_STRUCT_MANUFACT

**error returns:**

- EINVAL physical.layer\_num exceeds number of layers
- EIO Received invalid response from drive

DVD\_WRITE\_STRUCT Write structure

Not implemented, as of 2.6.8.1

**DVD\_AUTH Authentication**

usage:

```
dvd_authinfo ai;
ioctl(fd, DVD_AUTH, &ai);
```

**inputs:**

dvd\_authinfo structure. See <linux/cdrom.h>

**outputs:**

dvd\_authinfo structure.

**error return:**

- ENOTTY ai.type not recognized.

**CDROM\_SEND\_PACKET**

send a packet to the drive

usage:

```
struct cdrom_generic_command cgc;
ioctl(fd, CDROM_SEND_PACKET, &cgc);
```

**inputs:**

cdrom\_generic\_command structure containing the packet to send.

**outputs:**

none

cdrom\_generic\_command structure containing results.

**error return:**

- EIO  
command failed.
- EPERM

Operation not permitted, either because a write command was attempted on a drive which is opened read-only, or because the command requires CAP\_SYS\_RAWIO

- EINVAL  
cgc.data\_direction not set

**CDROM\_NEXT\_WRITABLE**

get next writable block

usage:

```
long next;
ioctl(fd, CDROM_NEXT_WRITABLE, &next);
```

**inputs:**

none

**outputs:**

The next writable block.

**notes:**

If the device does not support this ioctl directly, the ioctl will return CDROM\_LAST\_WRITTEN + 7.

### CDROM\_LAST\_WRITTEN

get last block written on disc

usage:

```
long last;  
  
ioctl(fd, CDROM_LAST_WRITTEN, &last);
```

**inputs:**

none

**outputs:**

The last block written on disc

**notes:**

If the device does not support this ioctl directly, the result is derived from the disc's table of contents. If the table of contents can't be read, this ioctl returns an error.

## 10.4 Summary of *HDIO\_ioctl* calls

- Edward A. Falk <[efalk@google.com](mailto:efalk@google.com)>

November, 2004

This document attempts to describe the ioctl(2) calls supported by the HD/IDE layer. These are by-and-large implemented (as of Linux 5.11) drivers/ata/libata-scsi.c.

ioctl values are listed in <linux/hdreg.h>. As of this writing, they are as follows:

ioctls that pass argument pointers to user space:

HDIO_GETGEO	get device geometry
HDIO_GET_32BIT	get current io_32bit setting
HDIO_GET_IDENTITY	get IDE identification info
HDIO_DRIVE_TASKFILE	execute raw taskfile
HDIO_DRIVE_TASK	execute task and special drive command
HDIO_DRIVE_CMD	execute a special drive command

ioctls that pass non-pointer values:

HDIO_SET_32BIT	change io_32bit flags
----------------	-----------------------

The information that follows was determined from reading kernel source code. It is likely that some corrections will be made over time.

---

## General:

Unless otherwise specified, all ioctl calls return 0 on success and -1 with errno set to an appropriate value on error.

Unless otherwise specified, all ioctl calls return -1 and set errno to EFAULT on a failed attempt to copy data to or from user address space.

Unless otherwise specified, all data structures and constants are defined in <linux/hdreg.h>

---

## **HDIO\_GETGEO**

get device geometry

usage:

```
struct hd_geometry geom;
ioctl(fd, HDIO_GETGEO, &geom);
```

**inputs:**

none

**outputs:**

hd\_geometry structure containing:

heads	number of heads
sectors	number of sectors/track
cylinders	number of cylinders, mod 65536
start	starting sector of this partition.

**error returns:**

- EINVAL

if the device is not a disk drive or floppy drive, or if the user passes a null pointer

**notes:**

Not particularly useful with modern disk drives, whose geometry is a polite fiction anyway. Modern drives are addressed purely by sector number nowadays (lba addressing), and the drive geometry is an abstraction which is actually subject to change. Currently (as of Nov 2004), the geometry values are the "bios" values -- presumably the values the drive had when Linux first booted.

In addition, the cylinders field of the hd\_geometry is an unsigned short, meaning that on most architectures, this ioctl will not return a meaningful value on drives with more than 65535 tracks.

The start field is unsigned long, meaning that it will not contain a meaningful value for disks over 219 Gb in size.

## **HDIO\_GET\_IDENTITY**

get IDE identification info

usage:

```
unsigned char identity[512];  
  
ioctl(fd, HDIO_GET_IDENTITY, identity);
```

### **inputs:**

none

### **outputs:**

ATA drive identity information. For full description, see the IDENTIFY DEVICE and IDENTIFY PACKET DEVICE commands in the ATA specification.

### **error returns:**

- EINVAL Called on a partition instead of the whole disk device
- ENOMSG IDENTIFY DEVICE information not available

### **notes:**

Returns information that was obtained when the drive was probed. Some of this information is subject to change, and this ioctl does not re-probe the drive to update the information.

This information is also available from /proc/ide/hdX/identify

## **HDIO\_GET\_32BIT**

get current io\_32bit setting

usage:

```
long val;  
  
ioctl(fd, HDIO_GET_32BIT, &val);
```

### **inputs:**

none

### **outputs:**

The value of the current io\_32bit setting

### **notes:**

0=16-bit, 1=32-bit, 2,3 = 32bit+sync

## **HDIO\_DRIVE\_TASKFILE**

execute raw taskfile

### **Note:**

If you don't have a copy of the ANSI ATA specification handy, you should probably ignore this ioctl.

- Execute an ATA disk command directly by writing the "taskfile" registers of the drive. Requires ADMIN and RAWIO access privileges.

usage:

```

struct {

    ide_task_request_t req_task;
    u8 outbuf[OUTPUT_SIZE];
    u8 inbuf[INPUT_SIZE];
} task;
memset(&task.req_task, 0, sizeof(task.req_task));
task.req_task.out_size = sizeof(task.outbuf);
task.req_task.in_size = sizeof(task.inbuf);
...
ioctl(fd, HDIO_DRIVE_TASKFILE, &task);
...

```

inputs:

(See below for details on memory area passed to ioctl.)

io_ports[8]	values to be written to taskfile registers
hob_ports[8]	high-order bytes, for extended commands.
out_flags	flags indicating which registers are valid
in_flags	flags indicating which registers should be returned
data_phase	see below
req_cmd	command type to be executed
out_size	size of output buffer
outbuf	buffer of data to be transmitted to disk
inbuf	buffer of data to be received from disk (see [1])

outputs:

io_ports[]	values returned in the taskfile registers
hob_ports[]	high-order bytes, for extended commands.
out_flags	flags indicating which registers are valid (see [2])
in_flags	flags indicating which registers should be returned
outbuf	buffer of data to be transmitted to disk (see [1])
inbuf	buffer of data to be received from disk

#### error returns:

- EACCES CAP\_SYS\_ADMIN or CAP\_SYS\_RAWIO privilege not set.
- ENOMSG Device is not a disk drive.
- ENOMEM Unable to allocate memory for task
- EFAULT req\_cmd == TASKFILE\_IN\_OUT (not implemented as of 2.6.8)
- EPERM
  - req\_cmd == TASKFILE\_MULTI\_OUT and drive multi-count not yet set.
- EIO Drive failed the command.

notes:

[1] READ THE FOLLOWING NOTES *CAREFULLY*. THIS IOCTL IS FULL OF GOTCHAS. Extreme caution should be used with using this ioctl. A mistake can easily corrupt data or hang the system.

[2] Both the input and output buffers are copied from the user and written back to the user, even when not used.

[3] If one or more bits are set in `out_flags` and `in_flags` is zero, the following values are used for `in_flags.all` and written back into `in_flags` on completion.

- `IDE_TASKFILE_STD_IN_FLAGS | (IDE_HOB_STD_IN_FLAGS << 8)` if LBA48 addressing is enabled for the drive
- `IDE_TASKFILE_STD_IN_FLAGS` if CHS/LBA28

The association between `in_flags.all` and each enable bitfield flips depending on endianness; fortunately, `TASKFILE` only uses `inflags.b.data` bit and ignores all other bits. The end result is that, on any endian machines, it has no effect other than modifying `in_flags` on completion.

[4] The default value of `SELECT` is `(0xa0|DEV_bit|LBA_bit)` except for four drives per port chipsets. For four drives per port chipsets, it's `(0xa0|DEV_bit|LBA_bit)` for the first pair and `(0x80|DEV_bit|LBA_bit)` for the second pair.

[5] The argument to the ioctl is a pointer to a region of memory containing a `ide_task_request_t` structure, followed by an optional buffer of data to be transmitted to the drive, followed by an optional buffer to receive data from the drive.

Command is passed to the disk drive via the `ide_task_request_t` structure, which contains these fields:

<code>io_ports[8]</code>	values for the taskfile registers
<code>hob_ports[8]</code>	high-order bytes, for extended commands
<code>out_flags</code>	flags indicating which entries in the <code>io_ports[]</code> and <code>hob_ports[]</code> arrays contain valid values. Type <code>ide_reg_valid_t</code> .
<code>in_flags</code>	flags indicating which entries in the <code>io_ports[]</code> and <code>hob_ports[]</code> arrays are expected to contain valid values on return.
<code>data_phase</code>	See below
<code>req_cmd</code>	Command type, see below
<code>out_size</code>	output (user->drive) buffer size, bytes
<code>in_size</code>	input (drive->user) buffer size, bytes

When `out_flags` is zero, the following registers are loaded.

HOB_FEATURE	If the drive supports LBA48
HOB_NSECTOR	If the drive supports LBA48
HOB_SECTOR	If the drive supports LBA48
HOB_LCYL	If the drive supports LBA48
HOB_HCYL	If the drive supports LBA48
FEATURE	
NSECTOR	
SECTOR	
LCYL	
HCYL	
SELECT	First, masked with 0xE0 if LBA48, 0xEF otherwise; then, or'ed with the default value of SELECT.

If any bit in out\_flags is set, the following registers are loaded.

HOB_DATA	If out_flags.b.data is set. HOB_DATA will travel on DD8-DD15 on little endian machines and on DD0-DD7 on big endian machines.
DATA	If out_flags.b.data is set. DATA will travel on DD0-DD7 on little endian machines and on DD8-DD15 on big endian machines.
HOB_NSECTOR	If out_flags.b.nsector_hob is set
HOB_SECTOR	If out_flags.b.sector_hob is set
HOB_LCYL	If out_flags.b.lcyl_hob is set
HOB_HCYL	If out_flags.b.hcyl_hob is set
FEATURE	If out_flags.b.feature is set
NSECTOR	If out_flags.b.nsector is set
SECTOR	If out_flags.b.sector is set
LCYL	If out_flags.b.lcyl is set
HCYL	If out_flags.b.hcyl is set
SELECT	Or'ed with the default value of SELECT and loaded regardless of out_flags.b.select.

Taskfile registers are read back from the drive into {io|hob}\_ports[] after the command completes iff one of the following conditions is met; otherwise, the original values will be written back, unchanged.

1. The drive fails the command (EIO).
2. One or more than one bits are set in out\_flags.
3. The requested data\_phase is TASKFILE\_NO\_DATA.

HOB_DATA	If in_flags.b.data is set. It will contain DD8-DD15 on little endian machines and DD0-DD7 on big endian machines.
DATA	If in_flags.b.data is set. It will contain DD0-DD7 on little endian machines and DD8-DD15 on big endian machines.
HOB_FEATURE	If the drive supports LBA48
HOB_NSECTOR	If the drive supports LBA48
HOB_SECTOR	If the drive supports LBA48
HOB_LCYL	If the drive supports LBA48
HOB_HCYL	If the drive supports LBA48
NSECTOR	
SECTOR	
LCYL	
HCYL	

The data\_phase field describes the data transfer to be performed. Value is one of:

TASKFILE_IN	
TASKFILE_MULTI_IN	
TASKFILE_OUT	
TASKFILE_MULTI_OUT	
TASKFILE_IN_OUT	
TASKFILE_IN_DMA	
TASKFILE_IN_DMAQ	== IN_DMA (queueing not supported)
TASKFILE_OUT_DMA	
TASKFILE_OUT_DMAQ	== OUT_DMA (queueing not supported)
TASKFILE_P_IN	unimplemented
TASKFILE_P_IN_DMA	unimplemented
TASKFILE_P_IN_DMAQ	unimplemented
TASKFILE_P_OUT	unimplemented
TASKFILE_P_OUT_DMA	unimplemented
TASKFILE_P_OUT_DMAQ	unimplemented

The req\_cmd field classifies the command type. It may be one of:

IDE_DRIVE_TASK_NO_DATA	
IDE_DRIVE_TASK_SET_XFER	unimplemented
IDE_DRIVE_TASK_IN	
IDE_DRIVE_TASK_OUT	unimplemented
IDE_DRIVE_TASK_RAW_WRITE	

[6] Do not access {in|out}\_flags->all except for resetting all the bits. Always access individual bit fields. ->all value will flip depending on endianness. For the same reason, do not use IDE\_{TASKFILE|HOB}\_STD\_{OUT|IN}\_FLAGS constants defined in hdreg.h.

## HDIO\_DRIVE\_CMD

execute a special drive command

Note: If you don't have a copy of the ANSI ATA specification handy, you should probably ignore this ioctl.

usage:

```
u8 args[4+XFER_SIZE];
...
ioctl(fd, HDIO_DRIVE_CMD, args);
```

#### **inputs:**

Commands other than WIN\_SMART:

args[0]	COMMAND
args[1]	NSECTOR
args[2]	FEATURE
args[3]	NSECTOR

WIN\_SMART:

args[0]	COMMAND
args[1]	SECTOR
args[2]	FEATURE
args[3]	NSECTOR

#### **outputs:**

args[] buffer is filled with register values followed by any data returned by the disk.

args[0]	status
args[1]	error
args[2]	NSECTOR
args[3]	undefined
args[4+]	NSECTOR * 512 bytes of data returned by the command.

#### **error returns:**

- EACCES Access denied: requires CAP\_SYS\_RAWIO
- ENOMEM Unable to allocate memory for task
- EIO Drive reports error

notes:

[1] For commands other than WIN\_SMART, args[1] should equal args[3]. SEC-TOR, LCYL and HCYL are undefined. For WIN\_SMART, 0x4f and 0xc2 are loaded into LCYL and HCYL respectively. In both cases SELECT will contain the default value for the drive. Please refer to HDIO\_DRIVE\_TASKFILE notes for the default value of SELECT.

[2] If NSECTOR value is greater than zero and the drive sets DRQ when interrupting for the command, NSECTOR \* 512 bytes are read from the device

into the area following NSECTOR. In the above example, the area would be args[4..4+XFER\_SIZE]. 16bit PIO is used regardless of HDIO\_SET\_32BIT setting.

[3] If COMMAND == WIN\_SETFEATURES && FEATURE == SETFEATURES\_XFER && NSECTOR >= XFER\_SW\_DMA\_0 && the drive supports any DMA mode, IDE driver will try to tune the transfer mode of the drive accordingly.

### **HDIO\_DRIVE\_TASK**

execute task and special drive command

Note: If you don't have a copy of the ANSI ATA specification handy, you should probably ignore this ioctl.

usage:

```
u8 args[7];  
...  
ioctl(fd, HDIO_DRIVE_TASK, args);
```

#### **inputs:**

Taskfile register values:

args[0]	COMMAND
args[1]	FEATURE
args[2]	NSECTOR
args[3]	SECTOR
args[4]	LCYL
args[5]	HCYL
args[6]	SELECT

#### **outputs:**

Taskfile register values:

args[0]	status
args[1]	error
args[2]	NSECTOR
args[3]	SECTOR
args[4]	LCYL
args[5]	HCYL
args[6]	SELECT

#### **error returns:**

- EACCES Access denied: requires CAP\_SYS\_RAWIO
- ENOMEM Unable to allocate memory for task
- ENOMSG Device is not a disk drive.
- EIO Drive failed the command.

notes:

[1] DEV bit (0x10) of SELECT register is ignored and the appropriate value for the drive is used. All other bits are used unaltered.

## **HDIO\_SET\_32BIT**

change io\_32bit flags

usage:

```
int val;  
  
ioctl(fd, HDIO_SET_32BIT, val);
```

### **inputs:**

New value for io\_32bit flag

### **outputs:**

none

### **error return:**

- EINVAL Called on a partition instead of the whole disk device
- EACCES Access denied: requires CAP\_SYS\_ADMIN
- EINVAL value out of range [0 3]
- EBUSY Controller busy



## IOMMU USERSPACE API

IOMMU UAPI is used for virtualization cases where communications are needed between physical and virtual IOMMU drivers. For baremetal usage, the IOMMU is a system device which does not need to communicate with userspace directly.

The primary use cases are guest Shared Virtual Address (SVA) and guest IO virtual address (IOVA), wherein the vIOMMU implementation relies on the physical IOMMU and for this reason requires interactions with the host driver.

- *Functionalities*
- *Requirements*
- *Interfaces*
  - *Extension Rules & Precautions*
  - *Compatibility Checking*
  - *Feature Checking*
  - *Data Passing Example with VFIO*
  - *Sharing UAPI with in-kernel users*

### 11.1 Functionalities

Communications of user and kernel involve both directions. The supported user-kernel APIs are as follows:

1. Bind/Unbind guest PASID (e.g. Intel VT-d)
2. Bind/Unbind guest PASID table (e.g. ARM SMMU)
3. Invalidate IOMMU caches upon guest requests
4. Report errors to the guest and serve page requests

## 11.2 Requirements

The IOMMU UAPIs are generic and extensible to meet the following requirements:

1. Emulated and para-virtualised vIOMMUs
2. Multiple vendors (Intel VT-d, ARM SMMU, etc.)
3. Extensions to the UAPI shall not break existing userspace

## 11.3 Interfaces

Although the data structures defined in IOMMU UAPI are self-contained, there are no user API functions introduced. Instead, IOMMU UAPI is designed to work with existing user driver frameworks such as VFIO.

### 11.3.1 Extension Rules & Precautions

When IOMMU UAPI gets extended, the data structures can *only* be modified in two ways:

1. Adding new fields by re-purposing the padding[] field. No size change.
2. Adding new union members at the end. May increase the structure sizes.

No new fields can be added *after* the variable sized union in that it will break backward compatibility when offset moves. A new flag must be introduced whenever a change affects the structure using either method. The IOMMU driver processes the data based on flags which ensures backward compatibility.

Version field is only reserved for the unlikely event of UAPI upgrade at its entirety.

It's *always* the caller's responsibility to indicate the size of the structure passed by setting argsz appropriately. Though at the same time, argsz is user provided data which is not trusted. The argsz field allows the user app to indicate how much data it is providing; it's still the kernel's responsibility to validate whether it's correct and sufficient for the requested operation.

### 11.3.2 Compatibility Checking

When IOMMU UAPI extension results in some structure size increase, IOMMU UAPI code shall handle the following cases:

1. User and kernel has exact size match
2. An older user with older kernel header (smaller UAPI size) running on a newer kernel (larger UAPI size)
3. A newer user with newer kernel header (larger UAPI size) running on an older kernel.
4. A malicious/misbehaving user passing illegal/invalid size but within range. The data may contain garbage.

### 11.3.3 Feature Checking

While launching a guest with vIOMMU, it is strongly advised to check the compatibility upfront, as some subsequent errors happening during vIOMMU operation, such as cache invalidation failures cannot be nicely escalated to the guest due to IOMMU specifications. This can lead to catastrophic failures for the users.

User applications such as QEMU are expected to import kernel UAPI headers. Backward compatibility is supported per feature flags. For example, an older QEMU (with older kernel header) can run on newer kernel. Newer QEMU (with new kernel header) may refuse to initialize on an older kernel if new feature flags are not supported by older kernel. Simply recompiling existing code with newer kernel header should not be an issue in that only existing flags are used.

IOMMU vendor driver should report the below features to IOMMU UAPI consumers (e.g. via VFIO).

1. IOMMU\_NESTING\_FEAT\_SYSWIDE\_PASID
2. IOMMU\_NESTING\_FEAT\_BIND\_PGTBL
3. IOMMU\_NESTING\_FEAT\_BIND\_PASID\_TABLE
4. IOMMU\_NESTING\_FEAT\_CACHE\_INVLD
5. IOMMU\_NESTING\_FEAT\_PAGE\_REQUEST

Take VFIO as example, upon request from VFIO userspace (e.g. QEMU), VFIO kernel code shall query IOMMU vendor driver for the support of the above features. Query result can then be reported back to the userspace caller. Details can be found in Documentation/driver-api/vfio.rst.

### 11.3.4 Data Passing Example with VFIO

As the ubiquitous userspace driver framework, VFIO is already IOMMU aware and shares many key concepts such as device model, group, and protection domain. Other user driver frameworks can also be extended to support IOMMU UAPI but it is outside the scope of this document.

In this tight-knit VFIO-IOMMU interface, the ultimate consumer of the IOMMU UAPI data is the host IOMMU driver. VFIO facilitates user-kernel transport, capability checking, security, and life cycle management of process address space ID (PASID).

VFIO layer conveys the data structures down to the IOMMU driver. It follows the pattern below:

```
struct {
    __u32 argsz;
    __u32 flags;
    __u8  data[];
};
```

Here data[] contains the IOMMU UAPI data structures. VFIO has the freedom to bundle the data as well as parse data size based on its own flags.

In order to determine the size and feature set of the user data, argsz and flags (or the equivalent) are also embedded in the IOMMU UAPI data structures.

A “\_\_u32 argsz” field is *always* at the beginning of each structure.

For example:

```

struct iommu_cache_invalidate_info {
    __u32 argsz;
#define IOMMU_CACHE_INVALIDATE_INFO_VERSION_1 1
    __u32 version;
    /* IOMMU paging structure cache */
#define IOMMU_CACHE_INV_TYPE_IOTLB      (1 << 0) /* IOMMU IOTLB */
#define IOMMU_CACHE_INV_TYPE_DEV_IOTLB   (1 << 1) /* Device IOTLB */
#define IOMMU_CACHE_INV_TYPE_PASID      (1 << 2) /* PASID cache */
#define IOMMU_CACHE_INV_TYPE_NR         (3)
    __u8 cache;
    __u8 granularity;
    __u8 padding[6];
    union {
        struct iommu_inv_pasid_info pasid_info;
        struct iommu_inv_addr_info addr_info;
    } granu;
};


```

VFIO is responsible for checking its own argsz and flags. It then invokes appropriate IOMMU UAPI functions. The user pointers are passed to the IOMMU layer for further processing. The responsibilities are divided as follows:

- Generic IOMMU layer checks argsz range based on UAPI data in the current kernel version.
- Generic IOMMU layer checks content of the UAPI data for non-zero reserved bits in flags, padding fields, and unsupported version. This is to ensure not breaking userspace in the future when these fields or flags are used.
- Vendor IOMMU driver checks argsz based on vendor flags. UAPI data is consumed based on flags. Vendor driver has access to unadulterated argsz value in case of vendor specific future extensions. Currently, it does not perform the `copy_from_user()` itself. A `_user` pointer can be provided in some future scenarios where there's vendor data outside of the structure definition.

IOMMU code treats UAPI data in two categories:

- structure contains vendor data (Example: `iommu_uapi_cache_invalidate()`)
- structure contains only generic data (Example: `iommu_uapi_sva_bind_gpasid()`)

### 11.3.5 Sharing UAPI with in-kernel users

For UAPIs that are shared with in-kernel users, a wrapper function is provided to distinguish the callers. For example,

Userspace caller

```

int iommu_uapi_sva_unbind_gpasid(struct iommu_domain *domain,
                                   struct device *dev,
                                   void __user *userdata)

```

In-kernel caller

```
int iommu_sva_unbind_gpasid(struct iommu_domain *domain,
                           struct device *dev, ioasid_t ioasid);
```



## **IOMMUFD**

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### **12.1 Overview**

IOMMUFD is the user API to control the IOMMU subsystem as it relates to managing IO page tables from userspace using file descriptors. It intends to be general and consumable by any driver that wants to expose DMA to userspace. These drivers are eventually expected to deprecate any internal IOMMU logic they may already/historically implement (e.g. `vfio_iommu_type1.c`).

At minimum iommufd provides universal support of managing I/O address spaces and I/O page tables for all IOMMUs, with room in the design to add non-generic features to cater to specific hardware functionality.

In this context the capital letter (IOMMUFD) refers to the subsystem while the small letter (iommufd) refers to the file descriptors created via /dev/iommu for use by userspace.

### **12.2 Key Concepts**

#### **12.2.1 User Visible Objects**

Following IOMMUFD objects are exposed to userspace:

- IOMMUFD\_OBJ\_IOAS, representing an I/O address space (IOAS), allowing map/unmap of user space memory into ranges of I/O Virtual Address (IOVA).

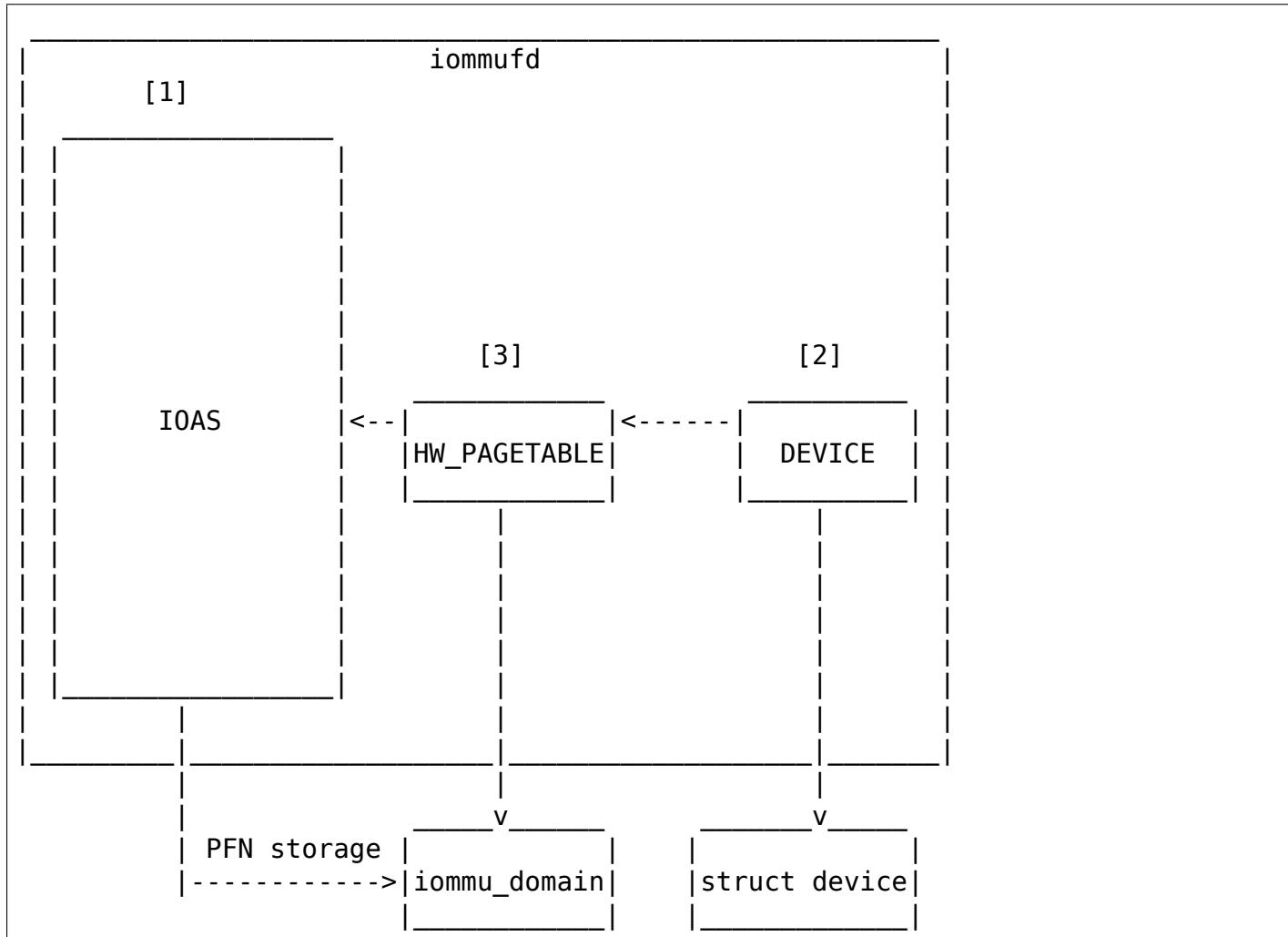
The IOAS is a functional replacement for the VFIO container, and like the VFIO container it copies an IOVA map to a list of `iommu_domains` held within it.

- IOMMUFD\_OBJ\_DEVICE, representing a device that is bound to iommufd by an external driver.
- IOMMUFD\_OBJ\_HW\_PAGETABLE, representing an actual hardware I/O page table (i.e. a single struct `iommu_domain`) managed by the iommu driver.

The IOAS has a list of HW\_PAGETABLES that share the same IOVA mapping and it will synchronize its mapping with each member HW\_PAGETABLE.

All user-visible objects are destroyed via the IOMMU\_DESTROY uAPI.

The diagram below shows relationship between user-visible objects and kernel datastructures (external to iommufd), with numbers referred to operations creating the objects and links:



1. IOMMUFD\_OBJ\_IOAS is created via the IOMMU\_IOAS\_ALLOC uAPI. An iommufd can hold multiple IOAS objects. IOAS is the most generic object and does not expose interfaces that are specific to single IOMMU drivers. All operations on the IOAS must operate equally on each of the iommu\_domains inside of it.
2. IOMMUFD\_OBJ\_DEVICE is created when an external driver calls the IOMMUFD kAPI to bind a device to an iommufd. The driver is expected to implement a set of ioctls to allow userspace to initiate the binding operation. Successful completion of this operation establishes the desired DMA ownership over the device. The driver must also set the driver\_managed\_dma flag and must not touch the device until this operation succeeds.
3. IOMMUFD\_OBJ\_HW\_PAGETABLE is created when an external driver calls the IOMMUFD kAPI to attach a bound device to an IOAS. Similarly the external driver uAPI allows userspace to initiate the attaching operation. If a compatible pagetable already exists then it is reused for the attachment. Otherwise a new pagetable object and iommu\_domain is created. Successful completion of this operation sets up the linkages among IOAS, device

and iommu\_domain. Once this completes the device could do DMA.

Every iommu\_domain inside the IOAS is also represented to userspace as a HW\_PAGETABLE object.

---

**Note:** Future IOMMUFD updates will provide an API to create and manipulate the HW\_PAGETABLE directly.

---

A device can only bind to an iommufd due to DMA ownership claim and attach to at most one IOAS object (no support of PASID yet).

### 12.2.2 Kernel Datastructure

User visible objects are backed by following datastructures:

- iommufd\_ioas for IOMMUFD\_OBJ\_IOAS.
- iommufd\_device for IOMMUFD\_OBJ\_DEVICE.
- iommufd\_hw\_pagetable for IOMMUFD\_OBJ\_HW\_PAGETABLE.

Several terminologies when looking at these datastructures:

- Automatic domain - refers to an iommu domain created automatically when attaching a device to an IOAS object. This is compatible to the semantics of VFIO type1.
- Manual domain - refers to an iommu domain designated by the user as the target pagetable to be attached to by a device. Though currently there are no uAPIs to directly create such domain, the datastructure and algorithms are ready for handling that use case.
- In-kernel user - refers to something like a VFIO mdev that is using the IOMMUFD access interface to access the IOAS. This starts by creating an iommufd\_access object that is similar to the domain binding a physical device would do. The access object will then allow converting IOVA ranges into struct page \* lists, or doing direct read/write to an IOVA.

iommufd\_ioas serves as the metadata datastructure to manage how IOVA ranges are mapped to memory pages, composed of:

- struct io\_pagetable holding the IOVA map
- struct iopt\_area's representing populated portions of IOVA
- struct iopt\_pages representing the storage of PFNs
- struct iommu\_domain representing the IO page table in the IOMMU
- struct iopt\_pages\_access representing in-kernel users of PFNs
- struct xarray pinned\_pfns holding a list of pages pinned by in-kernel users

Each iopt\_pages represents a logical linear array of full PFNs. The PFNs are ultimately derived from userspace VAs via an mm\_struct. Once they have been pinned the PFNs are stored in IOPTEs of an iommu\_domain or inside the pinned\_pfns xarray if they have been pinned through an iommufd\_access.

PFN have to be copied between all combinations of storage locations, depending on what domains are present and what kinds of in-kernel "software access" users exist. The mechanism ensures that a page is pinned only once.

An io\_pagetable is composed of iopt\_areas pointing at iopt\_pages, along with a list of iommu\_domains that mirror the IOVA to PFN map.

Multiple io\_pagetable-s, through their iopt\_area-s, can share a single iopt\_pages which avoids multi-pinning and double accounting of page consumption.

iommufd\_ioas is shareable between subsystems, e.g. VFIO and VDPA, as long as devices managed by different subsystems are bound to a same iommufd.

## 12.3 IOMMUFD User API

### General ioctl format

The ioctl interface follows a general format to allow for extensibility. Each ioctl is passed in a structure pointer as the argument providing the size of the structure in the first u32. The kernel checks that any structure space beyond what it understands is 0. This allows userspace to use the backward compatible portion while consistently using the newer, larger, structures. ioctls use a standard meaning for common errnos:

- ENOTTY: The IOCTL number itself is not supported at all
- E2BIG: The IOCTL number is supported, but the provided structure has non-zero in a part the kernel does not understand.
- EOPNOTSUPP: The IOCTL number is supported, and the structure is understood, however a known field has a value the kernel does not understand or support.
- EINVAL: Everything about the IOCTL was understood, but a field is not correct.
- ENOENT: An ID or IOVA provided does not exist.
- ENOMEM: Out of memory.
- EOVERRLOW: Mathematics overflowed.

As well as additional errnos, within specific ioctls.

```
struct iommu_destroy
    ioctl(IOMMU_DESTROY)
```

#### Definition:

```
struct iommu_destroy {
    __u32 size;
    __u32 id;
};
```

#### Members

##### size

sizeof(*struct iommu\_destroy*)

##### id

iommufd object ID to destroy. Can be any destroyable object type.

#### Description

Destroy any object held within iommufd.

```
struct iommu_ioas_alloc
    ioctl(IOMMU_IOAS_ALLOC)
```

**Definition:**

```
struct iommu_ioas_alloc {
    __u32 size;
    __u32 flags;
    __u32 out_ioas_id;
};
```

**Members****size**

sizeof(*struct iommu\_ioas\_alloc*)

**flags**

Must be 0

**out\_ioas\_id**

Output IOAS ID for the allocated object

**Description**

Allocate an IO Address Space (IOAS) which holds an IO Virtual Address (IOVA) to memory mapping.

```
struct iommu_iova_range
    ioctl(IOMMU_IOVA_RANGE)
```

**Definition:**

```
struct iommu_iova_range {
    __aligned_u64 start;
    __aligned_u64 last;
};
```

**Members****start**

First IOVA

**last**

Inclusive last IOVA

**Description**

An interval in IOVA space.

```
struct iommu_ioas_iova_ranges
    ioctl(IOMMU_IOAS_IOVA_RANGES)
```

**Definition:**

```
struct iommu_ioas_iova_ranges {
    __u32 size;
    __u32 ioas_id;
    __u32 num_iovas;
```

```

__u32 __reserved;
__aligned_u64 allowed_iovas;
__aligned_u64 out_iova_alignment;
};

```

**Members****size**

sizeof(*struct iommu\_ioas\_iova\_ranges*)

**ioas\_id**

IOAS ID to read ranges from

**num\_iovas**

Input/Output total number of ranges in the IOAS

**\_\_reserved**

Must be 0

**allowed\_iovas**

Pointer to the output array of *struct iommu\_iova\_range*

**out\_iova\_alignment**

Minimum alignment required for mapping IOVA

**Description**

Query an IOAS for ranges of allowed IOVAs. Mapping IOVA outside these ranges is not allowed. num\_iovas will be set to the total number of iovas and the allowed\_iovas[] will be filled in as space permits.

The allowed ranges are dependent on the HW path the DMA operation takes, and can change during the lifetime of the IOAS. A fresh empty IOAS will have a full range, and each attached device will narrow the ranges based on that device's HW restrictions. Detaching a device can widen the ranges. Userspace should query ranges after every attach/detach to know what IOVAs are valid for mapping.

On input num\_iovas is the length of the allowed\_iovas array. On output it is the total number of iovas filled in. The ioctl will return -EMSGSIZE and set num\_iovas to the required value if num\_iovas is too small. In this case the caller should allocate a larger output array and re-issue the ioctl.

out\_iova\_alignment returns the minimum IOVA alignment that can be given to IOMMU\_IOAS\_MAP/COPY. IOVA's must satisfy:

```

starting_iova % out_iova_alignment == 0
(starting_iova + length) % out_iova_alignment == 0

```

out\_iova\_alignment can be 1 indicating any IOVA is allowed. It cannot be higher than the system PAGE\_SIZE.

**struct iommu\_ioas\_allow\_iovas**

ioctl(IOMMU\_IOAS\_ALLOW\_IOVAS)

**Definition:**

```
struct iommu_ioas_allow iovas {
    __u32 size;
    __u32 ioas_id;
    __u32 num_ivolas;
    __u32 __reserved;
    __aligned_u64 allowed_ivolas;
};
```

## Members

### **size**

sizeof(*struct iommu\_ioas\_allow iovas*)

### **ioas\_id**

IOAS ID to allow IOVAs from

### **num\_ivolas**

Input/Output total number of ranges in the IOAS

### **\_\_reserved**

Must be 0

### **allowed\_ivolas**

Pointer to array of *struct iommu\_iova\_range*

## Description

Ensure a range of IOVAs are always available for allocation. If this call succeeds then IOMMU\_IOAS\_IOVA\_RANGES will never return a list of IOVA ranges that are narrower than the ranges provided here. This call will fail if IOMMU\_IOAS\_IOVA\_RANGES is currently narrower than the given ranges.

When an IOAS is first created the IOVA\_RANGES will be maximally sized, and as devices are attached the IOVA will narrow based on the device restrictions. When an allowed range is specified any narrowing will be refused, ie device attachment can fail if the device requires limiting within the allowed range.

Automatic IOVA allocation is also impacted by this call. MAP will only allocate within the allowed IOVAs if they are present.

This call replaces the entire allowed list with the given list.

### enum **iommufd\_ioas\_map\_flags**

Flags for map and copy

## Constants

### **IOMMU\_IOAS\_MAP\_FIXED\_IOVA**

If clear the kernel will compute an appropriate IOVA to place the mapping at

### **IOMMU\_IOAS\_MAP\_WRITEABLE**

DMA is allowed to write to this mapping

### **IOMMU\_IOAS\_MAP\_READABLE**

DMA is allowed to read from this mapping

### struct **iommu\_ioas\_map**

ioctl(IOMMU\_IOAS\_MAP)

**Definition:**

```
struct iommu_ioas_map {
    __u32 size;
    __u32 flags;
    __u32 ioas_id;
    __u32 __reserved;
    __aligned_u64 user_va;
    __aligned_u64 length;
    __aligned_u64 iova;
};
```

**Members****size**

sizeof(*struct iommu\_ioas\_map*)

**flags**

Combination of *enum iommufd\_ioas\_map\_flags*

**ioas\_id**

IOAS ID to change the mapping of

**\_\_reserved**

Must be 0

**user\_va**

Userspace pointer to start mapping from

**length**

Number of bytes to map

**iova**

IOVA the mapping was placed at. If IOMMU\_IOAS\_MAP\_FIXED\_IOVA is set then this must be provided as input.

**Description**

Set an IOVA mapping from a user pointer. If FIXED\_IOVA is specified then the mapping will be established at iova, otherwise a suitable location based on the reserved and allowed lists will be automatically selected and returned in iova.

If IOMMU\_IOAS\_MAP\_FIXED\_IOVA is specified then the iova range must currently be unused, existing IOVA cannot be replaced.

```
struct iommu_ioas_copy
    ioctl(IOMMU_IOAS_COPY)
```

**Definition:**

```
struct iommu_ioas_copy {
    __u32 size;
    __u32 flags;
    __u32 dst_ioas_id;
    __u32 src_ioas_id;
    __aligned_u64 length;
    __aligned_u64 dst_iova;
```

```
    __aligned_u64 src_iova;
};
```

**Members****size**

sizeof(*struct iommu\_ioas\_copy*)

**flags**

Combination of *enum iommufd\_ioas\_map\_flags*

**dst\_ioas\_id**

IOAS ID to change the mapping of

**src\_ioas\_id**

IOAS ID to copy from

**length**

Number of bytes to copy and map

**dst\_iova**

IOVA the mapping was placed at. If IOMMU\_IOAS\_MAP\_FIXED\_IOVA is set then this must be provided as input.

**src\_iova**

IOVA to start the copy

**Description**

Copy an already existing mapping from src\_ioas\_id and establish it in dst\_ioas\_id. The src iova/length must exactly match a range used with IOMMU\_IOAS\_MAP.

This may be used to efficiently clone a subset of an IOAS to another, or as a kind of 'cache' to speed up mapping. Copy has an efficiency advantage over establishing equivalent new mappings, as internal resources are shared, and the kernel will pin the user memory only once.

```
struct iommu_ioas_unmap
    ioctl(IOMMU_IOAS_UNMAP)
```

**Definition:**

```
struct iommu_ioas_unmap {
    __u32 size;
    __u32 ioas_id;
    __aligned_u64 iova;
    __aligned_u64 length;
};
```

**Members****size**

sizeof(*struct iommu\_ioas\_unmap*)

**ioas\_id**

IOAS ID to change the mapping of

## iova

IOVA to start the unmapping at

## length

Number of bytes to unmap, and return back the bytes unmapped

## Description

Unmap an IOVA range. The iova/length must be a superset of a previously mapped range used with IOMMU\_IOAS\_MAP or IOMMU\_IOAS\_COPY. Splitting or truncating ranges is not allowed. The values 0 to U64\_MAX will unmap everything.

## enum iommufd\_option

ioctl(IOMMU\_OPTION\_RLIMIT\_MODE) and ioctl(IOMMU\_OPTION\_HUGE\_PAGES)

## Constants

### IOMMU\_OPTION\_RLIMIT\_MODE

Change how RLIMIT\_MEMLOCK accounting works. The caller must have privilege to invoke this. Value 0 (default) is user based accounting, 1 uses process based accounting. Global option, object\_id must be 0

### IOMMU\_OPTION\_HUGE\_PAGES

Value 1 (default) allows contiguous pages to be combined when generating iommu mappings. Value 0 disables combining, everything is mapped to PAGE\_SIZE. This can be useful for benchmarking. This is a per-IOAS option, the object\_id must be the IOAS ID.

## enum iommufd\_option\_ops

ioctl(IOMMU\_OPTION\_OP\_SET) and ioctl(IOMMU\_OPTION\_OP\_GET)

## Constants

### IOMMU\_OPTION\_OP\_SET

Set the option's value

### IOMMU\_OPTION\_OP\_GET

Get the option's value

## struct iommu\_option

iommu option multiplexer

## Definition:

```
struct iommu_option {
    __u32 size;
    __u32 option_id;
    __u16 op;
    __u16 __reserved;
    __u32 object_id;
    __aligned_u64 val64;
};
```

## Members

### size

sizeof(*struct iommu\_option*)

**option\_id**  
One of *enum iommufd\_option*

**op**  
One of *enum iommufd\_option\_ops*

**\_reserved**  
Must be 0

**object\_id**  
ID of the object if required

**val64**  
Option value to set or value returned on get

## Description

Change a simple option value. This multiplexor allows controlling options on objects. IOMMU\_OPTION\_OP\_SET will load an option and IOMMU\_OPTION\_OP\_GET will return the current value.

**enum iommufd\_vfio\_ioas\_op**  
IOMMU\_VFIO\_IOAS\_\* ioctl

## Constants

**IOMMU\_VFIO\_IOAS\_GET**  
Get the current compatibility IOAS

**IOMMU\_VFIO\_IOAS\_SET**  
Change the current compatibility IOAS

**IOMMU\_VFIO\_IOAS\_CLEAR**  
Disable VFIO compatibility

**struct iommufd\_vfio\_ioas**  
ioctl(IOMMU\_VFIO\_IOAS)

## Definition:

```
struct iommufd_vfio_ioas {
    __u32 size;
    __u32 ioas_id;
    __u16 op;
    __u16 __reserved;
};
```

## Members

**size**  
`sizeof(struct iommufd_vfio_ioas)`

**ioas\_id**  
For IOMMU\_VFIO\_IOAS\_SET the input IOAS ID to set For IOMMU\_VFIO\_IOAS\_GET will output the IOAS ID

**op**  
One of *enum iommufd\_vfio\_ioas\_op*

**— reserved**

Must be 0

**Description**

The VFIO compatibility support uses a single ioas because VFIO APIs do not support the ID field. Set or Get the IOAS that VFIO compatibility will use. When VFIO\_GROUP\_SET\_CONTAINER is used on an iommufd it will get the compatibility ioas, either by taking what is already set, or auto creating one. From then on VFIO will continue to use that ioas and is not effected by this ioctl. SET or CLEAR does not destroy any auto-created IOAS.

**enum *iommufd\_hwpt\_alloc\_flags***

Flags for HWPT allocation

**Constants****IOMMU\_HWPT\_ALLOC\_NEST\_PARENT**

If set, allocate a HWPT that can serve as the parent HWPT in a nesting configuration.

**IOMMU\_HWPT\_ALLOC\_DIRTY\_TRACKING**

Dirty tracking support for device IOMMU is enforced on device attachment

**enum *iommu\_hwpt\_vtd\_s1\_flags***

Intel VT-d stage-1 page table entry attributes

**Constants****IOMMU\_VTD\_S1\_SRE**

Supervisor request

**IOMMU\_VTD\_S1\_EAFE**

Extended access enable

**IOMMU\_VTD\_S1\_WPE**

Write protect enable

**struct *iommu\_hwpt\_vtd\_s1***

Intel VT-d stage-1 page table info (IOMMU\_HWPT\_DATA\_VTD\_S1)

**Definition:**

```
struct iommu_hwpt_vtd_s1 {  
    __aligned_u64 flags;  
    __aligned_u64 pgtbl_addr;  
    __u32 addr_width;  
    __u32 __reserved;  
};
```

**Members****flags**

Combination of [\*enum iommu\\_hwpt\\_vtd\\_s1\\_flags\*](#)

**pgtbl\_addr**

The base address of the stage-1 page table.

**addr\_width**

The address width of the stage-1 page table

**\_\_reserved**

Must be 0

**enum iommu\_hwpt\_data\_type**

IOMMU HWPT Data Type

**Constants****IOMMU\_HWPT\_DATA\_NONE**

no data

**IOMMU\_HWPT\_DATA\_VTD\_S1**

Intel VT-d stage-1 page table

**struct iommu\_hwpt\_alloc**

ioctl(IOMMU\_HWPT\_ALLOC)

**Definition:**

```
struct iommu_hwpt_alloc {
    __u32 size;
    __u32 flags;
    __u32 dev_id;
    __u32 pt_id;
    __u32 out_hwpt_id;
    __u32 __reserved;
    __u32 data_type;
    __u32 data_len;
    __aligned_u64 data_uptr;
};
```

**Members****size**

sizeof(*struct iommu\_hwpt\_alloc*)

**flags**

Combination of *enum iommufd\_hwpt\_alloc\_flags*

**dev\_id**

The device to allocate this HWPT for

**pt\_id**

The IOAS or HWPT to connect this HWPT to

**out\_hwpt\_id**

The ID of the new HWPT

**\_\_reserved**

Must be 0

**data\_type**

One of *enum iommu\_hwpt\_data\_type*

**data\_len**

Length of the type specific data

**data\_uptr**

User pointer to the type specific data

## Description

Explicitly allocate a hardware page table object. This is the same object type that is returned by `iommufd_device_attach()` and represents the underlying iommu driver's `iommu_domain` kernel object.

A kernel-managed HWPT will be created with the mappings from the given IOAS via the `pt_id`. The `data_type` for this allocation must be set to `IOMMU_HWPT_DATA_NONE`. The HWPT can be allocated as a parent HWPT for a nesting configuration by passing `IOMMU_HWPT_ALLOC_NEST_PARENT` via `flags`.

A user-managed nested HWPT will be created from a given parent HWPT via `pt_id`, in which the parent HWPT must be allocated previously via the same ioctl from a given IOAS (`pt_id`). In this case, the `data_type` must be set to a pre-defined type corresponding to an I/O page table type supported by the underlying IOMMU hardware.

If the `data_type` is set to `IOMMU_HWPT_DATA_NONE`, `data_len` and `data_uptr` should be zero. Otherwise, both `data_len` and `data_uptr` must be given.

### `enum iommu_hw_info_vtd_flags`

Flags for VT-d hw\_info

## Constants

### `IOMMU_HW_INFO_VTD_ERRATA_772415_SPR17`

If set, disallow read-only mappings on a nested\_parent domain. <https://www.intel.com/content/www/us/en/content-details/772415/content-details.html>

### `struct iommu_hw_info_vtd`

Intel VT-d hardware information

## Definition:

```
struct iommu_hw_info_vtd {
    __u32 flags;
    __u32 __reserved;
    __aligned_u64 cap_reg;
    __aligned_u64 ecap_reg;
};
```

## Members

### `flags`

Combination of `enum iommu_hw_info_vtd_flags`

### `__reserved`

Must be 0

### `cap_reg`

Value of Intel VT-d capability register defined in VT-d spec section 11.4.2 Capability Register.

### `ecap_reg`

Value of Intel VT-d capability register defined in VT-d spec section 11.4.3 Extended Capability Register.

## Description

User needs to understand the Intel VT-d specification to decode the register value.

**enum iommu\_hw\_info\_type**  
IOMMU Hardware Info Types

## Constants

**IOMMU\_HW\_INFO\_TYPE\_NONE**  
Used by the drivers that do not report hardware info

**IOMMU\_HW\_INFO\_TYPE\_INTEL\_VTD**  
Intel VT-d iommu info type

**enum iommufd\_hw\_capabilities**

## Constants

**IOMMU\_HW\_CAP\_DIRTY\_TRACKING**

IOMMU hardware support for dirty tracking If available, it means the following APIs are supported:

IOMMU\_HWPT\_GET\_DIRTY\_BITMAP IOMMU\_HWPT\_SET\_DIRTY\_TRACKING

**struct iommu\_hw\_info**

ioctl(IOMMU\_GET\_HW\_INFO)

## Definition:

```
struct iommu_hw_info {
    __u32 size;
    __u32 flags;
    __u32 dev_id;
    __u32 data_len;
    __aligned_u64 data_uptr;
    __u32 out_data_type;
    __u32 __reserved;
    __aligned_u64 out_capabilities;
};
```

## Members

### size

sizeof(*struct iommu\_hw\_info*)

### flags

Must be 0

### dev\_id

The device bound to the iommufd

### data\_len

Input the length of a user buffer in bytes. Output the length of data that kernel supports

### data\_uptr

User pointer to a user-space buffer used by the kernel to fill the iommu type specific hardware information data

### out\_data\_type

Output the iommu hardware info type as defined in the *enum iommu\_hw\_info\_type*.

**\_\_reserved**

Must be 0

**out\_capabilities**

Output the generic iommu capability info type as defined in the enum iommu\_hw\_capabilities.

**Description**

Query an iommu type specific hardware information data from an iommu behind a given device that has been bound to iommufd. This hardware info data will be used to sync capabilities between the virtual iommu and the physical iommu, e.g. a nested translation setup needs to check the hardware info, so a guest stage-1 page table can be compatible with the physical iommu.

To capture an iommu type specific hardware information data, **data\_uptr** and its length **data\_len** must be provided. Trailing bytes will be zeroed if the user buffer is larger than the data that kernel has. Otherwise, kernel only fills the buffer using the given length in **data\_len**. If the ioctl succeeds, **data\_len** will be updated to the length that kernel actually supports, **out\_data\_type** will be filled to decode the data filled in the buffer pointed by **data\_uptr**. Input **data\_len == zero** is allowed.

```
struct iommu_hwpt_set_dirty_tracking  
    ioctl(IOMMU_HWPT_SET_DIRTY_TRACKING)
```

**Definition:**

```
struct iommu_hwpt_set_dirty_tracking {  
    __u32 size;  
    __u32 flags;  
    __u32 hwpt_id;  
    __u32 __reserved;  
};
```

**Members****size**

sizeof(*struct iommu\_hwpt\_set\_dirty\_tracking*)

**flags**

Combination of enum iommufd\_hwpt\_set\_dirty\_tracking\_flags

**hwpt\_id**

HW pagetable ID that represents the IOMMU domain

**\_\_reserved**

Must be 0

**Description**

Toggle dirty tracking on an HW pagetable.

**enum iommufd\_hwpt\_get\_dirty\_bitmap\_flags**

Flags for getting dirty bits

**Constants**

**IOMMU\_HWPT\_GET\_DIRTY\_BITMAP\_NO\_CLEAR**

Just read the PTEs without clearing any dirty bits metadata. This flag can be passed in the expectation where the next operation is an unmap of the same IOVA range.

```
struct iommu_hwpt_get_dirty_bitmap
    ioctl(IOMMU_HWPT_GET_DIRTY_BITMAP)
```

**Definition:**

```
struct iommu_hwpt_get_dirty_bitmap {
    __u32 size;
    __u32 hwpt_id;
    __u32 flags;
    __u32 __reserved;
    __aligned_u64 iova;
    __aligned_u64 length;
    __aligned_u64 page_size;
    __aligned_u64 data;
};
```

**Members****size**

sizeof(*struct iommu\_hwpt\_get\_dirty\_bitmap*)

**hwpt\_id**

HW pagetable ID that represents the IOMMU domain

**flags**

Combination of *enum iommufd\_hwpt\_get\_dirty\_bitmap\_flags*

**\_\_reserved**

Must be 0

**iova**

base IOVA of the bitmap first bit

**length**

IOVA range size

**page\_size**

page size granularity of each bit in the bitmap

**data**

bitmap where to set the dirty bits. The bitmap bits each represent a `page_size` which you deviate from an arbitrary `iova`.

**Description**

Checking a given IOVA is dirty:

```
data[(iova / page_size) / 64] & (1ULL << ((iova / page_size) % 64))
```

Walk the IOMMU pagetables for a given IOVA range to return a bitmap with the dirty IOVAs. In doing so it will also by default clear any dirty bit metadata set in the IOPTE.

**enum iommu\_hwpt\_invalidate\_data\_type**

IOMMU HWPT Cache Invalidation Data Type

## Constants

### **IOMMU\_HWPT\_INVALIDATE\_DATA\_VTD\_S1**

Invalidation data for VTD\_S1

### **enum iommu\_hwpt\_vtd\_s1\_invalidate\_flags**

Flags for Intel VT-d stage-1 cache invalidation

## Constants

### **IOMMU\_VTD\_INV\_FLAGS\_LEAF**

Indicates whether the invalidation applies to all-levels page structure cache or just the leaf PTE cache.

### **struct iommu\_hwpt\_vtd\_s1\_invalidate**

Intel VT-d cache invalidation (IOMMU\_HWPT\_INVALIDATE\_DATA\_VTD\_S1)

#### Definition:

```
struct iommu_hwpt_vtd_s1_invalidate {
    __aligned_u64 addr;
    __aligned_u64 npages;
    __u32 flags;
    __u32 __reserved;
};
```

## Members

### **addr**

The start address of the range to be invalidated. It needs to be 4KB aligned.

### **npages**

Number of contiguous 4K pages to be invalidated.

### **flags**

Combination of [\*enum iommu\\_hwpt\\_vtd\\_s1\\_invalidate\\_flags\*](#)

### **\_\_reserved**

Must be 0

## Description

The Intel VT-d specific invalidation data for user-managed stage-1 cache invalidation in nested translation. Userspace uses this structure to tell the impacted cache scope after modifying the stage-1 page table.

Invalidating all the caches related to the page table by setting **addr** to be 0 and **npages** to be U64\_MAX.

The device TLB will be invalidated automatically if ATS is enabled.

### **struct iommu\_hwpt\_invalidate**

ioctl(IOMMU\_HWPT\_INVALIDATE)

#### Definition:

```
struct iommu_hwpt_invalidate {
    __u32 size;
    __u32 hwpt_id;
```

```

__aligned_u64 data_uptr;
__u32 data_type;
__u32 entry_len;
__u32 entry_num;
__u32 __reserved;
};

```

## Members

### **size**

sizeof(*struct iommu\_hwpt\_invalidate*)

### **hwpt\_id**

ID of a nested HWPT for cache invalidation

### **data\_uptr**

User pointer to an array of driver-specific cache invalidation data.

### **data\_type**

One of *enum iommu\_hwpt\_invalidate\_data\_type*, defining the data type of all the entries in the invalidation request array. It should be a type supported by the hwpt pointed by **hwpt\_id**.

### **entry\_len**

Length (in bytes) of a request entry in the request array

### **entry\_num**

Input the number of cache invalidation requests in the array. Output the number of requests successfully handled by kernel.

### **\_\_reserved**

Must be 0.

## Description

Invalidate the iommu cache for user-managed page table. Modifications on a user-managed page table should be followed by this operation to sync cache. Each ioctl can support one or more cache invalidation requests in the array that has a total size of **entry\_len \* entry\_num**.

An empty invalidation request array by setting **entry\_num==0 is allowed, and \*\*entry\_len and data\_uptr would be ignored in this case**. This can be used to check if the given **data\_type** is supported or not by kernel.

## 12.4 IOMMUFD Kernel API

The IOMMUFD kAPI is device-centric with group-related tricks managed behind the scene. This allows the external drivers calling such kAPI to implement a simple device-centric uAPI for connecting its device to an iommufd, instead of explicitly imposing the group semantics in its uAPI as VFIO does.

```
struct iommufd_device *iommufd_device_bind(struct iommufd_ctx *ictx, struct device *dev,
                                            u32 *id)
```

Bind a physical device to an iommu fd

## Parameters

**struct iommufd\_ctx \*ictx**  
iommufd file descriptor

**struct device \*dev**  
Pointer to a physical device struct

**u32 \*id**  
Output ID number to return to userspace for this device

### Description

A successful bind establishes an ownership over the device and returns struct iommufd\_device pointer, otherwise returns error pointer.

A driver using this API must set driver\_managed\_dma and must not touch the device until this routine succeeds and establishes ownership.

Binding a PCI device places the entire RID under iommufd control.

The caller must undo this with *iommufd\_device\_unbind()*

**bool iommufd\_ctx\_has\_group(struct iommufd\_ctx \*ictx, struct iommu\_group \*group)**  
True if any device within the group is bound to the ictx

### Parameters

**struct iommufd\_ctx \*ictx**  
iommufd file descriptor

**struct iommu\_group \*group**  
Pointer to a physical iommu\_group struct

### Description

True if any device within the group has been bound to this ictx, ex. via *iommufd\_device\_bind()*, therefore implying ictx ownership of the group.

**void iommufd\_device\_unbind(struct iommufd\_device \*idev)**  
Undo *iommufd\_device\_bind()*

### Parameters

**struct iommufd\_device \*idev**  
Device returned by *iommufd\_device\_bind()*

### Description

Release the device from iommufd control. The DMA ownership will return back to unowned with DMA controlled by the DMA API. This invalidates the iommufd\_device pointer, other APIs that consume it must not be called concurrently.

**int iommufd\_device\_attach(struct iommufd\_device \*idev, u32 \*pt\_id)**  
Connect a device to an iommu\_domain

### Parameters

**struct iommufd\_device \*idev**  
device to attach

**u32 \*pt\_id**  
Input a IOMMUFD\_OBJ\_IOAS, or IOMMUFD\_OBJ\_HWPT\_PAGING Output the IOMMUFD\_OBJ\_HWPT\_PAGING ID

## Description

This connects the device to an iommu\_domain, either automatically or manually selected. Once this completes the device could do DMA.

The caller should return the resulting pt\_id back to userspace. This function is undone by calling [\*iommufd\\_device\\_detach\(\)\*](#).

```
int iommufd_device_replace(struct iommufd_device *idev, u32 *pt_id)
```

Change the device's iommu\_domain

## Parameters

**struct iommufd\_device \*idev**

device to change

**u32 \*pt\_id**

Input a IOMMUFD\_OBJ\_IOAS, or IOMMUFD\_OBJ\_HWPT\_PAGING Output the IOMMUFD\_OBJ\_HWPT\_PAGING ID

## Description

This is the same as:

```
iommufd_device_detach();
iommufd_device_attach();
```

If it fails then no change is made to the attachment. The iommu driver may implement this so there is no disruption in translation. This can only be called if [\*iommufd\\_device\\_attach\(\)\*](#) has already succeeded.

```
void iommufd_device_detach(struct iommufd_device *idev)
```

Disconnect a device to an iommu\_domain

## Parameters

**struct iommufd\_device \*idev**

device to detach

## Description

Undo [\*iommufd\\_device\\_attach\(\)\*](#). This disconnects the idev from the previously attached pt\_id. The device returns back to a blocked DMA translation.

```
struct iommufd_access *iommufd_access_create(struct iommufd_ctx *ictx, const struct
                                               iommufd_access_ops *ops, void *data, u32
                                               *id)
```

Create an iommufd\_access

## Parameters

**struct iommufd\_ctx \*ictx**

iommufd file descriptor

**const struct iommufd\_access\_ops \*ops**

Driver's ops to associate with the access

**void \*data**

Opaque data to pass into ops functions

## **u32 \*id**

Output ID number to return to userspace for this access

### **Description**

An iommufd\_access allows a driver to read/write to the IOAS without using DMA. The underlying CPU memory can be accessed using the [\*iommufd\\_access\\_pin\\_pages\(\)\*](#) or [\*iommufd\\_access\\_rw\(\)\*](#) functions.

The provided ops are required to use [\*iommufd\\_access\\_pin\\_pages\(\)\*](#).

## **void *iommufd\_access\_destroy*(struct iommufd\_access \*access)**

Destroy an iommufd\_access

### **Parameters**

#### **struct iommufd\_access \*access**

The access to destroy

### **Description**

The caller must stop using the access before destroying it.

## **void *iommufd\_access\_unpin\_pages*(struct iommufd\_access \*access, unsigned long iova, unsigned long length)**

Undo iommufd\_access\_pin\_pages

### **Parameters**

#### **struct iommufd\_access \*access**

IOAS access to act on

#### **unsigned long iova**

Starting IOVA

#### **unsigned long length**

Number of bytes to access

### **Description**

Return the struct page's. The caller must stop accessing them before calling this. The iova/length must exactly match the one provided to access\_pages.

## **int *iommufd\_access\_pin\_pages*(struct iommufd\_access \*access, unsigned long iova, unsigned long length, struct page \*\*out\_pages, unsigned int flags)**

Return a list of pages under the iova

### **Parameters**

#### **struct iommufd\_access \*access**

IOAS access to act on

#### **unsigned long iova**

Starting IOVA

#### **unsigned long length**

Number of bytes to access

#### **struct page \*\*out\_pages**

Output page list

```
unsigned int flags
    IOPMMUFD_ACCESS_RW_* flags
```

### Description

Reads **length** bytes starting at iova and returns the struct page \* pointers. These can be kmap'd by the caller for CPU access.

The caller must perform *iommufd\_access\_unpin\_pages()* when done to balance this.

This API always requires a page aligned iova. This happens naturally if the ioas alignment is  $\geq$  PAGE\_SIZE and the iova is PAGE\_SIZE aligned. However smaller alignments have corner cases where this API can fail on otherwise aligned iova.

```
int iommufd_access_rw(struct iommufd_access *access, unsigned long iova, void *data, size_t
                           length, unsigned int flags)
```

Read or write data under the iova

### Parameters

**struct iommufd\_access \*access**

IOAS access to act on

**unsigned long iova**

Starting IOVA

**void \*data**

Kernel buffer to copy to/from

**size\_t length**

Number of bytes to access

**unsigned int flags**

IOMMUFD\_ACCESS\_RW\_\* flags

### Description

Copy kernel to/from data into the range given by IOVA/length. If flags indicates IOMMUFD\_ACCESS\_RW\_KTHREAD then a large copy can be optimized by changing it into `copy_to/from_user()`.

```
void iommufd_ctx_get(struct iommufd_ctx *ictx)
```

Get a context reference

### Parameters

**struct iommufd\_ctx \*ictx**

Context to get

### Description

The caller must already hold a valid reference to ictx.

```
struct iommufd_ctx *iommufd_ctx_from_file(struct file *file)
```

Acquires a reference to the iommufd context

### Parameters

**struct file \*file**

File to obtain the reference from

## Description

Returns a pointer to the iommufd\_ctx, otherwise ERR\_PTR. The struct file remains owned by the caller and the caller must still do fput. On success the caller is responsible to call [\*iommufd\\_ctx\\_put\(\)\*](#).

```
struct iommufd_ctx *iommufd_ctx_from_fd(int fd)
```

Acquires a reference to the iommufd context

## Parameters

**int fd**

File descriptor to obtain the reference from

## Description

Returns a pointer to the iommufd\_ctx, otherwise ERR\_PTR. On success the caller is responsible to call [\*iommufd\\_ctx\\_put\(\)\*](#).

```
void iommufd_ctx_put(struct iommufd_ctx *ictx)
```

Put back a reference

## Parameters

**struct iommufd\_ctx \*ictx**

Context to put back

## 12.4.1 VFIO and IOMMUFD

Connecting a VFIO device to iommufd can be done in two ways.

First is a VFIO compatible way by directly implementing the /dev/vfio/vfio container IOCTLs by mapping them into io\_pagetable operations. Doing so allows the use of iommufd in legacy VFIO applications by symlinking /dev/vfio/vfio to /dev/iommufd or extending VFIO to SET\_CONTAINER using an iommufd instead of a container fd.

The second approach directly extends VFIO to support a new set of device-centric user API based on aforementioned IOMMUFD kernel API. It requires userspace change but better matches the IOMMUFD API semantics and easier to support new iommufd features when comparing it to the first approach.

Currently both approaches are still work-in-progress.

There are still a few gaps to be resolved to catch up with VFIO type1, as documented in `iommufd_vfio_check_extension()`.

## 12.5 Future TODOs

Currently IOMMUFD supports only kernel-managed I/O page table, similar to VFIO type1. New features on the radar include:

- Binding iommu\_domain's to PASID/SSID
- Userspace page tables, for ARM, x86 and S390
- Kernel bypass'd invalidation of user page tables

- Re-use of the KVM page table in the IOMMU
- Dirty page tracking in the IOMMU
- Runtime Increase/Decrease of IOPTE size
- PRI support with faults resolved in userspace



## LINUX MEDIA INFRASTRUCTURE USERSPACE API

This section contains the driver development information and Kernel APIs used by media devices.

Please see:

[Documentation/admin-guide/media/index.rst](#)

- for usage information about media subsystem and supported drivers;

[Documentation/driver-api/media/index.rst](#)

- for driver development information and Kernel APIs used by media devices;

### 13.1 Introduction

This document covers the Linux Kernel to Userspace API's used by video and radio streaming devices, including video cameras, analog and digital TV receiver cards, AM/FM receiver cards, Software Defined Radio (SDR), streaming capture and output devices, codec devices and remote controllers.

A typical media device hardware is shown at *Typical Media Device*.

The media infrastructure API was designed to control such devices. It is divided into five parts.

1. The *first part* covers radio, video capture and output, cameras, analog TV devices and codecs.
2. The *second part* covers the API used for digital TV and Internet reception via one of the several digital tv standards. While it is called as DVB API, in fact it covers several different video standards including DVB-T/T2, DVB-S/S2, DVB-C, ATSC, ISDB-T, ISDB-S, DTMB, etc. The complete list of supported standards can be found at [\*fe\\_delivery\\_system\*](#).
3. The *third part* covers the Remote Controller API.
4. The *fourth part* covers the Media Controller API.
5. The *fifth part* covers the CEC (Consumer Electronics Control) API.

It should also be noted that a media device may also have audio components, like mixers, PCM capture, PCM playback, etc, which are controlled via ALSA API. For additional information and for the latest development code, see: <https://linuxtv.org>. For discussing improvements, reporting troubles, sending new drivers, etc, please mail to: [Linux Media Mailing List \(LMML\)](#).

Fig. 1: Typical Media Device

## 13.2 Part I - Video for Linux API

This part describes the Video for Linux API version 2 (V4L2 API) specification.

### Revision 4.5

#### 13.2.1 Common API Elements

Programming a V4L2 device consists of these steps:

- Opening the device
- Changing device properties, selecting a video and audio input, video standard, picture brightness a. o.
- Negotiating a data format
- Negotiating an input/output method
- The actual input/output loop
- Closing the device

In practice most steps are optional and can be executed out of order. It depends on the V4L2 device type, you can read about the details in [Interfaces](#). In this chapter we will discuss the basic concepts applicable to all devices.

### Opening and Closing Devices

#### Controlling a hardware peripheral via V4L2

Hardware that is supported using the V4L2 uAPI often consists of multiple devices or peripherals, each of which have their own driver.

The bridge driver exposes one or more V4L2 device nodes (see [V4L2 Device Node Naming](#)).

There are other drivers providing support for other components of the hardware, which may also expose device nodes, called V4L2 sub-devices.

When such V4L2 sub-devices are exposed, they allow controlling those other hardware components - usually connected via a serial bus (like I<sup>2</sup>C, SMBus or SPI). Depending on the bridge driver, those sub-devices can be controlled indirectly via the bridge driver or explicitly via the [Media Controller](#) and via the [V4L2 sub-devices](#).

The devices that require the use of the [Media Controller](#) are called **MC-centric** devices. The devices that are fully controlled via V4L2 device nodes are called **video-node-centric**.

Userspace can check if a V4L2 hardware peripheral is MC-centric by calling `ioctl VID-IOC_QUERYCAP` and checking the `device_caps` field.

If the device returns `V4L2_CAP_IO_MC` flag at `device_caps`, then it is MC-centric, otherwise, it is video-node-centric.

It is required for MC-centric drivers to identify the V4L2 sub-devices and to configure the pipelines via the [media controller API](#) before using the peripheral. Also, the sub-devices' configuration shall be controlled via the [sub-device API](#).

## Note:

A video-node-centric may still provide media-controller and sub-device interfaces as well.

However, in that case the media-controller and the sub-device interfaces are read-only and just provide information about the device. The actual configuration is done via the video nodes.

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## V4L2 Device Node Naming

V4L2 drivers are implemented as kernel modules, loaded manually by the system administrator or automatically when a device is first discovered. The driver modules plug into the videodev kernel module. It provides helper functions and a common application interface specified in this document.

Each driver thus loaded registers one or more device nodes with major number 81. Minor numbers are allocated dynamically unless the kernel is compiled with the kernel option CONFIG\_VIDEO\_FIXED\_MINOR\_RANGES. In that case minor numbers are allocated in ranges depending on the device node type.

The device nodes supported by the Video4Linux subsystem are:

Default device node name	Usage
/dev/videoX	Video and metadata for capture/output devices
/dev/vbiX	Vertical blank data (i.e. closed captions, teletext)
/dev/radioX	Radio tuners and modulators
/dev/swradioX	Software Defined Radio tuners and modulators
/dev/v4l-touchX	Touch sensors
/dev/v4l-subdevX	Video sub-devices (used by sensors and other components of the hardware peripheral) <sup>1</sup>

Where X is a non-negative integer.

## Note:

1. The actual device node name is system-dependent, as udev rules may apply.
2. There is no guarantee that X will remain the same for the same device, as the number depends on the device driver's probe order. If you need an unique name, udev default rules produce /dev/v4l/by-id/ and /dev/v4l/by-path/ directories containing links that can be used uniquely to identify a V4L2 device node:

```
$ tree /dev/v4l
/dev/v4l
└── by-id
    └── usb-0mniVision._USB_Camera-B4.04.27.1-video-index0 -> ../../video0
└── by-path
    └── pci-0000:00:14.0-usb-0:2:1.0-video-index0 -> ../../video0
```

<sup>1</sup> **V4L2 sub-device nodes** (e. g. /dev/v4l-subdevX) use a different set of system calls, as covered at [Sub-device Interface](#).

Many drivers support "video\_nr", "radio\_nr" or "vbi\_nr" module options to select specific video/radio/vbi node numbers. This allows the user to request that the device node is named e.g. /dev/video5 instead of leaving it to chance. When the driver supports multiple devices of the same type more than one device node number can be assigned, separated by commas:

```
# modprobe mydriver video_nr=0,1 radio_nr=0,1
```

In /etc/modules.conf this may be written as:

```
options mydriver video_nr=0,1 radio_nr=0,1
```

When no device node number is given as module option the driver supplies a default.

Normally udev will create the device nodes in /dev automatically for you. If udev is not installed, then you need to enable the CONFIG\_VIDEO\_FIXED\_MINOR\_RANGES kernel option in order to be able to correctly relate a minor number to a device node number. I.e., you need to be certain that minor number 5 maps to device node name video5. With this kernel option different device types have different minor number ranges. These ranges are listed in [Interfaces](#).

The creation of character special files (with mknod) is a privileged operation and devices cannot be opened by major and minor number. That means applications cannot *reliably* scan for loaded or installed drivers. The user must enter a device name, or the application can try the conventional device names.

## Related Devices

Devices can support several functions. For example video capturing, VBI capturing and radio support.

The V4L2 API creates different V4L2 device nodes for each of these functions.

The V4L2 API was designed with the idea that one device node could support all functions. However, in practice this never worked: this 'feature' was never used by applications and many drivers did not support it and if they did it was certainly never tested. In addition, switching a device node between different functions only works when using the streaming I/O API, not with the [read\(\)/write\(\)](#) API.

Today each V4L2 device node supports just one function.

Besides video input or output the hardware may also support audio sampling or playback. If so, these functions are implemented as ALSA PCM devices with optional ALSA audio mixer devices.

One problem with all these devices is that the V4L2 API makes no provisions to find these related V4L2 device nodes. Some really complex hardware use the Media Controller (see [Part IV - Media Controller API](#)) which can be used for this purpose. But several drivers do not use it, and while some code exists that uses sysfs to discover related V4L2 device nodes (see libmedia\_dev in the [v4l-utils](#) git repository), there is no library yet that can provide a single API towards both Media Controller-based devices and devices that do not use the Media Controller. If you want to work on this please write to the linux-media mailing list: <https://linuxtv.org/lists.php>.

### Multiple Opens

V4L2 devices can be opened more than once.<sup>2</sup> When this is supported by the driver, users can for example start a "panel" application to change controls like brightness or audio volume, while another application captures video and audio. In other words, panel applications are comparable to an ALSA audio mixer application. Just opening a V4L2 device should not change the state of the device.<sup>3</sup>

Once an application has allocated the memory buffers needed for streaming data (by calling the `ioctl VIDIOC_REQBUFS` or `ioctl VIDIOC_CREATE_BUFS` ioctls, or implicitly by calling the `read()` or `write()` functions) that application (filehandle) becomes the owner of the device. It is no longer allowed to make changes that would affect the buffer sizes (e.g. by calling the `VIDIOC_S_FMT` ioctl) and other applications are no longer allowed to allocate buffers or start or stop streaming. The EBUSY error code will be returned instead.

Merely opening a V4L2 device does not grant exclusive access.<sup>4</sup> Initiating data exchange however assigns the right to read or write the requested type of data, and to change related properties, to this file descriptor. Applications can request additional access privileges using the priority mechanism described in *Application Priority*.

### Shared Data Streams

V4L2 drivers should not support multiple applications reading or writing the same data stream on a device by copying buffers, time multiplexing or similar means. This is better handled by a proxy application in user space.

### Functions

To open and close V4L2 devices applications use the `open()` and `close()` function, respectively. Devices are programmed using the `ioctl()` function as explained in the following sections.

### Querying Capabilities

Because V4L2 covers a wide variety of devices not all aspects of the API are equally applicable to all types of devices. Furthermore devices of the same type have different capabilities and this specification permits the omission of a few complicated and less important parts of the API.

The `ioctl VIDIOC_QUERYCAP` ioctl is available to check if the kernel device is compatible with this specification, and to query the *functions* and *I/O methods* supported by the device.

Starting with kernel version 3.1, `ioctl VIDIOC_QUERYCAP` will return the V4L2 API version used by the driver, which generally matches the Kernel version. There's no need of using `ioctl VIDIOC_QUERYCAP` to check if a specific ioctl is supported, the V4L2 core now returns ENOTTY if a driver doesn't provide support for an ioctl.

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<sup>2</sup> There are still some old and obscure drivers that have not been updated to allow for multiple opens. This implies that for such drivers `open()` can return an EBUSY error code when the device is already in use.

<sup>3</sup> Unfortunately, opening a radio device often switches the state of the device to radio mode in many drivers. This behavior should be fixed eventually as it violates the V4L2 specification.

<sup>4</sup> Drivers could recognize the `O_EXCL` open flag. Presently this is not required, so applications cannot know if it really works.

Other features can be queried by calling the respective ioctl, for example *ioctl VIDIOC\_ENUMINPUT* to learn about the number, types and names of video connectors on the device. Although abstraction is a major objective of this API, the *ioctl VIDIOC\_QUERYCAP* ioctl also allows driver specific applications to reliably identify the driver.

All V4L2 drivers must support *ioctl VIDIOC\_QUERYCAP*. Applications should always call this ioctl after opening the device.

## Application Priority

When multiple applications share a device it may be desirable to assign them different priorities. Contrary to the traditional "rm -rf /" school of thought, a video recording application could for example block other applications from changing video controls or switching the current TV channel. Another objective is to permit low priority applications working in background, which can be preempted by user controlled applications and automatically regain control of the device at a later time.

Since these features cannot be implemented entirely in user space V4L2 defines the *VIDIOC\_G\_PRIORITY* and *VIDIOC\_S\_PRIORITY* ioctls to request and query the access priority associate with a file descriptor. Opening a device assigns a medium priority, compatible with earlier versions of V4L2 and drivers not supporting these ioctls. Applications requiring a different priority will usually call *VIDIOC\_S\_PRIORITY* after verifying the device with the *ioctl VIDIOC\_QUERYCAP* ioctl.

Ioctls changing driver properties, such as *VIDIOC\_S\_INPUT*, return an EBUSY error code after another application obtained higher priority.

## Video Inputs and Outputs

Video inputs and outputs are physical connectors of a device. These can be for example: RF connectors (antenna/cable), CVBS a.k.a. Composite Video, S-Video and RGB connectors. Camera sensors are also considered to be a video input. Video and VBI capture devices have inputs. Video and VBI output devices have outputs, at least one each. Radio devices have no video inputs or outputs.

To learn about the number and attributes of the available inputs and outputs applications can enumerate them with the *ioctl VIDIOC\_ENUMINPUT* and *ioctl VIDIOC\_ENUMOUTPUT* ioctl, respectively. The struct `v4l2_input` returned by the *ioctl VIDIOC\_ENUMINPUT* ioctl also contains signal status information applicable when the current video input is queried.

The *VIDIOC\_G\_INPUT* and *VIDIOC\_G\_OUTPUT* ioctls return the index of the current video input or output. To select a different input or output applications call the *VIDIOC\_S\_INPUT* and *VIDIOC\_S\_OUTPUT* ioctls. Drivers must implement all the input ioctls when the device has one or more inputs, all the output ioctls when the device has one or more outputs.

**Example: Information about the current video input**

```
struct v4l2_input input;
int index;

if (-1 == ioctl(fd, VIDIOC_G_INPUT, &index)) {
    perror("VIDIOC_G_INPUT");
    exit(EXIT_FAILURE);
}

memset(&input, 0, sizeof(input));
input.index = index;

if (-1 == ioctl(fd, VIDIOC_ENUMINPUT, &input)) {
    perror("VIDIOC_ENUMINPUT");
    exit(EXIT_FAILURE);
}

printf("Current input: %s\n", input.name);
```

**Example: Switching to the first video input**

```
int index;

index = 0;

if (-1 == ioctl(fd, VIDIOC_S_INPUT, &index)) {
    perror("VIDIOC_S_INPUT");
    exit(EXIT_FAILURE);
}
```

**Audio Inputs and Outputs**

Audio inputs and outputs are physical connectors of a device. Video capture devices have inputs, output devices have outputs, zero or more each. Radio devices have no audio inputs or outputs. They have exactly one tuner which in fact *is* an audio source, but this API associates tuners with video inputs or outputs only, and radio devices have none of these.<sup>1</sup> A connector on a TV card to loop back the received audio signal to a sound card is not considered an audio output.

Audio and video inputs and outputs are associated. Selecting a video source also selects an audio source. This is most evident when the video and audio source is a tuner. Further audio connectors can combine with more than one video input or output. Assumed two composite video inputs and two audio inputs exist, there may be up to four valid combinations. The relation of video and audio connectors is defined in the audioset field of the respective struct

<sup>1</sup> Actually struct v4l2\_audio ought to have a tuner field like struct v4l2\_input, not only making the API more consistent but also permitting radio devices with multiple tuners.

`v4l2_input` or `struct v4l2_output`, where each bit represents the index number, starting at zero, of one audio input or output.

To learn about the number and attributes of the available inputs and outputs applications can enumerate them with the `ioctl VIDIOC_ENUMAUDIO` and `VIDIOC_ENUMAUDOUT` ioctl, respectively. The `struct v4l2_audio` returned by the `ioctl VIDIOC_ENUMAUDIO` ioctl also contains signal status information applicable when the current audio input is queried.

The `VIDIOC_G_AUDIO` and `VIDIOC_G_AUDOUT` ioctls report the current audio input and output, respectively.

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**Note:** Note that, unlike `VIDIOC_G_INPUT` and `VIDIOC_G_OUTPUT` these ioctls return a structure as `ioctl VIDIOC_ENUMAUDIO` and `VIDIOC_ENUMAUDOUT` do, not just an index.

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To select an audio input and change its properties applications call the `VIDIOC_S_AUDIO` ioctl. To select an audio output (which presently has no changeable properties) applications call the `VIDIOC_S_AUDOUT` ioctl.

Drivers must implement all audio input ioctls when the device has multiple selectable audio inputs, all audio output ioctls when the device has multiple selectable audio outputs. When the device has any audio inputs or outputs the driver must set the `V4L2_CAP_AUDIO` flag in the `struct v4l2_capability` returned by the `ioctl VIDIOC_QUERYCAP` ioctl.

### Example: Information about the current audio input

```
struct v4l2_audio audio;

memset(&audio, 0, sizeof(audio));

if (-1 == ioctl(fd, VIDIOC_G_AUDIO, &audio)) {
    perror("VIDIOC_G_AUDIO");
    exit(EXIT_FAILURE);
}

printf("Current input: %s\n", audio.name);
```

### Example: Switching to the first audio input

```
struct v4l2_audio audio;

memset(&audio, 0, sizeof(audio)); /* clear audio.mode, audio.reserved */

audio.index = 0;

if (-1 == ioctl(fd, VIDIOC_S_AUDIO, &audio)) {
    perror("VIDIOC_S_AUDIO");
    exit(EXIT_FAILURE);
}
```

## Tuners and Modulators

### Tuners

Video input devices can have one or more tuners demodulating a RF signal. Each tuner is associated with one or more video inputs, depending on the number of RF connectors on the tuner. The type field of the respective struct `v4l2_input` returned by the `ioctl VIDIOC_ENUMINPUT` ioctl is set to `V4L2_INPUT_TYPE_TUNER` and its `tuner` field contains the index number of the tuner.

Radio input devices have exactly one tuner with index zero, no video inputs.

To query and change tuner properties applications use the `VIDIOC_G_TUNER` and `VIDIOC_S_TUNER` ioctls, respectively. The struct `v4l2_tuner` returned by `VIDIOC_G_TUNER` also contains signal status information applicable when the tuner of the current video or radio input is queried.

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**Note:** `VIDIOC_S_TUNER` does not switch the current tuner, when there is more than one. The tuner is solely determined by the current video input. Drivers must support both ioctls and set the `V4L2_CAP_TUNER` flag in the struct `v4l2_capability` returned by the `ioctl VIDIOC_QUERYCAP` ioctl when the device has one or more tuners.

---

### Modulators

Video output devices can have one or more modulators, that modulate a video signal for radiation or connection to the antenna input of a TV set or video recorder. Each modulator is associated with one or more video outputs, depending on the number of RF connectors on the modulator. The type field of the respective struct `v4l2_output` returned by the `ioctl VIDIOC_ENUMOUTPUT` ioctl is set to `V4L2_OUTPUT_TYPE_MODULATOR` and its `modulator` field contains the index number of the modulator.

Radio output devices have exactly one modulator with index zero, no video outputs.

A video or radio device cannot support both a tuner and a modulator. Two separate device nodes will have to be used for such hardware, one that supports the tuner functionality and one that supports the modulator functionality. The reason is a limitation with the `VIDIOC_S_FREQUENCY` ioctl where you cannot specify whether the frequency is for a tuner or a modulator.

To query and change modulator properties applications use the `VIDIOC_G_MODULATOR` and `VIDIOC_S_MODULATOR` ioctl. Note that `VIDIOC_S_MODULATOR` does not switch the current modulator, when there is more than one at all. The modulator is solely determined by the current video output. Drivers must support both ioctls and set the `V4L2_CAP_MODULATOR` flag in the struct `v4l2_capability` returned by the `ioctl VIDIOC_QUERYCAP` ioctl when the device has one or more modulators.

## Radio Frequency

To get and set the tuner or modulator radio frequency applications use the `VIDIOC_G_FREQUENCY` and `VIDIOC_S_FREQUENCY` ioctl which both take a pointer to a struct `v4l2_frequency`. These ioctls are used for TV and radio devices alike. Drivers must support both ioctls when the tuner or modulator ioctls are supported, or when the device is a radio device.

## Video Standards

Video devices typically support one or more different video standards or variations of standards. Each video input and output may support another set of standards. This set is reported by the `std` field of struct `v4l2_input` and struct `v4l2_output` returned by the `ioctl VIDIOC_ENUMINPUT` and `ioctl VIDIOC_ENUMOUTPUT` ioctls, respectively.

V4L2 defines one bit for each analog video standard currently in use worldwide, and sets aside bits for driver defined standards, e. g. hybrid standards to watch NTSC video tapes on PAL TVs and vice versa. Applications can use the predefined bits to select a particular standard, although presenting the user a menu of supported standards is preferred. To enumerate and query the attributes of the supported standards applications use the `ioctl VIDIOC_ENUMSTD`, `VIDIOC_SUBDEV_ENUMSTD` ioctl.

Many of the defined standards are actually just variations of a few major standards. The hardware may in fact not distinguish between them, or do so internal and switch automatically. Therefore enumerated standards also contain sets of one or more standard bits.

Assume a hypothetic tuner capable of demodulating B/PAL, G/PAL and I/PAL signals. The first enumerated standard is a set of B and G/PAL, switched automatically depending on the selected radio frequency in UHF or VHF band. Enumeration gives a "PAL-B/G" or "PAL-I" choice. Similar a Composite input may collapse standards, enumerating "PAL-B/G/H/I", "NTSC-M" and "SECAM-D/K".<sup>1</sup>

To query and select the standard used by the current video input or output applications call the `VIDIOC_G_STD` and `VIDIOC_S_STD` ioctl, respectively. The *received* standard can be sensed with the `ioctl VIDIOC_QUERYSTD`, `VIDIOC_SUBDEV_QUERYSTD` ioctl.

---

**Note:** The parameter of all these ioctls is a pointer to a `v4l2_std_id` type (a standard set), *not* an index into the standard enumeration. Drivers must implement all video standard ioctls when the device has one or more video inputs or outputs.

---

Special rules apply to devices such as USB cameras where the notion of video standards makes little sense. More generally for any capture or output device which is:

- incapable of capturing fields or frames at the nominal rate of the video standard, or
- that does not support the video standard formats at all.

Here the driver shall set the `std` field of struct `v4l2_input` and struct `v4l2_output` to zero and the `VIDIOC_G_STD`, `VIDIOC_S_STD`, `ioctl VIDIOC_QUERYSTD`, `VIDIOC_SUBDEV_QUERYSTD` and `ioctl VIDIOC_ENUMSTD`, `VIDIOC_SUBDEV_ENUMSTD` ioctls shall return the `ENOTTY` error code or the `EINVAL` error code.

---

<sup>1</sup> Some users are already confused by technical terms PAL, NTSC and SECAM. There is no point asking them to distinguish between B, G, D, or K when the software or hardware can do that automatically.

Applications can make use of the *Input capabilities* and *Output capabilities* flags to determine whether the video standard ioctls can be used with the given input or output.

### Example: Information about the current video standard

```
v4l2_std_id std_id;
struct v4l2_standard standard;

if (-1 == ioctl(fd, VIDIOC_G_STD, &std_id)) {
    /* Note when VIDIOC_ENUMSTD always returns ENOTTY this
       is no video device or it falls under the USB exception,
       and VIDIOC_G_STD returning ENOTTY is no error. */

    perror("VIDIOC_G_STD");
    exit(EXIT_FAILURE);
}

memset(&standard, 0, sizeof(standard));
standard.index = 0;

while (0 == ioctl(fd, VIDIOC_ENUMSTD, &standard)) {
    if (standard.id & std_id) {
        printf("Current video standard: %s\n", standard.name);
        exit(EXIT_SUCCESS);
    }

    standard.index++;
}

/* EINVAL indicates the end of the enumeration, which cannot be
   empty unless this device falls under the USB exception. */

if (errno == EINVAL || standard.index == 0) {
    perror("VIDIOC_ENUMSTD");
    exit(EXIT_FAILURE);
}
```

### Example: Listing the video standards supported by the current input

```
struct v4l2_input input;
struct v4l2_standard standard;

memset(&input, 0, sizeof(input));

if (-1 == ioctl(fd, VIDIOC_G_INPUT, &input.index)) {
    perror("VIDIOC_G_INPUT");
    exit(EXIT_FAILURE);
}
```

```

if (-1 == ioctl(fd, VIDIOC_ENUMINPUT, &input)) {
    perror("VIDIOC_ENUM_INPUT");
    exit(EXIT_FAILURE);
}

printf("Current input %s supports:\n", input.name);

memset(&standard, 0, sizeof(standard));
standard.index = 0;

while (0 == ioctl(fd, VIDIOC_ENUMSTD, &standard)) {
    if (standard.id & input.std)
        printf("%s\n", standard.name);

    standard.index++;
}

/* EINVAL indicates the end of the enumeration, which cannot be
   empty unless this device falls under the USB exception. */

if (errno != EINVAL || standard.index == 0) {
    perror("VIDIOC_ENUMSTD");
    exit(EXIT_FAILURE);
}

```

### Example: Selecting a new video standard

```

struct v4l2_input input;
v4l2_std_id std_id;

memset(&input, 0, sizeof(input));

if (-1 == ioctl(fd, VIDIOC_G_INPUT, &input.index)) {
    perror("VIDIOC_G_INPUT");
    exit(EXIT_FAILURE);
}

if (-1 == ioctl(fd, VIDIOC_ENUMINPUT, &input)) {
    perror("VIDIOC_ENUM_INPUT");
    exit(EXIT_FAILURE);
}

if (0 == (input.std & V4L2_STD_PAL_BG)) {
    fprintf(stderr, "Oops. B/G PAL is not supported.\n");
    exit(EXIT_FAILURE);
}

/* Note this is also supposed to work when only B

```

```
or G/PAL is supported. */

std_id = V4L2_STD_PAL_BG;

if (-1 == ioctl(fd, VIDIOC_S_STD, &std_id)) {
    perror("VIDIOC_S_STD");
    exit(EXIT_FAILURE);
}
```

## Digital Video (DV) Timings

The video standards discussed so far have been dealing with Analog TV and the corresponding video timings. Today there are many more different hardware interfaces such as High Definition TV interfaces (HDMI), VGA, DVI connectors etc., that carry video signals and there is a need to extend the API to select the video timings for these interfaces. Since it is not possible to extend the `v4l2_std_id` due to the limited bits available, a new set of ioctls was added to set/get video timings at the input and output.

These ioctls deal with the detailed digital video timings that define each video format. This includes parameters such as the active video width and height, signal polarities, frontporches, backporches, sync widths etc. The `linux/v4l2-dv-timings.h` header can be used to get the timings of the formats in the [CEA-861-E](#) and [VESA DMT](#) standards.

To enumerate and query the attributes of the DV timings supported by a device applications use the `ioctl VIDIOC_ENUM_DV_TIMINGS`, `VIDIOC_SUBDEV_ENUM_DV_TIMINGS` and `ioctl VIDIOC_DV_TIMINGS_CAP`, `VIDIOC_SUBDEV_DV_TIMINGS_CAP` ioctls. To set DV timings for the device applications use the `VIDIOC_S_DV_TIMINGS` ioctl and to get current DV timings they use the `VIDIOC_G_DV_TIMINGS` ioctl. To detect the DV timings as seen by the video receiver applications use the `ioctl VIDIOC_QUERY_DV_TIMINGS` ioctl.

When the hardware detects a video source change (e.g. the video signal appears or disappears, or the video resolution changes), then it will issue a `V4L2_EVENT_SOURCE_CHANGE` event. Use the `ioctl VIDIOC_SUBSCRIBE_EVENT` and the `ioctl VIDIOC_DQEVENT` to check if this event was reported.

If the video signal changed, then the application has to stop streaming, free all buffers, and call the `ioctl VIDIOC_QUERY_DV_TIMINGS` to obtain the new video timings, and if they are valid, it can set those by calling the `ioctl VIDIOC_S_DV_TIMINGS`. This will also update the format, so use the `ioctl VIDIOC_G_FMT` to obtain the new format. Now the application can allocate new buffers and start streaming again.

The `ioctl VIDIOC_QUERY_DV_TIMINGS` will just report what the hardware detects, it will never change the configuration. If the currently set timings and the actually detected timings differ, then typically this will mean that you will not be able to capture any video. The correct approach is to rely on the `V4L2_EVENT_SOURCE_CHANGE` event so you know when something changed.

Applications can make use of the `Input capabilities` and `Output capabilities` flags to determine whether the digital video ioctls can be used with the given input or output.

## User Controls

Devices typically have a number of user-settable controls such as brightness, saturation and so on, which would be presented to the user on a graphical user interface. But, different devices will have different controls available, and furthermore, the range of possible values, and the default value will vary from device to device. The control ioctls provide the information and a mechanism to create a nice user interface for these controls that will work correctly with any device.

All controls are accessed using an ID value. V4L2 defines several IDs for specific purposes. Drivers can also implement their own custom controls using `V4L2_CID_PRIVATE_BASE1` and higher values. The pre-defined control IDs have the prefix `V4L2_CID_`, and are listed in [Control IDs](#). The ID is used when querying the attributes of a control, and when getting or setting the current value.

Generally applications should present controls to the user without assumptions about their purpose. Each control comes with a name string the user is supposed to understand. When the purpose is non-intuitive the driver writer should provide a user manual, a user interface plug-in or a driver specific panel application. Predefined IDs were introduced to change a few controls programmatically, for example to mute a device during a channel switch.

Drivers may enumerate different controls after switching the current video input or output, tuner or modulator, or audio input or output. Different in the sense of other bounds, another default and current value, step size or other menu items. A control with a certain *custom* ID can also change name and type.

If a control is not applicable to the current configuration of the device (for example, it doesn't apply to the current video input) drivers set the `V4L2_CTRL_FLAG_INACTIVE` flag.

Control values are stored globally, they do not change when switching except to stay within the reported bounds. They also do not change e. g. when the device is opened or closed, when the tuner radio frequency is changed or generally never without application request.

V4L2 specifies an event mechanism to notify applications when controls change value (see [ioctl VIDIOC\\_SUBSCRIBE\\_EVENT, VIDIOC\\_UNSUBSCRIBE\\_EVENT](#), event `V4L2_EVENT_CTRL`), panel applications might want to make use of that in order to always reflect the correct control value.

All controls use machine endianness.

---

<sup>1</sup> The use of `V4L2_CID_PRIVATE_BASE` is problematic because different drivers may use the same `V4L2_CID_PRIVATE_BASE` ID for different controls. This makes it hard to programmatically set such controls since the meaning of the control with that ID is driver dependent. In order to resolve this drivers use unique IDs and the `V4L2_CID_PRIVATE_BASE` IDs are mapped to those unique IDs by the kernel. Consider these `V4L2_CID_PRIVATE_BASE` IDs as aliases to the real IDs.

Many applications today still use the `V4L2_CID_PRIVATE_BASE` IDs instead of using [ioctls VIDIOC\\_QUERYCTRL, VIDIOC\\_QUERY\\_EXT\\_CTRL and VIDIOC\\_QUERYMENU](#) with the `V4L2_CTRL_FLAG_NEXT_CTRL` flag to enumerate all IDs, so support for `V4L2_CID_PRIVATE_BASE` is still around.

## Control IDs

### **V4L2\_CID\_BASE**

First predefined ID, equal to V4L2\_CID\_BRIGHTNESS.

### **V4L2\_CID\_USER\_BASE**

Synonym of V4L2\_CID\_BASE.

### **V4L2\_CID\_BRIGHTNESS (integer)**

Picture brightness, or more precisely, the black level.

### **V4L2\_CID\_CONTRAST (integer)**

Picture contrast or luma gain.

### **V4L2\_CID\_SATURATION (integer)**

Picture color saturation or chroma gain.

### **V4L2\_CID\_HUE (integer)**

Hue or color balance.

### **V4L2\_CID\_AUDIO\_VOLUME (integer)**

Overall audio volume. Note some drivers also provide an OSS or ALSA mixer interface.

### **V4L2\_CID\_AUDIO\_BALANCE (integer)**

Audio stereo balance. Minimum corresponds to all the way left, maximum to right.

### **V4L2\_CID\_AUDIO\_BASS (integer)**

Audio bass adjustment.

### **V4L2\_CID\_AUDIO\_TREBLE (integer)**

Audio treble adjustment.

### **V4L2\_CID\_AUDIO\_MUTE (boolean)**

Mute audio, i. e. set the volume to zero, however without affecting V4L2\_CID\_AUDIO\_VOLUME. Like ALSA drivers, V4L2 drivers must mute at load time to avoid excessive noise. Actually the entire device should be reset to a low power consumption state.

### **V4L2\_CID\_AUDIOLOUDNESS (boolean)**

Loudness mode (bass boost).

### **V4L2\_CID\_BLACK\_LEVEL (integer)**

Another name for brightness (not a synonym of V4L2\_CID\_BRIGHTNESS). This control is deprecated and should not be used in new drivers and applications.

### **V4L2\_CID\_AUTO\_WHITE\_BALANCE (boolean)**

Automatic white balance (cameras).

### **V4L2\_CID\_DO\_WHITE\_BALANCE (button)**

This is an action control. When set (the value is ignored), the device will do a white balance and then hold the current setting. Contrast this with the boolean V4L2\_CID\_AUTO\_WHITE\_BALANCE, which, when activated, keeps adjusting the white balance.

### **V4L2\_CID\_RED\_BALANCE (integer)**

Red chroma balance.

### **V4L2\_CID\_BLUE\_BALANCE (integer)**

Blue chroma balance.

**V4L2\_CID\_GAMMA (integer)**

Gamma adjust.

**V4L2\_CID\_WHITENESS (integer)**

Whiteness for grey-scale devices. This is a synonym for V4L2\_CID\_GAMMA. This control is deprecated and should not be used in new drivers and applications.

**V4L2\_CID\_EXPOSURE (integer)**

Exposure (cameras). [Unit?]

**V4L2\_CID\_AUTOGAIN (boolean)**

Automatic gain/exposure control.

**V4L2\_CID\_GAIN (integer)**

Gain control.

Primarily used to control gain on e.g. TV tuners but also on webcams. Most devices control only digital gain with this control but on some this could include analogue gain as well. Devices that recognise the difference between digital and analogue gain use controls V4L2\_CID\_DIGITAL\_GAIN and V4L2\_CID\_ANALOGUE\_GAIN.

**V4L2\_CID\_HFLIP (boolean)**

Mirror the picture horizontally.

**V4L2\_CID\_VFLIP (boolean)**

Mirror the picture vertically.

**V4L2\_CID\_POWER\_LINE\_FREQUENCY (enum)**

Enables a power line frequency filter to avoid flicker. Possible values for enum v4l2\_power\_line\_frequency are:

V4L2_CID_POWER_LINE_FREQUENCY_DISABLED	0
V4L2_CID_POWER_LINE_FREQUENCY_50HZ	1
V4L2_CID_POWER_LINE_FREQUENCY_60HZ	2
V4L2_CID_POWER_LINE_FREQUENCY_AUTO	3

**V4L2\_CID\_HUE\_AUTO (boolean)**

Enables automatic hue control by the device. The effect of setting V4L2\_CID\_HUE while automatic hue control is enabled is undefined, drivers should ignore such request.

**V4L2\_CID\_WHITE\_BALANCE\_TEMPERATURE (integer)**

This control specifies the white balance settings as a color temperature in Kelvin. A driver should have a minimum of 2800 (incandescent) to 6500 (daylight). For more information about color temperature see [Wikipedia](#).

**V4L2\_CID\_SHARPNESS (integer)**

Adjusts the sharpness filters in a camera. The minimum value disables the filters, higher values give a sharper picture.

**V4L2\_CID\_BACKLIGHT\_COMPENSATION (integer)**

Adjusts the backlight compensation in a camera. The minimum value disables backlight compensation.

**V4L2\_CID\_CHROMA\_AGC (boolean)**

Chroma automatic gain control.

**V4L2\_CID\_CHROMA\_GAIN (integer)**

Adjusts the Chroma gain control (for use when chroma AGC is disabled).

**V4L2\_CID\_COLOR\_KILLER (boolean)**

Enable the color killer (i. e. force a black & white image in case of a weak video signal).

**V4L2\_CID\_COLORFX (enum)**

Selects a color effect. The following values are defined:

<code>V4L2_COLORFX_NONE</code>	Color effect is disabled.
<code>V4L2_COLORFX_ANTIQUE</code>	An aging (old photo) effect.
<code>V4L2_COLORFX_ART_FREEZE</code>	Frost color effect.
<code>V4L2_COLORFX_AQUA</code>	Water color, cool tone.
<code>V4L2_COLORFX_BW</code>	Black and white.
<code>V4L2_COLORFX_EMBOSS</code>	Emboss, the highlights and shadows replace light/dark boundaries and low contrast areas are set to a gray background.
<code>V4L2_COLORFX_GRASS_GREEN</code>	Grass green.
<code>V4L2_COLORFX_NEGATIVE</code>	Negative.
<code>V4L2_COLORFX_SEPIA</code>	Sepia tone.
<code>V4L2_COLORFX_SKETCH</code>	Sketch.
<code>V4L2_COLORFX_SKIN_WHITEN</code>	Skin whiten.
<code>V4L2_COLORFX_SKY_BLUE</code>	Sky blue.
<code>V4L2_COLORFX_SOLARIZATION</code>	Solarization, the image is partially reversed in tone, only color values above or below a certain threshold are inverted.
<code>V4L2_COLORFX_SILHOUETTE</code>	Silhouette (outline).
<code>V4L2_COLORFX_VIVID</code>	Vivid colors.
<code>V4L2_COLORFX_SET_CBCR</code>	The Cb and Cr chroma components are replaced by fixed coefficients determined by <code>V4L2_CID_COLORFX_CBCR</code> control.
<code>V4L2_COLORFX_SET_RGB</code>	The RGB components are replaced by the fixed RGB components determined by <code>V4L2_CID_COLORFX_RGB</code> control.

**V4L2\_CID\_COLORFX\_RGB (integer)**

Determines the Red, Green, and Blue coefficients for `V4L2_COLORFX_SET_RGB` color effect. Bits [7:0] of the supplied 32 bit value are interpreted as Blue component, bits [15:8] as Green component, bits [23:16] as Red component, and bits [31:24] must be zero.

**V4L2\_CID\_COLORFX\_CBCR (integer)**

Determines the Cb and Cr coefficients for `V4L2_COLORFX_SET_CBCR` color effect. Bits [7:0] of the supplied 32 bit value are interpreted as Cr component, bits [15:8] as Cb component and bits [31:16] must be zero.

**V4L2\_CID\_AUTOBRIGHTNESS (boolean)**

Enable Automatic Brightness.

**V4L2\_CID\_ROTATE (integer)**

Rotates the image by specified angle. Common angles are 90, 270 and 180. Rotating the image to 90 and 270 will reverse the height and width of the display window. It is necessary to set the new height and width of the picture using the `VIDIOC_S_FMT` ioctl according to the rotation angle selected.

**V4L2\_CID\_BG\_COLOR (integer)**

Sets the background color on the current output device. Background color needs to be specified in the RGB24 format. The supplied 32 bit value is interpreted as bits 0-7 Red

color information, bits 8-15 Green color information, bits 16-23 Blue color information and bits 24-31 must be zero.

#### **V4L2\_CID\_ILLUMINATORS\_1 V4L2\_CID\_ILLUMINATORS\_2 (boolean)**

Switch on or off the illuminator 1 or 2 of the device (usually a microscope).

#### **V4L2\_CID\_MIN\_BUFFERS\_FOR\_CAPTURE (integer)**

This is a read-only control that can be read by the application and used as a hint to determine the number of CAPTURE buffers to pass to REQBUFS. The value is the minimum number of CAPTURE buffers that is necessary for hardware to work.

#### **V4L2\_CID\_MIN\_BUFFERS\_FOR\_OUTPUT (integer)**

This is a read-only control that can be read by the application and used as a hint to determine the number of OUTPUT buffers to pass to REQBUFS. The value is the minimum number of OUTPUT buffers that is necessary for hardware to work.

#### **V4L2\_CID\_ALPHA\_COMPONENT (integer)**

Sets the alpha color component. When a capture device (or capture queue of a mem-to-mem device) produces a frame format that includes an alpha component (e.g. *packed RGB image formats*) and the alpha value is not defined by the device or the mem-to-mem input data this control lets you select the alpha component value of all pixels. When an output device (or output queue of a mem-to-mem device) consumes a frame format that doesn't include an alpha component and the device supports alpha channel processing this control lets you set the alpha component value of all pixels for further processing in the device.

#### **V4L2\_CID\_LASTP1**

End of the predefined control IDs (currently V4L2\_CID\_ALPHA\_COMPONENT + 1).

#### **V4L2\_CID\_PRIVATE\_BASE**

ID of the first custom (driver specific) control. Applications depending on particular custom controls should check the driver name and version, see *Querying Capabilities*.

Applications can enumerate the available controls with the *ioctl VIDIOC\_QUERYCTRL*, *VIDIOC\_QUERY\_EXT\_CTRL* and *VIDIOC\_QUERYMENU* and *VIDIOC\_QUERYMENU* ioctls, get and set a control value with the *VIDIOC\_G\_CTRL* and *VIDIOC\_S\_CTRL* ioctls. Drivers must implement VIDIOC\_QUERYCTRL, VIDIOC\_G\_CTRL and VIDIOC\_S\_CTRL when the device has one or more controls, VIDIOC\_QUERYMENU when it has one or more menu type controls.

### **Example: Enumerating all controls**

```
struct v4l2_queryctrl queryctrl;
struct v4l2_querymenu querymenu;

static void enumerate_menu(__u32 id)
{
    printf("  Menu items:\n");

    memset(&querymenu, 0, sizeof(querymenu));
    querymenu.id = id;

    for (querymenu.index = queryctrl.minimum;
         querymenu.index <= queryctrl.maximum;
         querymenu.index++) {
```

```

        if (0 == ioctl(fd, VIDIOC_QUERYMENU, &querymenu)) {
            printf(" %s\n", querymenu.name);
        }
    }

memset(&queryctrl, 0, sizeof(queryctrl));

queryctrl.id = V4L2_CTRL_FLAG_NEXT_CTRL;
while (0 == ioctl(fd, VIDIOC_QUERYCTRL, &queryctrl)) {
    if (!(queryctrl.flags & V4L2_CTRL_FLAG_DISABLED)) {
        printf("Control %s\n", queryctrl.name);

        if (queryctrl.type == V4L2_CTRL_TYPE_MENU)
            enumerate_menu(queryctrl.id);
    }

    queryctrl.id |= V4L2_CTRL_FLAG_NEXT_CTRL;
}
if (errno != EINVAL) {
    perror("VIDIOC_QUERYCTRL");
    exit(EXIT_FAILURE);
}

```

**Example: Enumerating all controls including compound controls**

```

struct v4l2_query_ext_ctrl query_ext_ctrl;

memset(&query_ext_ctrl, 0, sizeof(query_ext_ctrl));

query_ext_ctrl.id = V4L2_CTRL_FLAG_NEXT_CTRL | V4L2_CTRL_FLAG_NEXT_COMPOUND;
while (0 == ioctl(fd, VIDIOC_QUERY_EXT_CTRL, &query_ext_ctrl)) {
    if (!(query_ext_ctrl.flags & V4L2_CTRL_FLAG_DISABLED)) {
        printf("Control %s\n", query_ext_ctrl.name);

        if (query_ext_ctrl.type == V4L2_CTRL_TYPE_MENU)
            enumerate_menu(query_ext_ctrl.id);
    }

    query_ext_ctrl.id |= V4L2_CTRL_FLAG_NEXT_CTRL | V4L2_CTRL_FLAG_NEXT_
COMPOUND;
}
if (errno != EINVAL) {
    perror("VIDIOC_QUERY_EXT_CTRL");
    exit(EXIT_FAILURE);
}

```

**Example: Enumerating all user controls (old style)**

```

memset(&queryctrl, 0, sizeof(queryctrl));

for (queryctrl.id = V4L2_CID_BASE;
     queryctrl.id < V4L2_CID_LASTP1;
     queryctrl.id++) {
    if (0 == ioctl(fd, VIDIOC_QUERYCTRL, &queryctrl)) {
        if (queryctrl.flags & V4L2_CTRL_FLAG_DISABLED)
            continue;

        printf("Control %s\\n", queryctrl.name);

        if (queryctrl.type == V4L2_CTRL_TYPE_MENU)
            enumerate_menu(queryctrl.id);
    } else {
        if (errno == EINVAL)
            continue;

        perror("VIDIOC_QUERYCTRL");
        exit(EXIT_FAILURE);
    }
}

for (queryctrl.id = V4L2_CID_PRIVATE_BASE;;
     queryctrl.id++) {
    if (0 == ioctl(fd, VIDIOC_QUERYCTRL, &queryctrl)) {
        if (queryctrl.flags & V4L2_CTRL_FLAG_DISABLED)
            continue;

        printf("Control %s\\n", queryctrl.name);

        if (queryctrl.type == V4L2_CTRL_TYPE_MENU)
            enumerate_menu(queryctrl.id);
    } else {
        if (errno == EINVAL)
            break;

        perror("VIDIOC_QUERYCTRL");
        exit(EXIT_FAILURE);
    }
}

```

## Example: Changing controls

```

struct v4l2_queryctrl queryctrl;
struct v4l2_control control;

memset(&queryctrl, 0, sizeof(queryctrl));
queryctrl.id = V4L2_CID_BRIGHTNESS;

if (-1 == ioctl(fd, VIDIOC_QUERYCTRL, &queryctrl)) {
    if (errno != EINVAL) {
        perror("VIDIOC_QUERYCTRL");
        exit(EXIT_FAILURE);
    } else {
        printf("V4L2_CID_BRIGHTNESS is not supported\n");
    }
} else if (queryctrl.flags & V4L2_CTRL_FLAG_DISABLED) {
    printf("V4L2_CID_BRIGHTNESS is not supported\n");
} else {
    memset(&control, 0, sizeof (control));
    control.id = V4L2_CID_BRIGHTNESS;
    control.value = queryctrl.default_value;

    if (-1 == ioctl(fd, VIDIOC_S_CTRL, &control)) {
        perror("VIDIOC_S_CTRL");
        exit(EXIT_FAILURE);
    }
}

memset(&control, 0, sizeof(control));
control.id = V4L2_CID_CONTRAST;

if (0 == ioctl(fd, VIDIOC_G_CTRL, &control)) {
    control.value += 1;

    /* The driver may clamp the value or return ERANGE, ignored here */

    if (-1 == ioctl(fd, VIDIOC_S_CTRL, &control)
        && errno != ERANGE) {
        perror("VIDIOC_S_CTRL");
        exit(EXIT_FAILURE);
    }
    /* Ignore if V4L2_CID_CONTRAST is unsupported */
} else if (errno != EINVAL) {
    perror("VIDIOC_G_CTRL");
    exit(EXIT_FAILURE);
}

control.id = V4L2_CID_AUDIO_MUTE;
control.value = 1; /* silence */

```

```
/* Errors ignored */
ioctl(fd, VIDIOC_S_CTRL, &control);
```

## Extended Controls API

### Introduction

The control mechanism as originally designed was meant to be used for user settings (brightness, saturation, etc). However, it turned out to be a very useful model for implementing more complicated driver APIs where each driver implements only a subset of a larger API.

The MPEG encoding API was the driving force behind designing and implementing this extended control mechanism: the MPEG standard is quite large and the currently supported hardware MPEG encoders each only implement a subset of this standard. Further more, many parameters relating to how the video is encoded into an MPEG stream are specific to the MPEG encoding chip since the MPEG standard only defines the format of the resulting MPEG stream, not how the video is actually encoded into that format.

Unfortunately, the original control API lacked some features needed for these new uses and so it was extended into the (not terribly originally named) extended control API.

Even though the MPEG encoding API was the first effort to use the Extended Control API, nowadays there are also other classes of Extended Controls, such as Camera Controls and FM Transmitter Controls. The Extended Controls API as well as all Extended Controls classes are described in the following text.

### The Extended Control API

Three new ioctls are available: `VIDIOC_G_EXT_CTRLS`, `VIDIOC_S_EXT_CTRLS` and `VIDIOC_TRY_EXT_CTRLS`. These ioctls act on arrays of controls (as opposed to the `VIDIOC_G_CTRL` and `VIDIOC_S_CTRL` ioctls that act on a single control). This is needed since it is often required to atomically change several controls at once.

Each of the new ioctls expects a pointer to a struct `v4l2_ext_controls`. This structure contains a pointer to the control array, a count of the number of controls in that array and a control class. Control classes are used to group similar controls into a single class. For example, control class `V4L2_CTRL_CLASS_USER` contains all user controls (i. e. all controls that can also be set using the old `VIDIOC_S_CTRL` ioctl). Control class `V4L2_CTRL_CLASS_CODEC` contains controls relating to codecs.

All controls in the control array must belong to the specified control class. An error is returned if this is not the case.

It is also possible to use an empty control array (`count == 0`) to check whether the specified control class is supported.

The control array is a struct `v4l2_ext_control` array. The struct `v4l2_ext_control` is very similar to struct `v4l2_control`, except for the fact that it also allows for 64-bit values and pointers to be passed.

Since the struct `v4l2_ext_control` supports pointers it is now also possible to have controls with compound types such as N-dimensional arrays and/or structures. You need to specify the

`V4L2_CTRL_FLAG_NEXT_COMPOUND` when enumerating controls to actually be able to see such compound controls. In other words, these controls with compound types should only be used programmatically.

Since such compound controls need to expose more information about themselves than is possible with `VIDIOC_QUERYCTRL` the `VIDIOC_QUERY_EXT_CTRL` ioctl was added. In particular, this ioctl gives the dimensions of the N-dimensional array if this control consists of more than one element.

---

### Note:

1. It is important to realize that due to the flexibility of controls it is necessary to check whether the control you want to set actually is supported in the driver and what the valid range of values is. So use `ioctls VIDIOC_QUERYCTRL, VIDIOC_QUERY_EXT_CTRL and VIDIOC_QUERYMENU` to check this.
  2. It is possible that some of the menu indices in a control of type `V4L2_CTRL_TYPE_MENU` may not be supported (`VIDIOC_QUERYMENU` will return an error). A good example is the list of supported MPEG audio bitrates. Some drivers only support one or two bitrates, others support a wider range.
- 

All controls use machine endianness.

### Enumerating Extended Controls

The recommended way to enumerate over the extended controls is by using `ioctls VIDIOC_QUERYCTRL, VIDIOC_QUERY_EXT_CTRL and VIDIOC_QUERYMENU` in combination with the `V4L2_CTRL_FLAG_NEXT_CTRL` flag:

```
struct v4l2_queryctrl qctrl;

qctrl.id = V4L2_CTRL_FLAG_NEXT_CTRL;
while (0 == ioctl(fd, VIDIOC_QUERYCTRL, &qctrl)) {
    /* ... */
    qctrl.id |= V4L2_CTRL_FLAG_NEXT_CTRL;
}
```

The initial control ID is set to 0 ORed with the `V4L2_CTRL_FLAG_NEXT_CTRL` flag. The `VIDIOC_QUERYCTRL` ioctl will return the first control with a higher ID than the specified one. When no such controls are found an error is returned.

If you want to get all controls within a specific control class, then you can set the initial `qctrl.id` value to the control class and add an extra check to break out of the loop when a control of another control class is found:

```
qctrl.id = V4L2_CTRL_CLASS_CODEC | V4L2_CTRL_FLAG_NEXT_CTRL;
while (0 == ioctl(fd, VIDIOC_QUERYCTRL, &qctrl)) {
    if (V4L2_CTRL_ID2CLASS(qctrl.id) != V4L2_CTRL_CLASS_CODEC)
        break;
    /* ... */
    qctrl.id |= V4L2_CTRL_FLAG_NEXT_CTRL;
}
```

The 32-bit `qctrl.id` value is subdivided into three bit ranges: the top 4 bits are reserved for flags (e. g. `V4L2_CTRL_FLAG_NEXT_CTRL`) and are not actually part of the ID. The remaining 28 bits form the control ID, of which the most significant 12 bits define the control class and the least significant 16 bits identify the control within the control class. It is guaranteed that these last 16 bits are always non-zero for controls. The range of 0x1000 and up are reserved for driver-specific controls. The macro `V4L2_CTRL_ID2CLASS(id)` returns the control class ID based on a control ID.

If the driver does not support extended controls, then `VIDIOC_QUERYCTRL` will fail when used in combination with `V4L2_CTRL_FLAG_NEXT_CTRL`. In that case the old method of enumerating control should be used (see [Example: Enumerating all controls](#)). But if it is supported, then it is guaranteed to enumerate over all controls, including driver-private controls.

## Creating Control Panels

It is possible to create control panels for a graphical user interface where the user can select the various controls. Basically you will have to iterate over all controls using the method described above. Each control class starts with a control of type `V4L2_CTRL_TYPE_CTRL_CLASS`. `VIDIOC_QUERYCTRL` will return the name of this control class which can be used as the title of a tab page within a control panel.

The flags field of struct `v4l2_queryctrl` also contains hints on the behavior of the control. See the [ioctls `VIDIOC\_QUERYCTRL`, `VIDIOC\_QUERY\_EXT\_CTRL` and `VIDIOC\_QUERYMENU`](#) documentation for more details.

## Camera Control Reference

The Camera class includes controls for mechanical (or equivalent digital) features of a device such as controllable lenses or sensors.

### Camera Control IDs

#### `V4L2_CID_CAMERA_CLASS` (class)

The Camera class descriptor. Calling [ioctls `VIDIOC\_QUERYCTRL`, `VIDIOC\_QUERY\_EXT\_CTRL` and `VIDIOC\_QUERYMENU`](#) for this control will return a description of this control class.

#### `V4L2_CID_EXPOSURE_AUTO`

(enum)

##### **enum `v4l2_exposure_auto_type` -**

Enables automatic adjustments of the exposure time and/or iris aperture. The effect of manual changes of the exposure time or iris aperture while these features are enabled is undefined, drivers should ignore such requests. Possible values are:

<code>V4L2_EXPOSURE_AUTO</code>	Automatic exposure time, automatic iris aperture.
<code>V4L2_EXPOSURE_MANUAL</code>	Manual exposure time, manual iris.
<code>V4L2_EXPOSURE_SHUTTER_PRIORITY</code>	Manual exposure time, auto iris.
<code>V4L2_EXPOSURE_APERTURE_PRIORITY</code>	Auto exposure time, manual iris.

**V4L2\_CID\_EXPOSURE\_ABSOLUTE (integer)**

Determines the exposure time of the camera sensor. The exposure time is limited by the frame interval. Drivers should interpret the values as 100  $\mu$ s units, where the value 1 stands for 1/10000th of a second, 10000 for 1 second and 100000 for 10 seconds.

**V4L2\_CID\_EXPOSURE\_AUTO\_PRIORITY (boolean)**

When V4L2\_CID\_EXPOSURE\_AUTO is set to AUTO or APERTURE\_PRIORITY, this control determines if the device may dynamically vary the frame rate. By default this feature is disabled (0) and the frame rate must remain constant.

**V4L2\_CID\_AUTO\_EXPOSURE\_BIAS (integer menu)**

Determines the automatic exposure compensation, it is effective only when V4L2\_CID\_EXPOSURE\_AUTO control is set to AUTO, SHUTTER\_PRIORITY or APERTURE\_PRIORITY. It is expressed in terms of EV, drivers should interpret the values as 0.001 EV units, where the value 1000 stands for +1 EV.

Increasing the exposure compensation value is equivalent to decreasing the exposure value (EV) and will increase the amount of light at the image sensor. The camera performs the exposure compensation by adjusting absolute exposure time and/or aperture.

**V4L2\_CID\_EXPOSURE\_METERING**

(enum)

**enum v4l2\_exposure\_metering -**

Determines how the camera measures the amount of light available for the frame exposure. Possible values are:

V4L2_EXPOSURE_METERING_AVERAGE	Use the light information coming from the entire frame and average giving no weighting to any particular portion of the metered area.
V4L2_EXPOSURE_METERING_CENTER_WEIGHTED	Average the light information coming from the entire frame giving priority to the center of the metered area.
V4L2_EXPOSURE_METERING_SPOT	Measure only very small area at the center of the frame.
V4L2_EXPOSURE_METERING_MATRIX	A multi-zone metering. The light intensity is measured in several points of the frame and the results are combined. The algorithm of the zones selection and their significance in calculating the final value is device dependent.

**V4L2\_CID\_PAN\_RELATIVE (integer)**

This control turns the camera horizontally by the specified amount. The unit is undefined. A positive value moves the camera to the right (clockwise when viewed from above), a negative value to the left. A value of zero does not cause motion. This is a write-only control.

**V4L2\_CID\_TILT\_RELATIVE (integer)**

This control turns the camera vertically by the specified amount. The unit is undefined. A positive value moves the camera up, a negative value down. A value of zero does not cause motion. This is a write-only control.

**V4L2\_CID\_PAN\_RESET (button)**

When this control is set, the camera moves horizontally to the default position.

**V4L2\_CID\_TILT\_RESET (button)**

When this control is set, the camera moves vertically to the default position.

**V4L2\_CID\_PAN\_ABSOLUTE (integer)**

This control turns the camera horizontally to the specified position. Positive values move the camera to the right (clockwise when viewed from above), negative values to the left. Drivers should interpret the values as arc seconds, with valid values between  $-180 * 3600$  and  $+180 * 3600$  inclusive.

**V4L2\_CID\_TILT\_ABSOLUTE (integer)**

This control turns the camera vertically to the specified position. Positive values move the camera up, negative values down. Drivers should interpret the values as arc seconds, with valid values between  $-180 * 3600$  and  $+180 * 3600$  inclusive.

**V4L2\_CID\_FOCUS\_ABSOLUTE (integer)**

This control sets the focal point of the camera to the specified position. The unit is undefined. Positive values set the focus closer to the camera, negative values towards infinity.

**V4L2\_CID\_FOCUS\_RELATIVE (integer)**

This control moves the focal point of the camera by the specified amount. The unit is undefined. Positive values move the focus closer to the camera, negative values towards infinity. This is a write-only control.

**V4L2\_CID\_FOCUS\_AUTO (boolean)**

Enables continuous automatic focus adjustments. The effect of manual focus adjustments while this feature is enabled is undefined, drivers should ignore such requests.

**V4L2\_CID\_AUTO\_FOCUS\_START (button)**

Starts single auto focus process. The effect of setting this control when V4L2\_CID\_FOCUS\_AUTO is set to TRUE (1) is undefined, drivers should ignore such requests.

**V4L2\_CID\_AUTO\_FOCUS\_STOP (button)**

Aborts automatic focusing started with V4L2\_CID\_AUTO\_FOCUS\_START control. It is effective only when the continuous autofocus is disabled, that is when V4L2\_CID\_FOCUS\_AUTO control is set to FALSE (0).

**V4L2\_CID\_AUTO\_FOCUS\_STATUS (bitmask)**

The automatic focus status. This is a read-only control.

Setting V4L2\_LOCK\_FOCUS lock bit of the V4L2\_CID\_3A\_LOCK control may stop updates of the V4L2\_CID\_AUTO\_FOCUS\_STATUS control value.

V4L2_AUTO_FOCUS_STATUS_IDLE	Automatic focus is not active.
V4L2_AUTO_FOCUS_STATUS_BUSY	Automatic focusing is in progress.
V4L2_AUTO_FOCUS_STATUS_REACHED	Focus has been reached.
V4L2_AUTO_FOCUS_STATUS_FAILED	Automatic focus has failed, the driver will not transition from this state until another action is performed by an application.

**V4L2\_CID\_AUTO\_FOCUS\_RANGE**

(enum)

**enum v4l2\_auto\_focus\_range -**

Determines auto focus distance range for which lens may be adjusted.

V4L2_AUTO_FOCUS_RANGE_AUTO	The camera automatically selects the focus range.
V4L2_AUTO_FOCUS_RANGE_NORMAL	Normal distance range, limited for best automatic focus performance.
V4L2_AUTO_FOCUS_RANGE_MACRO	Macro (close-up) auto focus. The camera will use its minimum possible distance for auto focus.
V4L2_AUTO_FOCUS_RANGE_INFINITY	The lens is set to focus on an object at infinite distance.

**V4L2\_CID\_ZOOM\_ABSOLUTE (integer)**

Specify the objective lens focal length as an absolute value. The zoom unit is driver-specific and its value should be a positive integer.

**V4L2\_CID\_ZOOM\_RELATIVE (integer)**

Specify the objective lens focal length relatively to the current value. Positive values move the zoom lens group towards the telephoto direction, negative values towards the wide-angle direction. The zoom unit is driver-specific. This is a write-only control.

**V4L2\_CID\_ZOOM\_CONTINUOUS (integer)**

Move the objective lens group at the specified speed until it reaches physical device limits or until an explicit request to stop the movement. A positive value moves the zoom lens group towards the telephoto direction. A value of zero stops the zoom lens group movement. A negative value moves the zoom lens group towards the wide-angle direction. The zoom speed unit is driver-specific.

**V4L2\_CID\_IRIS\_ABSOLUTE (integer)**

This control sets the camera's aperture to the specified value. The unit is undefined. Larger values open the iris wider, smaller values close it.

**V4L2\_CID\_IRIS\_RELATIVE (integer)**

This control modifies the camera's aperture by the specified amount. The unit is undefined. Positive values open the iris one step further, negative values close it one step further. This is a write-only control.

**V4L2\_CID\_PRIVACY (boolean)**

Prevent video from being acquired by the camera. When this control is set to TRUE (1), no image can be captured by the camera. Common means to enforce privacy are mechanical obturation of the sensor and firmware image processing, but the device is not restricted to these methods. Devices that implement the privacy control must support read access and may support write access.

**V4L2\_CID\_BAND\_STOP\_FILTER (integer)**

Switch the band-stop filter of a camera sensor on or off, or specify its strength. Such band-stop filters can be used, for example, to filter out the fluorescent light component.

**V4L2\_CID\_AUTO\_N\_PRESET\_WHITE\_BALANCE**

(enum)

**enum v4l2\_auto\_n\_preset\_white\_balance -**

Sets white balance to automatic, manual or a preset. The presets determine color temperature of the light as a hint to the camera for white balance adjustments resulting in most accurate color representation. The following white balance presets are listed in order of increasing color temperature.

V4L2_WHITE_BALANCE_MANUAL	Manual white balance.
V4L2_WHITE_BALANCE_AUTO	Automatic white balance adjustments.
V4L2_WHITE_BALANCE_INCANDESCENT	White balance setting for incandescent (tungsten) lighting. It generally cools down the colors and corresponds approximately to 2500...3500 K color temperature range.
V4L2_WHITE_BALANCE_FLUORESCENT	White balance preset for fluorescent lighting. It corresponds approximately to 4000...5000 K color temperature.
V4L2_WHITE_BALANCE_FLUORESCENT_H	With this setting the camera will compensate for fluorescent H lighting.
V4L2_WHITE_BALANCE_HORIZON	White balance setting for horizon daylight. It corresponds approximately to 5000 K color temperature.
V4L2_WHITE_BALANCE_DAYLIGHT	White balance preset for daylight (with clear sky). It corresponds approximately to 5000...6500 K color temperature.
V4L2_WHITE_BALANCE_FLASH	With this setting the camera will compensate for the flash light. It slightly warms up the colors and corresponds roughly to 5000...5500 K color temperature.
V4L2_WHITE_BALANCE_CLOUDY	White balance preset for moderately overcast sky. This option corresponds approximately to 6500...8000 K color temperature range.
V4L2_WHITE_BALANCE_SHADE	White balance preset for shade or heavily overcast sky. It corresponds approximately to 9000...10000 K color temperature.

**V4L2\_CID\_WIDE\_DYNAMIC\_RANGE (boolean)**

Enables or disables the camera's wide dynamic range feature. This feature allows to obtain clear images in situations where intensity of the illumination varies significantly throughout the scene, i.e. there are simultaneously very dark and very bright areas. It is most commonly realized in cameras by combining two subsequent frames with different exposure times.<sup>1</sup>

**V4L2\_CID\_IMAGE\_STABILIZATION (boolean)**

Enables or disables image stabilization.

**V4L2\_CID\_ISO\_SENSITIVITY (integer menu)**

Determines ISO equivalent of an image sensor indicating the sensor's sensitivity to light. The numbers are expressed in arithmetic scale, as per [ISO 12232:2006](#) standard, where doubling the sensor sensitivity is represented by doubling the numerical ISO value. Applications should interpret the values as standard ISO values multiplied by 1000, e.g. control value 800 stands for ISO 0.8. Drivers will usually support only a subset of standard ISO values. The effect of setting this control while the V4L2\_CID\_ISO\_SENSITIVITY\_AUTO control is set to a value other than V4L2\_CID\_ISO\_SENSITIVITY\_MANUAL is undefined, drivers should ignore such requests.

**V4L2\_CID\_ISO\_SENSITIVITY\_AUTO**

(enum)

**enum v4l2\_iso\_sensitivity\_type -**

Enables or disables automatic ISO sensitivity adjustments.

<sup>1</sup> This control may be changed to a menu control in the future, if more options are required.

V4L2_CID_ISO_SENSITIVITY_MANUAL	Manual ISO sensitivity.
V4L2_CID_ISO_SENSITIVITY_AUTO	Automatic ISO sensitivity adjustments.

**V4L2\_CID\_SCENE\_MODE**

(enum)

**enum v4l2\_scene\_mode -**

This control allows to select scene programs as the camera automatic modes optimized for common shooting scenes. Within these modes the camera determines best exposure, aperture, focusing, light metering, white balance and equivalent sensitivity. The controls of those parameters are influenced by the scene mode control. An exact behavior in each mode is subject to the camera specification.

When the scene mode feature is not used, this control should be set to V4L2\_SCENE\_MODE\_NONE to make sure the other possibly related controls are accessible. The following scene programs are defined:

V4L2_SCENE_MODE_NONE	The scene mode feature is disabled.
V4L2_SCENE_MODE_BACKLIGHT	Backlight. Compensates for dark shadows when light is coming from behind a subject, also by automatically turning on the flash.
V4L2_SCENE_MODE_BEACH_SNOW	Beach and snow. This mode compensates for all-white or bright scenes, which tend to look gray and low contrast, when camera's automatic exposure is based on an average scene brightness. To compensate, this mode automatically slightly overexposes the frames. The white balance may also be adjusted to compensate for the fact that reflected snow looks bluish rather than white.
V4L2_SCENE_MODE_CANDLELIGHT	Candle light. The camera generally raises the ISO sensitivity and lowers the shutter speed. This mode compensates for relatively close subject in the scene. The flash is disabled in order to preserve the ambiance of the light.
V4L2_SCENE_MODE_DAWN_DUSK	Dawn and dusk. Preserves the colors seen in low natural light before dusk and after dawn. The camera may turn off the flash, and automatically focus at infinity. It will usually boost saturation and lower the shutter speed.
V4L2_SCENE_MODE_FALL_COLORS	Fall colors. Increases saturation and adjusts white balance for color enhancement. Pictures of autumn leaves get saturated reds and yellows.
V4L2_SCENE_MODE_FIREWORKS	Fireworks. Long exposure times are used to capture the expanding burst of light from a firework. The camera may invoke image stabilization.
V4L2_SCENE_MODE_LANDSCAPE	Landscape. The camera may choose a small aperture to provide deep depth of field and long exposure duration to help capture detail in dim light conditions. The focus is fixed at infinity. Suitable for distant and wide scenery.
V4L2_SCENE_MODE_NIGHT	Night, also known as Night Landscape. Designed for low light conditions, it preserves detail in the dark areas without blowing out bright objects. The camera generally sets itself to a medium-to-high ISO sensitivity, with a relatively long exposure time, and turns flash off. As such, there will be increased image noise and the possibility of blurred image.
V4L2_SCENE_MODE_PARTY_INDOOR	Party and indoor. Designed to capture indoor scenes that are lit by indoor background lighting as well as the flash. The camera usually increases ISO sensitivity, and adjusts exposure for the low light conditions.

continues on next page

Table 1 - continued from previous page

V4L2_SCENE_MODE_PORTRAIT	Portrait. The camera adjusts the aperture so that the depth of field is reduced, which helps to isolate the subject against a smooth background. Most cameras recognize the presence of faces in the scene and focus on them. The color hue is adjusted to enhance skin tones. The intensity of the flash is often reduced.
V4L2_SCENE_MODE_SPORTS	Sports. Significantly increases ISO and uses a fast shutter speed to freeze motion of rapidly-moving subjects. Increased image noise may be seen in this mode.
V4L2_SCENE_MODE_SUNSET	Sunset. Preserves deep hues seen in sunsets and sunrises. It bumps up the saturation.
V4L2_SCENE_MODE_TEXT	Text. It applies extra contrast and sharpness, it is typically a black-and-white mode optimized for readability. Automatic focus may be switched to close-up mode and this setting may also involve some lens-distortion correction.

**V4L2\_CID\_3A\_LOCK (bitmask)**

This control locks or unlocks the automatic focus, exposure and white balance. The automatic adjustments can be paused independently by setting the corresponding lock bit to 1. The camera then retains the settings until the lock bit is cleared. The following lock bits are defined:

When a given algorithm is not enabled, drivers should ignore requests to lock it and should return no error. An example might be an application setting bit V4L2\_LOCK\_WHITE\_BALANCE when the V4L2\_CID\_AUTO\_WHITE\_BALANCE control is set to FALSE. The value of this control may be changed by exposure, white balance or focus controls.

V4L2_LOCK_EXPOSURE	Automatic exposure adjustments lock.
V4L2_LOCK_WHITE_BALANCE	Automatic white balance adjustments lock.
V4L2_LOCK_FOCUS	Automatic focus lock.

**V4L2\_CID\_PAN\_SPEED (integer)**

This control turns the camera horizontally at the specific speed. The unit is undefined. A positive value moves the camera to the right (clockwise when viewed from above), a negative value to the left. A value of zero stops the motion if one is in progress and has no effect otherwise.

**V4L2\_CID\_TILT\_SPEED (integer)**

This control turns the camera vertically at the specified speed. The unit is undefined. A positive value moves the camera up, a negative value down. A value of zero stops the motion if one is in progress and has no effect otherwise.

**V4L2\_CID\_CAMERA\_ORIENTATION (menu)**

This read-only control describes the camera orientation by reporting its mounting position on the device where the camera is installed. The control value is constant and not modifiable by software. This control is particularly meaningful for devices which have a well defined orientation, such as phones, laptops and portable devices since the control is expressed as a position relative to the device's intended usage orientation. For example, a camera installed on the user-facing side of a phone, a tablet or a laptop device is said to be have V4L2\_CAMERA\_ORIENTATION\_FRONT orientation, while a camera installed on the opposite side of the front one is said to be have V4L2\_CAMERA\_ORIENTATION\_BACK orientation. Camera sensors not directly attached to the device, or attached in a way that allows them to move freely, such as webcams and digital cameras, are said to have the V4L2\_CAMERA\_ORIENTATION\_EXTERNAL orientation.

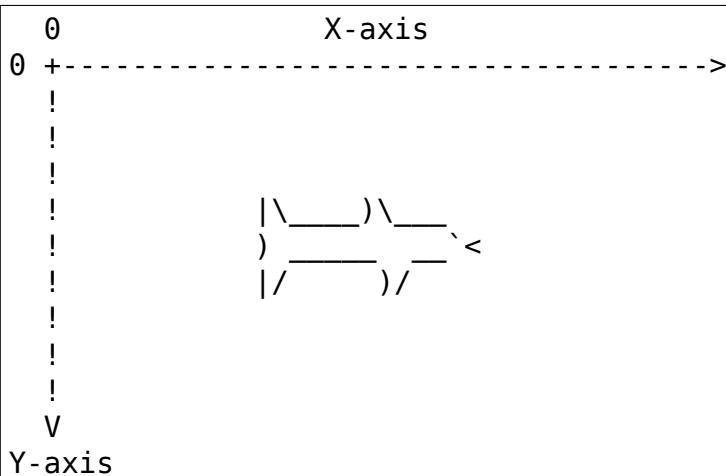
V4L2_CAMERA_ORIENTATION_FRONT	The camera is oriented towards the user facing side of the device.
V4L2_CAMERA_ORIENTATION_BACK	The camera is oriented towards the back facing side of the device.
V4L2_CAMERA_ORIENTATION_EXTERNAL	The camera is not directly attached to the device and is freely movable.

**V4L2\_CID\_CAMERA\_SENSOR\_ROTATION (integer)**

This read-only control describes the rotation correction in degrees in the counter-clockwise direction to be applied to the captured images once captured to memory to compensate for the camera sensor mounting rotation.

For a precise definition of the sensor mounting rotation refer to the extensive description of the 'rotation' properties in the device tree bindings file 'video-interfaces.txt'.

A few examples are below reported, using a shark swimming from left to right in front of the user as the example scene to capture.

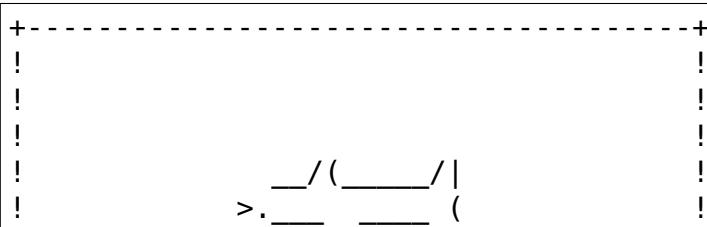


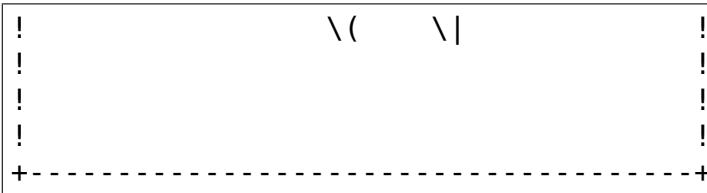
## Example one - Webcam

Assuming you can bring your laptop with you while swimming with sharks, the camera module of the laptop is installed on the user facing part of a laptop screen casing, and is typically used for video calls. The captured images are meant to be displayed in landscape mode (width > height) on the laptop screen.

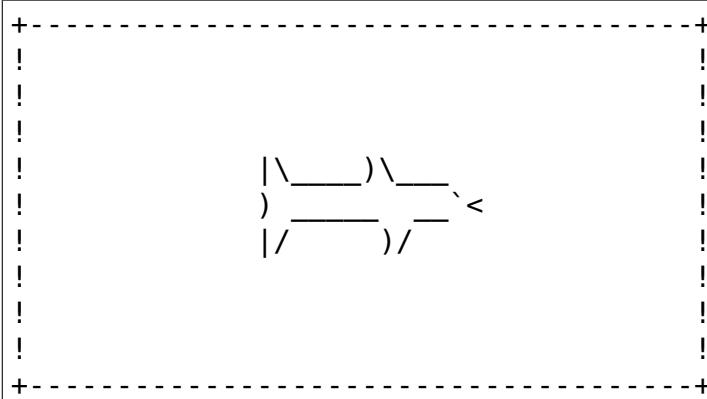
The camera is typically mounted upside-down to compensate the lens optical inversion effect. In this case the value of the V4L2\_CID\_CAMERA\_SENSOR\_ROTATION control is 0, no rotation is required to display images correctly to the user.

If the camera sensor is not mounted upside-down it is required to compensate the lens optical inversion effect and the value of the V4L2\_CID\_CAMERA\_SENSOR\_ROTATION control is 180 degrees, as images will result rotated when captured to memory.





A software rotation correction of 180 degrees has to be applied to correctly display the image on the user screen.

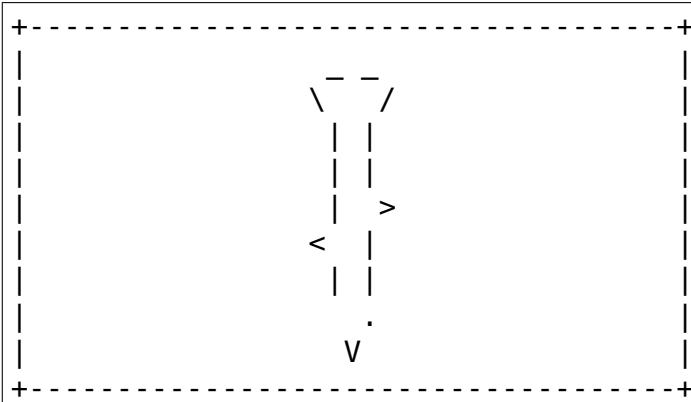


#### Example two - Phone camera

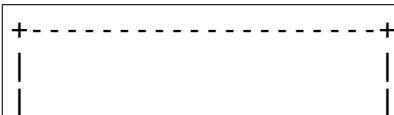
It is more handy to go and swim with sharks with only your mobile phone with you and take pictures with the camera that is installed on the back side of the device, facing away from the user. The captured images are meant to be displayed in portrait mode (height > width) to match the device screen orientation and the device usage orientation used when taking the picture.

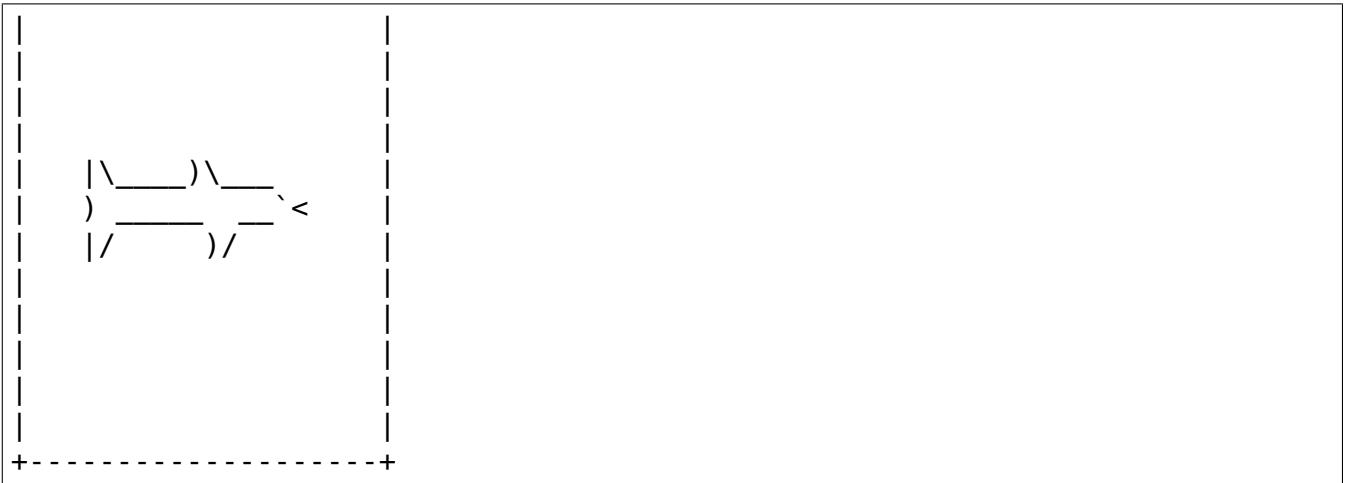
The camera sensor is typically mounted with its pixel array longer side aligned to the device longer side, upside-down mounted to compensate for the lens optical inversion effect.

The images once captured to memory will be rotated and the value of the V4L2\_CID\_CAMERA\_SENSOR\_ROTATION will report a 90 degree rotation.



A correction of 90 degrees in counter-clockwise direction has to be applied to correctly display the image in portrait mode on the device screen.





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### **V4L2\_CID\_HDR\_SENSOR\_MODE (menu)**

Change the sensor HDR mode. A HDR picture is obtained by merging two captures of the same scene using two different exposure periods. HDR mode describes the way these two captures are merged in the sensor.

As modes differ for each sensor, menu items are not standardized by this control and are left to the programmer.

## **Flash Control Reference**

The V4L2 flash controls are intended to provide generic access to flash controller devices. Flash controller devices are typically used in digital cameras.

The interface can support both LED and xenon flash devices. As of writing this, there is no xenon flash driver using this interface.

### **Supported use cases**

#### **Unsynchronised LED flash (software strobe)**

Unsynchronised LED flash is controlled directly by the host as the sensor. The flash must be enabled by the host before the exposure of the image starts and disabled once it ends. The host is fully responsible for the timing of the flash.

Example of such device: Nokia N900.

#### **Synchronised LED flash (hardware strobe)**

The synchronised LED flash is pre-programmed by the host (power and timeout) but controlled by the sensor through a strobe signal from the sensor to the flash.

The sensor controls the flash duration and timing. This information typically must be made available to the sensor.

## LED flash as torch

LED flash may be used as torch in conjunction with another use case involving camera or individually.

## Flash Control IDs

### **V4L2\_CID\_FLASH\_CLASS (class)**

The FLASH class descriptor.

### **V4L2\_CID\_FLASH\_LED\_MODE (menu)**

Defines the mode of the flash LED, the high-power white LED attached to the flash controller. Setting this control may not be possible in presence of some faults. See V4L2\_CID\_FLASH\_FAULT.

V4L2_FLASH_LED_MODE_NONE	Off.
V4L2_FLASH_LED_MODE_FLASH	Flash mode.
V4L2_FLASH_LED_MODE_TORCH	Torch mode. See V4L2_CID_FLASH_TORCH_INTENSITY.

### **V4L2\_CID\_FLASH\_STROBE\_SOURCE (menu)**

Defines the source of the flash LED strobe.

V4L2_FLASH_STROBE_SOURCE_SOFTWARE	The flash strobe is triggered by using the V4L2_CID_FLASH_STROBE control.
V4L2_FLASH_STROBE_SOURCE_EXTERNAL	The flash strobe is triggered by an external source. Typically this is a sensor, which makes it possible to synchronise the flash strobe start to exposure start.

### **V4L2\_CID\_FLASH\_STROBE (button)**

Strobe flash. Valid when V4L2\_CID\_FLASH\_LED\_MODE is set to V4L2\_FLASH\_LED\_MODE\_FLASH and V4L2\_CID\_FLASH\_STROBE\_SOURCE is set to V4L2\_FLASH\_STROBE\_SOURCE\_SOFTWARE. Setting this control may not be possible in presence of some faults. See V4L2\_CID\_FLASH\_FAULT.

### **V4L2\_CID\_FLASH\_STROBE\_STOP (button)**

Stop flash strobe immediately.

### **V4L2\_CID\_FLASH\_STROBE\_STATUS (boolean)**

Strobe status: whether the flash is strobing at the moment or not. This is a read-only control.

### **V4L2\_CID\_FLASH\_TIMEOUT (integer)**

Hardware timeout for flash. The flash strobe is stopped after this period of time has passed from the start of the strobe.

### **V4L2\_CID\_FLASH\_INTENSITY (integer)**

Intensity of the flash strobe when the flash LED is in flash mode (V4L2\_FLASH\_LED\_MODE\_FLASH). The unit should be millamps (mA) if possible.

**V4L2\_CID\_FLASH\_TORCH\_INTENSITY (integer)**

Intensity of the flash LED in torch mode (V4L2\_FLASH\_LED\_MODE\_TORCH). The unit should be millamps (mA) if possible. Setting this control may not be possible in presence of some faults. See V4L2\_CID\_FLASH\_FAULT.

**V4L2\_CID\_FLASH\_INDICATOR\_INTENSITY (integer)**

Intensity of the indicator LED. The indicator LED may be fully independent of the flash LED. The unit should be microamps (uA) if possible.

**V4L2\_CID\_FLASH\_FAULT (bitmask)**

Faults related to the flash. The faults tell about specific problems in the flash chip itself or the LEDs attached to it. Faults may prevent further use of some of the flash controls. In particular, V4L2\_CID\_FLASH\_LED\_MODE is set to V4L2\_FLASH\_LED\_MODE\_NONE if the fault affects the flash LED. Exactly which faults have such an effect is chip dependent. Reading the faults resets the control and returns the chip to a usable state if possible.

V4L2_FLASH_FAULT_OVER_VOLTAGE	Flash controller voltage to the flash LED has exceeded the limit specific to the flash controller.
V4L2_FLASH_FAULT_TIMEOUT	The flash strobe was still on when the timeout set by the user --- V4L2_CID_FLASH_TIMEOUT control --- has expired. Not all flash controllers may set this in all such conditions.
V4L2_FLASH_FAULT_OVER_TEMPERATURE	The flash controller has overheated.
V4L2_FLASH_FAULT_SHORT_CIRCUIT	The short circuit protection of the flash controller has been triggered.
V4L2_FLASH_FAULT_OVER_CURRENT	Current in the LED power supply has exceeded the limit specific to the flash controller.
V4L2_FLASH_FAULT_INDICATOR	The flash controller has detected a short or open circuit condition on the indicator LED.
V4L2_FLASH_FAULT_UNDER_VOLTAGE	Flash controller voltage to the flash LED has been below the minimum limit specific to the flash controller.
V4L2_FLASH_FAULT_INPUT_VOLTAGE	The input voltage of the flash controller is below the limit under which strobing the flash at full current will not be possible. The condition persists until this flag is no longer set.
V4L2_FLASH_FAULT_LED_OVER_TEMPERATURE	The temperature of the LED has exceeded its allowed upper limit.

**V4L2\_CID\_FLASH\_CHARGE (boolean)**

Enable or disable charging of the xenon flash capacitor.

**V4L2\_CID\_FLASH\_READY (boolean)**

Is the flash ready to strobe? Xenon flashes require their capacitors charged before strobing. LED flashes often require a cooldown period after strobe during which another strobe will not be possible. This is a read-only control.

## Image Source Control Reference

The Image Source control class is intended for low-level control of image source devices such as image sensors. The devices feature an analogue to digital converter and a bus transmitter to transmit the image data out of the device.

### Image Source Control IDs

#### **V4L2\_CID\_IMAGE\_SOURCE\_CLASS (class)**

The IMAGE\_SOURCE class descriptor.

#### **V4L2\_CID\_VBLANK (integer)**

Vertical blanking. The idle period after every frame during which no image data is produced. The unit of vertical blanking is a line. Every line has length of the image width plus horizontal blanking at the pixel rate defined by V4L2\_CID\_PIXEL\_RATE control in the same sub-device.

#### **V4L2\_CID\_HBLANK (integer)**

Horizontal blanking. The idle period after every line of image data during which no image data is produced. The unit of horizontal blanking is pixels.

#### **V4L2\_CID\_ANALOGUE\_GAIN (integer)**

Analogue gain is gain affecting all colour components in the pixel matrix. The gain operation is performed in the analogue domain before A/D conversion.

#### **V4L2\_CID\_TEST\_PATTERN\_RED (integer)**

Test pattern red colour component.

#### **V4L2\_CID\_TEST\_PATTERN\_GREENR (integer)**

Test pattern green (next to red) colour component.

#### **V4L2\_CID\_TEST\_PATTERN\_BLUE (integer)**

Test pattern blue colour component.

#### **V4L2\_CID\_TEST\_PATTERN\_GREENB (integer)**

Test pattern green (next to blue) colour component.

#### **V4L2\_CID\_UNIT\_CELL\_SIZE (struct)**

This control returns the unit cell size in nanometers. The struct *v4l2\_area* provides the width and the height in separate fields to take into consideration asymmetric pixels. This control does not take into consideration any possible hardware binning. The unit cell consists of the whole area of the pixel, sensitive and non-sensitive. This control is required for automatic calibration of sensors/cameras.

type **v4l2\_area**

Table 2: struct v4l2\_area

__u32	width	Width of the area.
__u32	height	Height of the area.

#### **V4L2\_CID\_NOTIFY\_GAINS (integer array)**

The sensor is notified what gains will be applied to the different colour channels by subsequent processing (such as by an ISP). The sensor is merely informed of these values in

case it performs processing that requires them, but it does not apply them itself to the output pixels.

Currently it is defined only for Bayer sensors, and is an array control taking 4 gain values, being the gains for each of the Bayer channels. The gains are always in the order B, Gb, Gr and R, irrespective of the exact Bayer order of the sensor itself.

The use of an array allows this control to be extended to sensors with, for example, non-Bayer CFAs (colour filter arrays).

The units for the gain values are linear, with the default value representing a gain of exactly 1.0. For example, if this default value is reported as being (say) 128, then a value of 192 would represent a gain of exactly 1.5.

## **Image Process Control Reference**

The Image Process control class is intended for low-level control of image processing functions. Unlike V4L2\_CID\_IMAGE\_SOURCE\_CLASS, the controls in this class affect processing the image, and do not control capturing of it.

### **Image Process Control IDs**

#### **V4L2\_CID\_IMAGE\_PROC\_CLASS (class)**

The IMAGE\_PROC class descriptor.

#### **V4L2\_CID\_LINK\_FREQ (integer menu)**

The frequency of the data bus (e.g. parallel or CSI-2).

#### **V4L2\_CID\_PIXEL\_RATE (64-bit integer)**

Pixel sampling rate in the device's pixel array. This control is read-only and its unit is pixels / second.

Some devices use horizontal and vertical blanking to configure the frame rate. The frame rate can be calculated from the pixel rate, analogue crop rectangle as well as horizontal and vertical blanking. The pixel rate control may be present in a different sub-device than the blanking controls and the analogue crop rectangle configuration.

The configuration of the frame rate is performed by selecting the desired horizontal and vertical blanking. The unit of this control is Hz.

#### **V4L2\_CID\_TEST\_PATTERN (menu)**

Some capture/display/sensor devices have the capability to generate test pattern images. These hardware specific test patterns can be used to test if a device is working properly.

#### **V4L2\_CID\_DEINTERLACING\_MODE (menu)**

The video deinterlacing mode (such as Bob, Weave, ...). The menu items are driver specific and are documented in uapi-v4l-drivers.

#### **V4L2\_CID\_DIGITAL\_GAIN (integer)**

Digital gain is the value by which all colour components are multiplied by. Typically the digital gain applied is the control value divided by e.g. 0x100, meaning that to get no digital gain the control value needs to be 0x100. The no-gain configuration is also typically the default.

## Codec Control Reference

Below all controls within the Codec control class are described. First the generic controls, then controls specific for certain hardware.

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**Note:** These controls are applicable to all codecs and not just MPEG. The defines are prefixed with V4L2\_CID\_MPEG/V4L2\_MPEG as the controls were originally made for MPEG codecs and later extended to cover all encoding formats.

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### Generic Codec Controls

#### Codec Control IDs

##### **V4L2\_CID\_CODEC\_CLASS (class)**

The Codec class descriptor. Calling *ioctls VIDIOC\_QUERYCTRL, VIDIOC\_QUERY\_EXT\_CTRL and VIDIOC\_QUERYMENU* for this control will return a description of this control class. This description can be used as the caption of a Tab page in a GUI, for example.

##### **V4L2\_CID\_MPEG\_STREAM\_TYPE**

(enum)

##### **enum v4l2\_mpeg\_stream\_type -**

The MPEG-1, -2 or -4 output stream type. One cannot assume anything here. Each hardware MPEG encoder tends to support different subsets of the available MPEG stream types. This control is specific to multiplexed MPEG streams. The currently defined stream types are:

V4L2_MPEG_STREAM_TYPE_MPEG2_PS	MPEG-2 program stream
V4L2_MPEG_STREAM_TYPE_MPEG2_TS	MPEG-2 transport stream
V4L2_MPEG_STREAM_TYPE_MPEG1_SS	MPEG-1 system stream
V4L2_MPEG_STREAM_TYPE_MPEG2_DVD	MPEG-2 DVD-compatible stream
V4L2_MPEG_STREAM_TYPE_MPEG1_VCD	MPEG-1 VCD-compatible stream
V4L2_MPEG_STREAM_TYPE_MPEG2_SVCD	MPEG-2 SVCD-compatible stream

##### **V4L2\_CID\_MPEG\_STREAM\_PID\_PMT (integer)**

Program Map Table Packet ID for the MPEG transport stream (default 16)

##### **V4L2\_CID\_MPEG\_STREAM\_PID\_AUDIO (integer)**

Audio Packet ID for the MPEG transport stream (default 256)

##### **V4L2\_CID\_MPEG\_STREAM\_PID\_VIDEO (integer)**

Video Packet ID for the MPEG transport stream (default 260)

##### **V4L2\_CID\_MPEG\_STREAM\_PID\_PCR (integer)**

Packet ID for the MPEG transport stream carrying PCR fields (default 259)

##### **V4L2\_CID\_MPEG\_STREAM\_PES\_ID\_AUDIO (integer)**

Audio ID for MPEG PES

##### **V4L2\_CID\_MPEG\_STREAM\_PES\_ID\_VIDEO (integer)**

Video ID for MPEG PES

**V4L2\_CID\_MPEG\_STREAM\_VBI\_FMT**

(enum)

**enum v4l2\_mpeg\_stream\_vbi\_fmt -**

Some cards can embed VBI data (e. g. Closed Caption, Teletext) into the MPEG stream. This control selects whether VBI data should be embedded, and if so, what embedding method should be used. The list of possible VBI formats depends on the driver. The currently defined VBI format types are:

V4L2_MPEG_STREAM_VBI_FMT_NONE	No VBI in the MPEG stream
V4L2_MPEG_STREAM_VBI_FMT_IVTV	VBI in private packets, IVTV format (documented in the kernel sources in the file Documentation/userspace-api/media/drivers/cx2341x-uapi.rst)

**V4L2\_CID\_MPEG\_AUDIO\_SAMPLING\_FREQ**

(enum)

**enum v4l2\_mpeg\_audio\_sampling\_freq -**

MPEG Audio sampling frequency. Possible values are:

V4L2_MPEG_AUDIO_SAMPLING_FREQ_44100	44.1 kHz
V4L2_MPEG_AUDIO_SAMPLING_FREQ_48000	48 kHz
V4L2_MPEG_AUDIO_SAMPLING_FREQ_32000	32 kHz

**V4L2\_CID\_MPEG\_AUDIO\_ENCODING**

(enum)

**enum v4l2\_mpeg\_audio\_encoding -**

MPEG Audio encoding. This control is specific to multiplexed MPEG streams. Possible values are:

V4L2_MPEG_AUDIO_ENCODING_LAYER_1	MPEG-1/2 Layer I encoding
V4L2_MPEG_AUDIO_ENCODING_LAYER_2	MPEG-1/2 Layer II encoding
V4L2_MPEG_AUDIO_ENCODING_LAYER_3	MPEG-1/2 Layer III encoding
V4L2_MPEG_AUDIO_ENCODING_AAC	MPEG-2/4 AAC (Advanced Audio Coding)
V4L2_MPEG_AUDIO_ENCODING_AC3	AC-3 aka ATSC A/52 encoding

**V4L2\_CID\_MPEG\_AUDIO\_L1\_BITRATE**

(enum)

**enum v4l2\_mpeg\_audio\_l1\_bitrate -**

MPEG-1/2 Layer I bitrate. Possible values are:

V4L2_MPEG_AUDIO_L1_BITRATE_32K	32 kbit/s
V4L2_MPEG_AUDIO_L1_BITRATE_64K	64 kbit/s
V4L2_MPEG_AUDIO_L1_BITRATE_96K	96 kbit/s
V4L2_MPEG_AUDIO_L1_BITRATE_128K	128 kbit/s
V4L2_MPEG_AUDIO_L1_BITRATE_160K	160 kbit/s
V4L2_MPEG_AUDIO_L1_BITRATE_192K	192 kbit/s
V4L2_MPEG_AUDIO_L1_BITRATE_224K	224 kbit/s
V4L2_MPEG_AUDIO_L1_BITRATE_256K	256 kbit/s
V4L2_MPEG_AUDIO_L1_BITRATE_288K	288 kbit/s
V4L2_MPEG_AUDIO_L1_BITRATE_320K	320 kbit/s
V4L2_MPEG_AUDIO_L1_BITRATE_352K	352 kbit/s
V4L2_MPEG_AUDIO_L1_BITRATE_384K	384 kbit/s
V4L2_MPEG_AUDIO_L1_BITRATE_416K	416 kbit/s
V4L2_MPEG_AUDIO_L1_BITRATE_448K	448 kbit/s

**V4L2\_CID\_MPEG\_AUDIO\_L2\_BITRATE**

(enum)

**enum v4l2\_mpeg\_audio\_l2\_bitrate -**

MPEG-1/2 Layer II bitrate. Possible values are:

V4L2_MPEG_AUDIO_L2_BITRATE_32K	32 kbit/s
V4L2_MPEG_AUDIO_L2_BITRATE_48K	48 kbit/s
V4L2_MPEG_AUDIO_L2_BITRATE_56K	56 kbit/s
V4L2_MPEG_AUDIO_L2_BITRATE_64K	64 kbit/s
V4L2_MPEG_AUDIO_L2_BITRATE_80K	80 kbit/s
V4L2_MPEG_AUDIO_L2_BITRATE_96K	96 kbit/s
V4L2_MPEG_AUDIO_L2_BITRATE_112K	112 kbit/s
V4L2_MPEG_AUDIO_L2_BITRATE_128K	128 kbit/s
V4L2_MPEG_AUDIO_L2_BITRATE_160K	160 kbit/s
V4L2_MPEG_AUDIO_L2_BITRATE_192K	192 kbit/s
V4L2_MPEG_AUDIO_L2_BITRATE_224K	224 kbit/s
V4L2_MPEG_AUDIO_L2_BITRATE_256K	256 kbit/s
V4L2_MPEG_AUDIO_L2_BITRATE_320K	320 kbit/s
V4L2_MPEG_AUDIO_L2_BITRATE_384K	384 kbit/s

**V4L2\_CID\_MPEG\_AUDIO\_L3\_BITRATE**

(enum)

**enum v4l2\_mpeg\_audio\_l3\_bitrate -**

MPEG-1/2 Layer III bitrate. Possible values are:

V4L2_MPEG_AUDIO_L3_BITRATE_32K	32 kbit/s
V4L2_MPEG_AUDIO_L3_BITRATE_40K	40 kbit/s
V4L2_MPEG_AUDIO_L3_BITRATE_48K	48 kbit/s
V4L2_MPEG_AUDIO_L3_BITRATE_56K	56 kbit/s
V4L2_MPEG_AUDIO_L3_BITRATE_64K	64 kbit/s
V4L2_MPEG_AUDIO_L3_BITRATE_80K	80 kbit/s
V4L2_MPEG_AUDIO_L3_BITRATE_96K	96 kbit/s
V4L2_MPEG_AUDIO_L3_BITRATE_112K	112 kbit/s
V4L2_MPEG_AUDIO_L3_BITRATE_128K	128 kbit/s
V4L2_MPEG_AUDIO_L3_BITRATE_160K	160 kbit/s
V4L2_MPEG_AUDIO_L3_BITRATE_192K	192 kbit/s
V4L2_MPEG_AUDIO_L3_BITRATE_224K	224 kbit/s
V4L2_MPEG_AUDIO_L3_BITRATE_256K	256 kbit/s
V4L2_MPEG_AUDIO_L3_BITRATE_320K	320 kbit/s

**V4L2\_CID\_MPEG\_AUDIO\_AAC\_BITRATE (integer)**

AAC bitrate in bits per second.

**V4L2\_CID\_MPEG\_AUDIO\_AC3\_BITRATE  
(enum)****enum v4l2\_mpeg\_audio\_ac3\_bitrate -**

AC-3 bitrate. Possible values are:

V4L2_MPEG_AUDIO_AC3_BITRATE_32K	32 kbit/s
V4L2_MPEG_AUDIO_AC3_BITRATE_40K	40 kbit/s
V4L2_MPEG_AUDIO_AC3_BITRATE_48K	48 kbit/s
V4L2_MPEG_AUDIO_AC3_BITRATE_56K	56 kbit/s
V4L2_MPEG_AUDIO_AC3_BITRATE_64K	64 kbit/s
V4L2_MPEG_AUDIO_AC3_BITRATE_80K	80 kbit/s
V4L2_MPEG_AUDIO_AC3_BITRATE_96K	96 kbit/s
V4L2_MPEG_AUDIO_AC3_BITRATE_112K	112 kbit/s
V4L2_MPEG_AUDIO_AC3_BITRATE_128K	128 kbit/s
V4L2_MPEG_AUDIO_AC3_BITRATE_160K	160 kbit/s
V4L2_MPEG_AUDIO_AC3_BITRATE_192K	192 kbit/s
V4L2_MPEG_AUDIO_AC3_BITRATE_224K	224 kbit/s
V4L2_MPEG_AUDIO_AC3_BITRATE_256K	256 kbit/s
V4L2_MPEG_AUDIO_AC3_BITRATE_320K	320 kbit/s
V4L2_MPEG_AUDIO_AC3_BITRATE_384K	384 kbit/s
V4L2_MPEG_AUDIO_AC3_BITRATE_448K	448 kbit/s
V4L2_MPEG_AUDIO_AC3_BITRATE_512K	512 kbit/s
V4L2_MPEG_AUDIO_AC3_BITRATE_576K	576 kbit/s
V4L2_MPEG_AUDIO_AC3_BITRATE_640K	640 kbit/s

**V4L2\_CID\_MPEG\_AUDIO\_MODE**

(enum)

**enum v4l2\_mpeg\_audio\_mode -**

MPEG Audio mode. Possible values are:

V4L2_MPEG_AUDIO_MODE_STEREO	Stereo
V4L2_MPEG_AUDIO_MODE_JOINT_STEREO	Joint Stereo
V4L2_MPEG_AUDIO_MODE_DUAL	Bilingual
V4L2_MPEG_AUDIO_MODE_MONO	Mono

**V4L2\_CID\_MPEG\_AUDIO\_MODE\_EXTENSION**  
(enum)**enum v4l2\_mpeg\_audio\_mode\_extension -**

Joint Stereo audio mode extension. In Layer I and II they indicate which subbands are in intensity stereo. All other subbands are coded in stereo. Layer III is not (yet) supported. Possible values are:

V4L2_MPEG_AUDIO_MODE_EXTENSION_BOUND_4	Subbands 4-31 in intensity stereo
V4L2_MPEG_AUDIO_MODE_EXTENSION_BOUND_8	Subbands 8-31 in intensity stereo
V4L2_MPEG_AUDIO_MODE_EXTENSION_BOUND_12	Subbands 12-31 in intensity stereo
V4L2_MPEG_AUDIO_MODE_EXTENSION_BOUND_16	Subbands 16-31 in intensity stereo

**V4L2\_CID\_MPEG\_AUDIO\_EMPHASIS**  
(enum)**enum v4l2\_mpeg\_audio\_emphasis -**

Audio Emphasis. Possible values are:

V4L2_MPEG_AUDIO_EMPHASIS_NONE	None
V4L2_MPEG_AUDIO_EMPHASIS_50_DIV_15_uS	50/15 microsecond emphasis
V4L2_MPEG_AUDIO_EMPHASIS_CCITT_J17	CCITT J.17

**V4L2\_CID\_MPEG\_AUDIO\_CRC**  
(enum)**enum v4l2\_mpeg\_audio\_crc -**

CRC method. Possible values are:

V4L2_MPEG_AUDIO_CRC_NONE	None
V4L2_MPEG_AUDIO_CRC_CRC16	16 bit parity check

**V4L2\_CID\_MPEG\_AUDIO\_MUTE (boolean)**

Mutes the audio when capturing. This is not done by muting audio hardware, which can still produce a slight hiss, but in the encoder itself, guaranteeing a fixed and reproducible audio bitstream. 0 = unmuted, 1 = muted.

**V4L2\_CID\_MPEG\_AUDIO\_DEC\_PLAYBACK**  
(enum)**enum v4l2\_mpeg\_audio\_dec\_playback -**

Determines how monolingual audio should be played back. Possible values are:

V4L2_MPEG_AUDIO_DEC_PLAYBACK_AUTO	Automatically determines the best playback mode.
V4L2_MPEG_AUDIO_DEC_PLAYBACK_STEREO	Stereo playback.
V4L2_MPEG_AUDIO_DEC_PLAYBACK_LEFT	Left channel playback.
V4L2_MPEG_AUDIO_DEC_PLAYBACK_RIGHT	Right channel playback.
V4L2_MPEG_AUDIO_DEC_PLAYBACK_MONO	Mono playback.
V4L2_MPEG_AUDIO_DEC_PLAYBACK_SWAPPED_STEREO	Stereo playback with swapped left and right channels.

**V4L2\_CID\_MPEG\_AUDIO\_DEC\_MULTILINGUAL\_PLAYBACK**  
(enum)

**enum v4l2\_mpeg\_audio\_dec\_playback -**

Determines how multilingual audio should be played back.

**V4L2\_CID\_MPEG\_VIDEO\_ENCODING**  
(enum)

**enum v4l2\_mpeg\_video\_encoding -**

MPEG Video encoding method. This control is specific to multiplexed MPEG streams.  
Possible values are:

V4L2_MPEG_VIDEO_ENCODING_MPEG_1	MPEG-1 Video encoding
V4L2_MPEG_VIDEO_ENCODING_MPEG_2	MPEG-2 Video encoding
V4L2_MPEG_VIDEO_ENCODING_MPEG_4_AVC	MPEG-4 AVC (H.264) Video encoding

**V4L2\_CID\_MPEG\_VIDEO\_ASPECT**  
(enum)

**enum v4l2\_mpeg\_video\_aspect -**

Video aspect. Possible values are:

V4L2_MPEG_VIDEO_ASPECT_1x1
V4L2_MPEG_VIDEO_ASPECT_4x3
V4L2_MPEG_VIDEO_ASPECT_16x9
V4L2_MPEG_VIDEO_ASPECT_221x100

**V4L2\_CID\_MPEG\_VIDEO\_B\_FRAMES (integer)**

Number of B-Frames (default 2)

**V4L2\_CID\_MPEG\_VIDEO\_GOP\_SIZE (integer)**

GOP size (default 12)

**V4L2\_CID\_MPEG\_VIDEO\_GOP\_CLOSURE (boolean)**

GOP closure (default 1)

**V4L2\_CID\_MPEG\_VIDEO\_PULLDOWN (boolean)**

Enable 3:2 pulldown (default 0)

**V4L2\_CID\_MPEG\_VIDEO\_BITRATE\_MODE**  
(enum)

**enum v4l2\_mpeg\_video\_bitrate\_mode -**

Video bitrate mode. Possible values are:

V4L2_MPEG_VIDEO_BITRATE_MODE_VBR	Variable bitrate
V4L2_MPEG_VIDEO_BITRATE_MODE_CBR	Constant bitrate
V4L2_MPEG_VIDEO_BITRATE_MODE_CQ	Constant quality

**V4L2\_CID\_MPEG\_VIDEO\_BITRATE (integer)**

Average video bitrate in bits per second.

**V4L2\_CID\_MPEG\_VIDEO\_BITRATE\_PEAK (integer)**

Peak video bitrate in bits per second. Must be larger or equal to the average video bitrate. It is ignored if the video bitrate mode is set to constant bitrate.

**V4L2\_CID\_MPEG\_VIDEO\_CONSTANT\_QUALITY (integer)**

Constant quality level control. This control is applicable when V4L2\_CID\_MPEG\_VIDEO\_BITRATE\_MODE value is V4L2\_MPEG\_VIDEO\_BITRATE\_MODE\_CQ. Valid range is 1 to 100 where 1 indicates lowest quality and 100 indicates highest quality. Encoder will decide the appropriate quantization parameter and bitrate to produce requested frame quality.

**V4L2\_CID\_MPEG\_VIDEO\_FRAME\_SKIP\_MODE (enum)****enum v4l2\_mpeg\_video\_frame\_skip\_mode -**

Indicates in what conditions the encoder should skip frames. If encoding a frame would cause the encoded stream to be larger then a chosen data limit then the frame will be skipped. Possible values are:

V4L2_MPEG_VIDEO_FRAME_SKIP_MODE_DISABLED	Frame skip mode is disabled.
V4L2_MPEG_VIDEO_FRAME_SKIP_MODE_LEVEL_LIMIT	Frame skip mode enabled and buffer limit is set by the chosen level and is defined by the standard.
V4L2_MPEG_VIDEO_FRAME_SKIP_MODE_BUF_LIMIT	Frame skip mode enabled and buffer limit is set by the <i>VBV (MPEG1/2/4)</i> or <i>CPB (H264) buffer size</i> control.

**V4L2\_CID\_MPEG\_VIDEO\_TEMPORAL\_DECIMATION (integer)**

For every captured frame, skip this many subsequent frames (default 0).

**V4L2\_CID\_MPEG\_VIDEO\_MUTE (boolean)**

"Mutes" the video to a fixed color when capturing. This is useful for testing, to produce a fixed video bitstream. 0 = unmuted, 1 = muted.

**V4L2\_CID\_MPEG\_VIDEO\_MUTE\_YUV (integer)**

Sets the "mute" color of the video. The supplied 32-bit integer is interpreted as follows (bit 0 = least significant bit):

Bit 0:7	V chrominance information
Bit 8:15	U chrominance information
Bit 16:23	Y luminance information
Bit 24:31	Must be zero.

**V4L2\_CID\_MPEG\_VIDEO\_DEC\_PTS (integer64)**

This read-only control returns the 33-bit video Presentation Time Stamp as defined in ITU-T-REC-H.222.0 and ISO/IEC 13818-1 of the currently displayed frame. This is the same PTS as is used in *ioctl VIDIOC\_DECODER\_CMD, VIDIOC\_TRY\_DECODER\_CMD*.

**V4L2\_CID\_MPEG\_VIDEO\_DEC\_FRAME (integer64)**

This read-only control returns the frame counter of the frame that is currently displayed (decoded). This value is reset to 0 whenever the decoder is started.

**V4L2\_CID\_MPEG\_VIDEO\_DEC\_CONCEAL\_COLOR (integer64)**

This control sets the conceal color in YUV color space. It describes the client preference of the error conceal color in case of an error where the reference frame is missing. The decoder should fill the reference buffer with the preferred color and use it for future decoding. The control is using 16 bits per channel. Applicable to decoders.

	8bit format	10bit format	12bit format
Y luminance	Bit 0:7	Bit 0:9	Bit 0:11
Cb chrominance	Bit 16:23	Bit 16:25	Bit 16:27
Cr chrominance	Bit 32:39	Bit 32:41	Bit 32:43
Must be zero	Bit 48:63	Bit 48:63	Bit 48:63

**V4L2\_CID\_MPEG\_VIDEO\_DECODER\_SLICE\_INTERFACE (boolean)**

If enabled the decoder expects to receive a single slice per buffer, otherwise the decoder expects a single frame in per buffer. Applicable to the decoder, all codecs.

**V4L2\_CID\_MPEG\_VIDEO\_DEC\_DISPLAY\_DELAY\_ENABLE (boolean)**

If the display delay is enabled then the decoder is forced to return a CAPTURE buffer (decoded frame) after processing a certain number of OUTPUT buffers. The delay can be set through V4L2\_CID\_MPEG\_VIDEO\_DEC\_DISPLAY\_DELAY. This feature can be used for example for generating thumbnails of videos. Applicable to the decoder.

**V4L2\_CID\_MPEG\_VIDEO\_DEC\_DISPLAY\_DELAY (integer)**

Display delay value for decoder. The decoder is forced to return a decoded frame after the set 'display delay' number of frames. If this number is low it may result in frames returned out of display order, in addition the hardware may still be using the returned buffer as a reference picture for subsequent frames.

**V4L2\_CID\_MPEG\_VIDEO\_AU\_DELIMITER (boolean)**

If enabled then, AUD (Access Unit Delimiter) NALUs will be generated. That could be useful to find the start of a frame without having to fully parse each NALU. Applicable to the H264 and HEVC encoders.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_VUI\_SAR\_ENABLE (boolean)**

Enable writing sample aspect ratio in the Video Usability Information. Applicable to the H264 encoder.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_VUI\_SAR\_IDC**

(enum)

**enum v4l2\_mpeg\_video\_h264\_vui\_sar\_idc -**

VUI sample aspect ratio indicator for H.264 encoding. The value is defined in the table E-1 in the standard. Applicable to the H264 encoder.

V4L2_MPEG_VIDEO_H264_VUI_SAR_IDC_UNSPECIFIED	Unspecified
V4L2_MPEG_VIDEO_H264_VUI_SAR_IDC_1x1	1x1
V4L2_MPEG_VIDEO_H264_VUI_SAR_IDC_12x11	12x11
V4L2_MPEG_VIDEO_H264_VUI_SAR_IDC_10x11	10x11
V4L2_MPEG_VIDEO_H264_VUI_SAR_IDC_16x11	16x11
V4L2_MPEG_VIDEO_H264_VUI_SAR_IDC_40x33	40x33
V4L2_MPEG_VIDEO_H264_VUI_SAR_IDC_24x11	24x11
V4L2_MPEG_VIDEO_H264_VUI_SAR_IDC_20x11	20x11
V4L2_MPEG_VIDEO_H264_VUI_SAR_IDC_32x11	32x11
V4L2_MPEG_VIDEO_H264_VUI_SAR_IDC_80x33	80x33
V4L2_MPEG_VIDEO_H264_VUI_SAR_IDC_18x11	18x11
V4L2_MPEG_VIDEO_H264_VUI_SAR_IDC_15x11	15x11
V4L2_MPEG_VIDEO_H264_VUI_SAR_IDC_64x33	64x33
V4L2_MPEG_VIDEO_H264_VUI_SAR_IDC_160x99	160x99
V4L2_MPEG_VIDEO_H264_VUI_SAR_IDC_4x3	4x3
V4L2_MPEG_VIDEO_H264_VUI_SAR_IDC_3x2	3x2
V4L2_MPEG_VIDEO_H264_VUI_SAR_IDC_2x1	2x1
V4L2_MPEG_VIDEO_H264_VUI_SAR_IDC_EXTENDED	Extended SAR

**V4L2\_CID\_MPEG\_VIDEO\_H264\_VUI\_EXT\_SAR\_WIDTH (integer)**

Extended sample aspect ratio width for H.264 VUI encoding. Applicable to the H264 encoder.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_VUI\_EXT\_SAR\_HEIGHT (integer)**

Extended sample aspect ratio height for H.264 VUI encoding. Applicable to the H264 encoder.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_LEVEL**

(enum)

**enum v4l2\_mpeg\_video\_h264\_level -**

The level information for the H264 video elementary stream. Applicable to the H264 encoder. Possible values are:

V4L2_MPEG_VIDEO_H264_LEVEL_1_0	Level 1.0
V4L2_MPEG_VIDEO_H264_LEVEL_1B	Level 1B
V4L2_MPEG_VIDEO_H264_LEVEL_1_1	Level 1.1
V4L2_MPEG_VIDEO_H264_LEVEL_1_2	Level 1.2
V4L2_MPEG_VIDEO_H264_LEVEL_1_3	Level 1.3
V4L2_MPEG_VIDEO_H264_LEVEL_2_0	Level 2.0
V4L2_MPEG_VIDEO_H264_LEVEL_2_1	Level 2.1
V4L2_MPEG_VIDEO_H264_LEVEL_2_2	Level 2.2
V4L2_MPEG_VIDEO_H264_LEVEL_3_0	Level 3.0
V4L2_MPEG_VIDEO_H264_LEVEL_3_1	Level 3.1
V4L2_MPEG_VIDEO_H264_LEVEL_3_2	Level 3.2
V4L2_MPEG_VIDEO_H264_LEVEL_4_0	Level 4.0
V4L2_MPEG_VIDEO_H264_LEVEL_4_1	Level 4.1
V4L2_MPEG_VIDEO_H264_LEVEL_4_2	Level 4.2
V4L2_MPEG_VIDEO_H264_LEVEL_5_0	Level 5.0
V4L2_MPEG_VIDEO_H264_LEVEL_5_1	Level 5.1
V4L2_MPEG_VIDEO_H264_LEVEL_5_2	Level 5.2
V4L2_MPEG_VIDEO_H264_LEVEL_6_0	Level 6.0
V4L2_MPEG_VIDEO_H264_LEVEL_6_1	Level 6.1
V4L2_MPEG_VIDEO_H264_LEVEL_6_2	Level 6.2

**V4L2\_CID\_MPEG\_VIDEO\_MPEG2\_LEVEL**

(enum)

**enum v4l2\_mpeg\_video\_mpeg2\_level -**

The level information for the MPEG2 elementary stream. Applicable to MPEG2 codecs.  
Possible values are:

V4L2_MPEG_VIDEO_MPEG2_LEVEL_LOW	Low Level (LL)
V4L2_MPEG_VIDEO_MPEG2_LEVEL_MAIN	Main Level (ML)
V4L2_MPEG_VIDEO_MPEG2_LEVEL_HIGH_1440	High-1440 Level (H-14)
V4L2_MPEG_VIDEO_MPEG2_LEVEL_HIGH	High Level (HL)

**V4L2\_CID\_MPEG\_VIDEO\_MPEG4\_LEVEL**

(enum)

**enum v4l2\_mpeg\_video\_mpeg4\_level -**

The level information for the MPEG4 elementary stream. Applicable to the MPEG4 encoder. Possible values are:

V4L2_MPEG_VIDEO_MPEG4_LEVEL_0	Level 0
V4L2_MPEG_VIDEO_MPEG4_LEVEL_0B	Level 0b
V4L2_MPEG_VIDEO_MPEG4_LEVEL_1	Level 1
V4L2_MPEG_VIDEO_MPEG4_LEVEL_2	Level 2
V4L2_MPEG_VIDEO_MPEG4_LEVEL_3	Level 3
V4L2_MPEG_VIDEO_MPEG4_LEVEL_3B	Level 3b
V4L2_MPEG_VIDEO_MPEG4_LEVEL_4	Level 4
V4L2_MPEG_VIDEO_MPEG4_LEVEL_5	Level 5

**V4L2\_CID\_MPEG\_VIDEO\_H264\_PROFILE**

(enum)

**enum v4l2\_mpeg\_video\_h264\_profile -**

The profile information for H264. Applicable to the H264 encoder. Possible values are:

V4L2_MPEG_VIDEO_H264_PROFILE_BASELINE	Baseline profile
V4L2_MPEG_VIDEO_H264_PROFILE_CONSTRAINED_BASELINE	Constrained Baseline profile
V4L2_MPEG_VIDEO_H264_PROFILE_MAIN	Main profile
V4L2_MPEG_VIDEO_H264_PROFILE_EXTENDED	Extended profile
V4L2_MPEG_VIDEO_H264_PROFILE_HIGH	High profile
V4L2_MPEG_VIDEO_H264_PROFILE_HIGH_10	High 10 profile
V4L2_MPEG_VIDEO_H264_PROFILE_HIGH_422	High 422 profile
V4L2_MPEG_VIDEO_H264_PROFILE_HIGH_444_PREDICTIVE	High 444 Predictive profile
V4L2_MPEG_VIDEO_H264_PROFILE_HIGH_10_INTRA	High 10 Intra profile
V4L2_MPEG_VIDEO_H264_PROFILE_HIGH_422_INTRA	High 422 Intra profile
V4L2_MPEG_VIDEO_H264_PROFILE_HIGH_444_INTRA	High 444 Intra profile
V4L2_MPEG_VIDEO_H264_PROFILE_CAVLC_444_INTRA	CAVLC 444 Intra profile
V4L2_MPEG_VIDEO_H264_PROFILE_SCALABLE_BASELINE	Scalable Baseline profile
V4L2_MPEG_VIDEO_H264_PROFILE_SCALABLE_HIGH	Scalable High profile
V4L2_MPEG_VIDEO_H264_PROFILE_SCALABLE_HIGH_INTRA	Scalable High Intra profile
V4L2_MPEG_VIDEO_H264_PROFILE_STEREO_HIGH	Stereo High profile
V4L2_MPEG_VIDEO_H264_PROFILE_MULTIVIEW_HIGH	Multiview High profile
V4L2_MPEG_VIDEO_H264_PROFILE_CONSTRAINED_HIGH	Constrained High profile

**V4L2\_CID\_MPEG\_VIDEO\_MPEG2\_PROFILE**

(enum)

**enum v4l2\_mpeg\_video\_mpeg2\_profile -**

The profile information for MPEG2. Applicable to MPEG2 codecs. Possible values are:

V4L2_MPEG_VIDEO_MPEG2_PROFILE_SIMPLE	Simple profile (SP)
V4L2_MPEG_VIDEO_MPEG2_PROFILE_MAIN	Main profile (MP)
V4L2_MPEG_VIDEO_MPEG2_PROFILE_SNR_SCALABLE	SNR Scalable profile (SNR)
V4L2_MPEG_VIDEO_MPEG2_PROFILE_SPATIALLY_SCALABLE	Spatially Scalable profile (Spt)
V4L2_MPEG_VIDEO_MPEG2_PROFILE_HIGH	High profile (HP)
V4L2_MPEG_VIDEO_MPEG2_PROFILE_MULTIVIEW	Multi-view profile (MVP)

**V4L2\_CID\_MPEG\_VIDEO\_MPEG4\_PROFILE**

(enum)

**enum v4l2\_mpeg\_video\_mpeg4\_profile -**

The profile information for MPEG4. Applicable to the MPEG4 encoder. Possible values are:

V4L2_MPEG_VIDEO_MPEG4_PROFILE_SIMPLE	Simple profile
V4L2_MPEG_VIDEO_MPEG4_PROFILE_ADVANCED_SIMPLE	Advanced Simple profile
V4L2_MPEG_VIDEO_MPEG4_PROFILE_CORE	Core profile
V4L2_MPEG_VIDEO_MPEG4_PROFILE_SIMPLE_SCALABLE	Simple Scalable profile
V4L2_MPEG_VIDEO_MPEG4_PROFILE_ADVANCED_CODING EFFICIENCY	Advanced Coding Efficiency profile

**V4L2\_CID\_MPEG\_VIDEO\_MAX\_REF\_PIC (integer)**

The maximum number of reference pictures used for encoding. Applicable to the encoder.

**V4L2\_CID\_MPEG\_VIDEO\_MULTI\_SLICE\_MODE**  
(enum)**enum v4l2\_mpeg\_video\_multi\_slice\_mode -**

Determines how the encoder should handle division of frame into slices. Applicable to the encoder. Possible values are:

V4L2_MPEG_VIDEO_MULTI_SLICE_MODE_SINGLE	Single slice per frame.
V4L2_MPEG_VIDEO_MULTI_SLICE_MODE_MAX_MB	Multiple slices with set maximum number of macroblocks per slice.
V4L2_MPEG_VIDEO_MULTI_SLICE_MODE_MAX_BYTES	Multiple slice with set maximum size in bytes per slice.

**V4L2\_CID\_MPEG\_VIDEO\_MULTI\_SLICE\_MAX\_MB (integer)**

The maximum number of macroblocks in a slice. Used when V4L2\_CID\_MPEG\_VIDEO\_MULTI\_SLICE\_MODE is set to V4L2\_MPEG\_VIDEO\_MULTI\_SLICE\_MODE\_MAX\_MB. Applicable to the encoder.

**V4L2\_CID\_MPEG\_VIDEO\_MULTI\_SLICE\_MAX\_BYTES (integer)**

The maximum size of a slice in bytes. Used when V4L2\_CID\_MPEG\_VIDEO\_MULTI\_SLICE\_MODE is set to V4L2\_MPEG\_VIDEO\_MULTI\_SLICE\_MODE\_MAX\_BYTES. Applicable to the encoder.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_LOOP\_FILTER\_MODE**  
(enum)**enum v4l2\_mpeg\_video\_h264\_loop\_filter\_mode -**

Loop filter mode for H264 encoder. Possible values are:

V4L2_MPEG_VIDEO_H264_LOOP_FILTER_MODE_ENABLED	Loop filter is enabled.
V4L2_MPEG_VIDEO_H264_LOOP_FILTER_MODE_DISABLED	Loop filter is disabled.
V4L2_MPEG_VIDEO_H264_LOOP_FILTER_MODE_DISABLED_AT_SLICE_BOUNDARY	Loop filter is disabled at the slice boundary.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_LOOP\_FILTER\_ALPHA (integer)**

Loop filter alpha coefficient, defined in the H264 standard. This value corresponds to the slice\_alpha\_c0\_offset\_div2 slice header field, and should be in the range of -6 to +6, inclusive. The actual alpha offset FilterOffsetA is twice this value. Applicable to the H264 encoder.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_LOOP\_FILTER\_BETA (integer)**

Loop filter beta coefficient, defined in the H264 standard. This corresponds to the slice\_beta\_offset\_div2 slice header field, and should be in the range of -6 to +6, inclusive. The actual beta offset FilterOffsetB is twice this value. Applicable to the H264 encoder.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_ENTROPY\_MODE**  
(enum)**enum v4l2\_mpeg\_video\_h264\_entropy\_mode -**

Entropy coding mode for H264 - CABAC/CAVLC. Applicable to the H264 encoder. Possible values are:

V4L2_MPEG_VIDEO_H264_ENTROPY_MODE_CAVLC	Use CAVLC entropy coding.
V4L2_MPEG_VIDEO_H264_ENTROPY_MODE_CABAC	Use CABAC entropy coding.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_8X8\_TRANSFORM (boolean)**

Enable 8x8 transform for H264. Applicable to the H264 encoder.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_CONSTRAINED\_INTRA\_PREDICTION (boolean)**

Enable constrained intra prediction for H264. Applicable to the H264 encoder.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_CHROMA\_QP\_INDEX\_OFFSET (integer)**

Specify the offset that should be added to the luma quantization parameter to determine the chroma quantization parameter. Applicable to the H264 encoder.

**V4L2\_CID\_MPEG\_VIDEO\_CYCLIC\_INTRA\_REFRESH\_MB (integer)**

Cyclic intra macroblock refresh. This is the number of continuous macroblocks refreshed every frame. Each frame a successive set of macroblocks is refreshed until the cycle completes and starts from the top of the frame. Setting this control to zero means that macroblocks will not be refreshed. Note that this control will not take effect when V4L2\_CID\_MPEG\_VIDEO\_INTRA\_REFRESH\_PERIOD control is set to non zero value. Applicable to H264, H263 and MPEG4 encoder.

**V4L2\_CID\_MPEG\_VIDEO\_INTRA\_REFRESH\_PERIOD\_TYPE (enum)****enum v4l2\_mpeg\_video\_intra\_refresh\_period\_type -**

Sets the type of intra refresh. The period to refresh the whole frame is specified by V4L2\_CID\_MPEG\_VIDEO\_INTRA\_REFRESH\_PERIOD. Note that if this control is not present, then it is undefined what refresh type is used and it is up to the driver to decide. Applicable to H264 and HEVC encoders. Possible values are:

V4L2_MPEG_VIDEO_INTRA_REFRESH_PERIOD_TYPE_RANDOM	hole frame is completely refreshed randomly after the specified period.
V4L2_MPEG_VIDEO_INTRA_REFRESH_PERIOD_TYPE_CYCLE	whole frame MBs are completely refreshed in cyclic order after the specified period.

**V4L2\_CID\_MPEG\_VIDEO\_INTRA\_REFRESH\_PERIOD (integer)**

Intra macroblock refresh period. This sets the period to refresh the whole frame. In other words, this defines the number of frames for which the whole frame will be intra-refreshed. An example: setting period to 1 means that the whole frame will be refreshed, setting period to 2 means that the half of macroblocks will be intra-refreshed on frameX and the other half of macroblocks will be refreshed in frameX + 1 and so on. Setting the period to zero means no period is specified. Note that if the client sets this control to non zero value the V4L2\_CID\_MPEG\_VIDEO\_CYCLIC\_INTRA\_REFRESH\_MB control shall be ignored. Applicable to H264 and HEVC encoders.

**V4L2\_CID\_MPEG\_VIDEO\_FRAME\_RC\_ENABLE (boolean)**

Frame level rate control enable. If this control is disabled then the quantization parameter for each frame type is constant and set with appropriate controls (e.g. V4L2\_CID\_MPEG\_VIDEO\_H263\_I\_FRAME\_QP). If frame rate control is enabled then quantization parameter is adjusted to meet the chosen bitrate. Minimum and maximum value for the quantization parameter can be set with appropriate controls (e.g. V4L2\_CID\_MPEG\_VIDEO\_H263\_MIN\_QP). Applicable to encoders.

**V4L2\_CID\_MPEG\_VIDEO\_MB\_RC\_ENABLE (boolean)**

Macroblock level rate control enable. Applicable to the MPEG4 and H264 encoders.

**V4L2\_CID\_MPEG\_VIDEO\_MPEG4\_QPEL (boolean)**

Quarter pixel motion estimation for MPEG4. Applicable to the MPEG4 encoder.

**V4L2\_CID\_MPEG\_VIDEO\_H263\_I\_FRAME\_QP (integer)**

Quantization parameter for an I frame for H263. Valid range: from 1 to 31.

**V4L2\_CID\_MPEG\_VIDEO\_H263\_MIN\_QP (integer)**

Minimum quantization parameter for H263. Valid range: from 1 to 31.

**V4L2\_CID\_MPEG\_VIDEO\_H263\_MAX\_QP (integer)**

Maximum quantization parameter for H263. Valid range: from 1 to 31.

**V4L2\_CID\_MPEG\_VIDEO\_H263\_P\_FRAME\_QP (integer)**

Quantization parameter for an P frame for H263. Valid range: from 1 to 31.

**V4L2\_CID\_MPEG\_VIDEO\_H263\_B\_FRAME\_QP (integer)**

Quantization parameter for an B frame for H263. Valid range: from 1 to 31.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_I\_FRAME\_QP (integer)**

Quantization parameter for an I frame for H264. Valid range: from 0 to 51.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_MIN\_QP (integer)**

Minimum quantization parameter for H264. Valid range: from 0 to 51.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_MAX\_QP (integer)**

Maximum quantization parameter for H264. Valid range: from 0 to 51.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_P\_FRAME\_QP (integer)**

Quantization parameter for an P frame for H264. Valid range: from 0 to 51.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_B\_FRAME\_QP (integer)**

Quantization parameter for an B frame for H264. Valid range: from 0 to 51.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_I\_FRAME\_MIN\_QP (integer)**

Minimum quantization parameter for the H264 I frame to limit I frame quality to a range. Valid range: from 0 to 51. If V4L2\_CID\_MPEG\_VIDEO\_H264\_MIN\_QP is also set, the quantization parameter should be chosen to meet both requirements.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_I\_FRAME\_MAX\_QP (integer)**

Maximum quantization parameter for the H264 I frame to limit I frame quality to a range. Valid range: from 0 to 51. If V4L2\_CID\_MPEG\_VIDEO\_H264\_MAX\_QP is also set, the quantization parameter should be chosen to meet both requirements.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_P\_FRAME\_MIN\_QP (integer)**

Minimum quantization parameter for the H264 P frame to limit P frame quality to a range. Valid range: from 0 to 51. If V4L2\_CID\_MPEG\_VIDEO\_H264\_MIN\_QP is also set, the quantization parameter should be chosen to meet both requirements.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_P\_FRAME\_MAX\_QP (integer)**

Maximum quantization parameter for the H264 P frame to limit P frame quality to a range. Valid range: from 0 to 51. If V4L2\_CID\_MPEG\_VIDEO\_H264\_MAX\_QP is also set, the quantization parameter should be chosen to meet both requirements.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_B\_FRAME\_MIN\_QP (integer)**

Minimum quantization parameter for the H264 B frame to limit B frame quality to a range. Valid range: from 0 to 51. If V4L2\_CID\_MPEG\_VIDEO\_H264\_MIN\_QP is also set, the quantization parameter should be chosen to meet both requirements.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_B\_FRAME\_MAX\_QP (integer)**

Maximum quantization parameter for the H264 B frame to limit B frame quality to a range. Valid range: from 0 to 51. If V4L2\_CID\_MPEG\_VIDEO\_H264\_MAX\_QP is also set, the quantization parameter should be chosen to meet both requirements.

**V4L2\_CID\_MPEG\_VIDEO\_MPEG4\_I\_FRAME\_QP (integer)**

Quantization parameter for an I frame for MPEG4. Valid range: from 1 to 31.

**V4L2\_CID\_MPEG\_VIDEO\_MPEG4\_MIN\_QP (integer)**

Minimum quantization parameter for MPEG4. Valid range: from 1 to 31.

**V4L2\_CID\_MPEG\_VIDEO\_MPEG4\_MAX\_QP (integer)**

Maximum quantization parameter for MPEG4. Valid range: from 1 to 31.

**V4L2\_CID\_MPEG\_VIDEO\_MPEG4\_P\_FRAME\_QP (integer)**

Quantization parameter for an P frame for MPEG4. Valid range: from 1 to 31.

**V4L2\_CID\_MPEG\_VIDEO\_MPEG4\_B\_FRAME\_QP (integer)**

Quantization parameter for an B frame for MPEG4. Valid range: from 1 to 31.

**V4L2\_CID\_MPEG\_VIDEO\_VBV\_SIZE (integer)**

The Video Buffer Verifier size in kilobytes, it is used as a limitation of frame skip. The VBV is defined in the standard as a mean to verify that the produced stream will be successfully decoded. The standard describes it as "Part of a hypothetical decoder that is conceptually connected to the output of the encoder. Its purpose is to provide a constraint on the variability of the data rate that an encoder or editing process may produce.". Applicable to the MPEG1, MPEG2, MPEG4 encoders.

**V4L2\_CID\_MPEG\_VIDEO\_VBV\_DELAY (integer)**

Sets the initial delay in milliseconds for VBV buffer control.

**V4L2\_CID\_MPEG\_VIDEO\_MV\_H\_SEARCH\_RANGE (integer)**

Horizontal search range defines maximum horizontal search area in pixels to search and match for the present Macroblock (MB) in the reference picture. This V4L2 control macro is used to set horizontal search range for motion estimation module in video encoder.

**V4L2\_CID\_MPEG\_VIDEO\_MV\_V\_SEARCH\_RANGE (integer)**

Vertical search range defines maximum vertical search area in pixels to search and match for the present Macroblock (MB) in the reference picture. This V4L2 control macro is used to set vertical search range for motion estimation module in video encoder.

**V4L2\_CID\_MPEG\_VIDEO\_FORCE\_KEY\_FRAME (button)**

Force a key frame for the next queued buffer. Applicable to encoders. This is a general, codec-agnostic keyframe control.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_CPB\_SIZE (integer)**

The Coded Picture Buffer size in kilobytes, it is used as a limitation of frame skip. The CPB is defined in the H264 standard as a mean to verify that the produced stream will be successfully decoded. Applicable to the H264 encoder.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_I\_PERIOD (integer)**

Period between I-frames in the open GOP for H264. In case of an open GOP this is the period between two I-frames. The period between IDR (Instantaneous Decoding Refresh) frames is taken from the GOP\_SIZE control. An IDR frame, which stands for Instantaneous Decoding Refresh is an I-frame after which no prior frames are referenced. This means that a stream can be restarted from an IDR frame without the need to store or decode any previous frames. Applicable to the H264 encoder.

**V4L2\_CID\_MPEG\_VIDEO\_HEADER\_MODE**

(enum)

**enum v4l2\_mpeg\_video\_header\_mode -**

Determines whether the header is returned as the first buffer or is it returned together

with the first frame. Applicable to encoders. Possible values are:

V4L2_MPEG_VIDEO_HEADER_MODE_SEPARATE	The stream header is returned separately in the first buffer.
V4L2_MPEG_VIDEO_HEADER_MODE_JOINED_WITH_1ST_FRAME	The stream header is returned together with the first encoded frame.

#### **V4L2\_CID\_MPEG\_VIDEO\_REPEAT\_SEQ\_HEADER (boolean)**

Repeat the video sequence headers. Repeating these headers makes random access to the video stream easier. Applicable to the MPEG1, 2 and 4 encoder.

#### **V4L2\_CID\_MPEG\_VIDEO\_DECODER\_MPEG4\_DEBLOCK\_FILTER (boolean)**

Enabled the deblocking post processing filter for MPEG4 decoder. Applicable to the MPEG4 decoder.

#### **V4L2\_CID\_MPEG\_VIDEO\_MPEG4\_VOP\_TIME\_RES (integer)**

vop\_time\_increment\_resolution value for MPEG4. Applicable to the MPEG4 encoder.

#### **V4L2\_CID\_MPEG\_VIDEO\_MPEG4\_VOP\_TIME\_INC (integer)**

vop\_time\_increment value for MPEG4. Applicable to the MPEG4 encoder.

#### **V4L2\_CID\_MPEG\_VIDEO\_H264\_SEI\_FRAME\_PACKING (boolean)**

Enable generation of frame packing supplemental enhancement information in the encoded bitstream. The frame packing SEI message contains the arrangement of L and R planes for 3D viewing. Applicable to the H264 encoder.

#### **V4L2\_CID\_MPEG\_VIDEO\_H264\_SEI\_FP\_CURRENT\_FRAME\_0 (boolean)**

Sets current frame as frame0 in frame packing SEI. Applicable to the H264 encoder.

#### **V4L2\_CID\_MPEG\_VIDEO\_H264\_SEI\_FP\_ARRANGEMENT\_TYPE**

(enum)

##### **enum v4l2\_mpeg\_video\_h264\_sei\_fp\_arrangement\_type -**

Frame packing arrangement type for H264 SEI. Applicable to the H264 encoder. Possible values are:

V4L2_MPEG_VIDEO_H264_SEI_FP_ARRANGEMENT_TYPE_CHEKERBOARD	Pixels are alternatively from L and R.
V4L2_MPEG_VIDEO_H264_SEI_FP_ARRANGEMENT_TYPE_COLUMN	L and R are interlaced by column.
V4L2_MPEG_VIDEO_H264_SEI_FP_ARRANGEMENT_TYPE_ROW	L and R are interlaced by row.
V4L2_MPEG_VIDEO_H264_SEI_FP_ARRANGEMENT_TYPE_SIDE_BY_SIDE	L is on the left, R on the right.
V4L2_MPEG_VIDEO_H264_SEI_FP_ARRANGEMENT_TYPE_TOP_BOTTOM	L is on top, R on bottom.
V4L2_MPEG_VIDEO_H264_SEI_FP_ARRANGEMENT_TYPE_TEMPORAL	One view per frame.

#### **V4L2\_CID\_MPEG\_VIDEO\_H264\_FMO (boolean)**

Enables flexible macroblock ordering in the encoded bitstream. It is a technique used for restructuring the ordering of macroblocks in pictures. Applicable to the H264 encoder.

#### **V4L2\_CID\_MPEG\_VIDEO\_H264\_FMO\_MAP\_TYPE**

(enum)

##### **enum v4l2\_mpeg\_video\_h264\_fmo\_map\_type -**

When using FMO, the map type divides the image in different scan patterns of macroblocks. Applicable to the H264 encoder. Possible values are:

V4L2_MPEG_VIDEO_H264_FMO_MAP_TYPE_INTERLEAVED_SLICES	Slices are interleaved one after other with macroblocks in run length order.
V4L2_MPEG_VIDEO_H264_FMO_MAP_TYPE_SCATTERED_SLICES	Scatters the macroblocks based on a mathematical function known to both encoder and decoder.
V4L2_MPEG_VIDEO_H264_FMO_MAP_TYPE_FOREGROUND_WITH_LEFT_OVER	Macroblocks arranged in rectangular areas or regions of interest.
V4L2_MPEG_VIDEO_H264_FMO_MAP_TYPE_BOX_OUT	Slice groups grow in a cyclic way from centre to outwards.
V4L2_MPEG_VIDEO_H264_FMO_MAP_TYPE_RASTER_SCAN	Slice groups grow in raster scan pattern from left to right.
V4L2_MPEG_VIDEO_H264_FMO_MAP_TYPE_WIPE_SCAN	Slice groups grow in wipe scan pattern from top to bottom.
V4L2_MPEG_VIDEO_H264_FMO_MAP_TYPE_EXPLICIT	User defined map type.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_FMO\_SLICE\_GROUP (integer)**

Number of slice groups in FMO. Applicable to the H264 encoder.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_FMO\_CHANGE\_DIRECTION  
(enum)****enum v4l2\_mpeg\_video\_h264\_fmo\_change\_dir -**

Specifies a direction of the slice group change for raster and wipe maps. Applicable to the H264 encoder. Possible values are:

V4L2_MPEG_VIDEO_H264_FMO_CHANGE_DIR_RIGHT	Raster scan or wipe right.
V4L2_MPEG_VIDEO_H264_FMO_CHANGE_DIR_LEFT	Reverse raster scan or wipe left.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_FMO\_CHANGE\_RATE (integer)**

Specifies the size of the first slice group for raster and wipe map. Applicable to the H264 encoder.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_FMO\_RUN\_LENGTH (integer)**

Specifies the number of consecutive macroblocks for the interleaved map. Applicable to the H264 encoder.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_ASO (boolean)**

Enables arbitrary slice ordering in encoded bitstream. Applicable to the H264 encoder.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_ASO\_SLICE\_ORDER (integer)**

Specifies the slice order in ASO. Applicable to the H264 encoder. The supplied 32-bit integer is interpreted as follows (bit 0 = least significant bit):

Bit 0:15	Slice ID
Bit 16:32	Slice position or order

**V4L2\_CID\_MPEG\_VIDEO\_H264\_HIERARCHICAL\_CODING (boolean)**

Enables H264 hierarchical coding. Applicable to the H264 encoder.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_HIERARCHICAL\_CODING\_TYPE**  
(enum)**enum v4l2\_mpeg\_video\_h264\_hierarchical\_coding\_type -**

Specifies the hierarchical coding type. Applicable to the H264 encoder. Possible values are:

V4L2_MPEG_VIDEO_H264_HIERARCHICAL_CODING_B	Hierarchical B coding.
V4L2_MPEG_VIDEO_H264_HIERARCHICAL_CODING_P	Hierarchical P coding.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_HIERARCHICAL\_CODING\_LAYER (integer)**

Specifies the number of hierarchical coding layers. Applicable to the H264 encoder.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_HIERARCHICAL\_CODING\_LAYER\_QP (integer)**

Specifies a user defined QP for each layer. Applicable to the H264 encoder. The supplied 32-bit integer is interpreted as follows (bit 0 = least significant bit):

Bit 0:15	QP value
Bit 16:32	Layer number

**V4L2\_CID\_MPEG\_VIDEO\_H264\_HIER\_CODING\_L0\_BR (integer)**

Indicates bit rate (bps) for hierarchical coding layer 0 for H264 encoder.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_HIER\_CODING\_L1\_BR (integer)**

Indicates bit rate (bps) for hierarchical coding layer 1 for H264 encoder.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_HIER\_CODING\_L2\_BR (integer)**

Indicates bit rate (bps) for hierarchical coding layer 2 for H264 encoder.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_HIER\_CODING\_L3\_BR (integer)**

Indicates bit rate (bps) for hierarchical coding layer 3 for H264 encoder.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_HIER\_CODING\_L4\_BR (integer)**

Indicates bit rate (bps) for hierarchical coding layer 4 for H264 encoder.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_HIER\_CODING\_L5\_BR (integer)**

Indicates bit rate (bps) for hierarchical coding layer 5 for H264 encoder.

**V4L2\_CID\_MPEG\_VIDEO\_H264\_HIER\_CODING\_L6\_BR (integer)**

Indicates bit rate (bps) for hierarchical coding layer 6 for H264 encoder.

**V4L2\_CID\_FWHT\_I\_FRAME\_QP (integer)**

Quantization parameter for an I frame for FWHT. Valid range: from 1 to 31.

**V4L2\_CID\_FWHT\_P\_FRAME\_QP (integer)**

Quantization parameter for a P frame for FWHT. Valid range: from 1 to 31.

## MFC 5.1 MPEG Controls

The following MPEG class controls deal with MPEG decoding and encoding settings that are specific to the Multi Format Codec 5.1 device present in the S5P family of SoCs by Samsung.

### MFC 5.1 Control IDs

#### **V4L2\_CID\_MPEG\_MFC51\_VIDEO\_DECODER\_H264\_DISPLAY\_DELAY\_ENABLE (boolean)**

If the display delay is enabled then the decoder is forced to return a CAPTURE buffer (decoded frame) after processing a certain number of OUTPUT buffers. The delay can be set through V4L2\_CID\_MPEG\_MFC51\_VIDEO\_DECODER\_H264\_DISPLAY\_DELAY. This feature can be used for example for generating thumbnails of videos. Applicable to the H264 decoder.

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**Note:** This control is deprecated. Use the standard V4L2\_CID\_MPEG\_VIDEO\_DEC\_DISPLAY\_DELAY\_ENABLE control instead.

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#### **V4L2\_CID\_MPEG\_MFC51\_VIDEO\_DECODER\_H264\_DISPLAY\_DELAY (integer)**

Display delay value for H264 decoder. The decoder is forced to return a decoded frame after the set 'display delay' number of frames. If this number is low it may result in frames returned out of display order, in addition the hardware may still be using the returned buffer as a reference picture for subsequent frames.

---

**Note:** This control is deprecated. Use the standard V4L2\_CID\_MPEG\_VIDEO\_DEC\_DISPLAY\_DELAY control instead.

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#### **V4L2\_CID\_MPEG\_MFC51\_VIDEO\_H264\_NUM\_REF\_PIC\_FOR\_P (integer)**

The number of reference pictures used for encoding a P picture. Applicable to the H264 encoder.

#### **V4L2\_CID\_MPEG\_MFC51\_VIDEO\_PADDING (boolean)**

Padding enable in the encoder - use a color instead of repeating border pixels. Applicable to encoders.

#### **V4L2\_CID\_MPEG\_MFC51\_VIDEO\_PADDING\_YUV (integer)**

Padding color in the encoder. Applicable to encoders. The supplied 32-bit integer is interpreted as follows (bit 0 = least significant bit):

Bit 0:7	V chrominance information
Bit 8:15	U chrominance information
Bit 16:23	Y luminance information
Bit 24:31	Must be zero.

#### **V4L2\_CID\_MPEG\_MFC51\_VIDEO\_RCREACTION\_COEFF (integer)**

Reaction coefficient for MFC rate control. Applicable to encoders.

---

**Note:**

1. Valid only when the frame level RC is enabled.

2. For tight CBR, this field must be small (ex. 2 ~ 10). For VBR, this field must be large (ex. 100 ~ 1000).
  3. It is not recommended to use the greater number than FRAME\_RATE \* (10^9 / BIT\_RATE).
- 

#### **V4L2\_CID\_MPEG\_MFC51\_VIDEO\_H264\_ADAPTIVE\_RC\_DARK (boolean)**

Adaptive rate control for dark region. Valid only when H.264 and macroblock level RC is enabled (V4L2\_CID\_MPEG\_VIDEO\_MB\_RC\_ENABLE). Applicable to the H264 encoder.

#### **V4L2\_CID\_MPEG\_MFC51\_VIDEO\_H264\_ADAPTIVE\_RC\_SMOOTH (boolean)**

Adaptive rate control for smooth region. Valid only when H.264 and macroblock level RC is enabled (V4L2\_CID\_MPEG\_VIDEO\_MB\_RC\_ENABLE). Applicable to the H264 encoder.

#### **V4L2\_CID\_MPEG\_MFC51\_VIDEO\_H264\_ADAPTIVE\_RC\_STATIC (boolean)**

Adaptive rate control for static region. Valid only when H.264 and macroblock level RC is enabled (V4L2\_CID\_MPEG\_VIDEO\_MB\_RC\_ENABLE). Applicable to the H264 encoder.

#### **V4L2\_CID\_MPEG\_MFC51\_VIDEO\_H264\_ADAPTIVE\_RC\_ACTIVITY (boolean)**

Adaptive rate control for activity region. Valid only when H.264 and macroblock level RC is enabled (V4L2\_CID\_MPEG\_VIDEO\_MB\_RC\_ENABLE). Applicable to the H264 encoder.

#### **V4L2\_CID\_MPEG\_MFC51\_VIDEO\_FRAME\_SKIP\_MODE**

(enum)

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<b>Note:</b>	This control is deprecated.	Use the standard
V4L2_CID_MPEG_VIDEO_FRAME_SKIP_MODE control instead.		

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#### **enum v4l2\_mpeg\_mfc51\_video\_frame\_skip\_mode -**

Indicates in what conditions the encoder should skip frames. If encoding a frame would cause the encoded stream to be larger then a chosen data limit then the frame will be skipped. Possible values are:

V4L2_MPEG_MFC51_VIDEO_FRAME_SKIP_MODE_DISABLED	Frame skip mode is disabled.
V4L2_MPEG_MFC51_VIDEO_FRAME_SKIP_MODE_LEVEL_LIMIT	Frame skip mode enabled and buffer limit is set by the chosen level and is defined by the standard.
V4L2_MPEG_MFC51_VIDEO_FRAME_SKIP_MODE_BUF_LIMIT	Frame skip mode enabled and buffer limit is set by the VBV (MPEG1/2/4) or CPB (H264) buffer size control.

#### **V4L2\_CID\_MPEG\_MFC51\_VIDEO\_RC\_FIXED\_TARGET\_BIT (integer)**

Enable rate-control with fixed target bit. If this setting is enabled, then the rate control logic of the encoder will calculate the average bitrate for a GOP and keep it below or equal the set bitrate target. Otherwise the rate control logic calculates the overall average bitrate for the stream and keeps it below or equal to the set bitrate. In the first case the average bitrate for the whole stream will be smaller then the set bitrate. This is caused because the average is calculated for smaller number of frames, on the other hand enabling this setting will ensure that the stream will meet tight bandwidth constraints. Applicable to encoders.

#### **V4L2\_CID\_MPEG\_MFC51\_VIDEO\_FORCE\_FRAME\_TYPE**

(enum)

**enum v4l2\_mpeg\_mfc51\_video\_force\_frame\_type -**

Force a frame type for the next queued buffer. Applicable to encoders. Possible values are:

V4L2_MPEG_MFC51_FORCE_FRAME_TYPE_DISABLED	Forcing a specific frame type disabled.
V4L2_MPEG_MFC51_FORCE_FRAME_TYPE_I_FRAME	Force an I-frame.
V4L2_MPEG_MFC51_FORCE_FRAME_TYPE_NOT_CODED	Force a non-coded frame.

**CX2341x MPEG Controls**

The following MPEG class controls deal with MPEG encoding settings that are specific to the Conexant CX23415 and CX23416 MPEG encoding chips.

**CX2341x Control IDs****V4L2\_CID\_MPEG\_CX2341X\_VIDEO\_SPATIAL\_FILTER\_MODE**

(enum)

**enum v4l2\_mpeg\_cx2341x\_video\_spatial\_filter\_mode -**

Sets the Spatial Filter mode (default MANUAL). Possible values are:

V4L2_MPEG_CX2341X_VIDEO_SPATIAL_FILTER_MODE_MANUAL	Choose the filter manually
V4L2_MPEG_CX2341X_VIDEO_SPATIAL_FILTER_MODE_AUTO	Choose the filter automatically

**V4L2\_CID\_MPEG\_CX2341X\_VIDEO\_SPATIAL\_FILTER (integer (0-15))**

The setting for the Spatial Filter. 0 = off, 15 = maximum. (Default is 0.)

**V4L2\_CID\_MPEG\_CX2341X\_VIDEO\_LUMA\_SPATIAL\_FILTER\_TYPE**

(enum)

**enum v4l2\_mpeg\_cx2341x\_video\_luma\_spatial\_filter\_type -**

Select the algorithm to use for the Luma Spatial Filter (default 1D\_HOR). Possible values:

V4L2_MPEG_CX2341X_VIDEO_LUMA_SPATIAL_FILTER_TYPE_OFF	No filter
V4L2_MPEG_CX2341X_VIDEO_LUMA_SPATIAL_FILTER_TYPE_1D_HOR	One-dimensional horizontal
V4L2_MPEG_CX2341X_VIDEO_LUMA_SPATIAL_FILTER_TYPE_1D_VERT	One-dimensional vertical
V4L2_MPEG_CX2341X_VIDEO_LUMA_SPATIAL_FILTER_TYPE_2D_HV_SEPARABLE	Two-dimensional separable
V4L2_MPEG_CX2341X_VIDEO_LUMA_SPATIAL_FILTER_TYPE_2D_SYM_NON_SEPARABLE	Two-dimensional symmetrical non-separable

**V4L2\_CID\_MPEG\_CX2341X\_VIDEO\_CHROMA\_SPATIAL\_FILTER\_TYPE**

(enum)

**enum v4l2\_mpeg\_cx2341x\_video\_chroma\_spatial\_filter\_type -**

Select the algorithm for the Chroma Spatial Filter (default 1D\_HOR). Possible values are:

V4L2_MPEG_CX2341X_VIDEO_CHROMA_SPATIAL_FILTER_TYPE_OFF	No filter
V4L2_MPEG_CX2341X_VIDEO_CHROMA_SPATIAL_FILTER_TYPE_1D_HOR	One-dimensional horizontal

**V4L2\_CID\_MPEG\_CX2341X\_VIDEO\_TEMPORAL\_FILTER\_MODE**

(enum)

**enum v4l2\_mpeg\_cx2341x\_video\_temporal\_filter\_mode -**

Sets the Temporal Filter mode (default MANUAL). Possible values are:

V4L2_MPEG_CX2341X_VIDEO_TEMPORAL_FILTER_MODE_MANUAL	Choose the filter manually
V4L2_MPEG_CX2341X_VIDEO_TEMPORAL_FILTER_MODE_AUTO	Choose the filter automatically

**V4L2\_CID\_MPEG\_CX2341X\_VIDEO\_TEMPORAL\_FILTER (integer (0-31))**

The setting for the Temporal Filter. 0 = off, 31 = maximum. (Default is 8 for full-scale capturing and 0 for scaled capturing.)

**V4L2\_CID\_MPEG\_CX2341X\_VIDEO\_MEDIAN\_FILTER\_TYPE**

(enum)

**enum v4l2\_mpeg\_cx2341x\_video\_median\_filter\_type -**

Median Filter Type (default OFF). Possible values are:

V4L2_MPEG_CX2341X_VIDEO_MEDIAN_FILTER_TYPE_OFF	No filter
V4L2_MPEG_CX2341X_VIDEO_MEDIAN_FILTER_TYPE_HOR	Horizontal filter
V4L2_MPEG_CX2341X_VIDEO_MEDIAN_FILTER_TYPE_VERT	Vertical filter
V4L2_MPEG_CX2341X_VIDEO_MEDIAN_FILTER_TYPE_HOR_VERT	Horizontal and vertical filter
V4L2_MPEG_CX2341X_VIDEO_MEDIAN_FILTER_TYPE_DIAG	Diagonal filter

**V4L2\_CID\_MPEG\_CX2341X\_VIDEO\_LUMA\_MEDIAN\_FILTER\_BOTTOM (integer (0-255))**

Threshold above which the luminance median filter is enabled (default 0)

**V4L2\_CID\_MPEG\_CX2341X\_VIDEO\_LUMA\_MEDIAN\_FILTER\_TOP (integer (0-255))**

Threshold below which the luminance median filter is enabled (default 255)

**V4L2\_CID\_MPEG\_CX2341X\_VIDEO\_CHROMA\_MEDIAN\_FILTER\_BOTTOM (integer (0-255))**

Threshold above which the chroma median filter is enabled (default 0)

**V4L2\_CID\_MPEG\_CX2341X\_VIDEO\_CHROMA\_MEDIAN\_FILTER\_TOP (integer (0-255))**

Threshold below which the chroma median filter is enabled (default 255)

**V4L2\_CID\_MPEG\_CX2341X\_STREAM\_INSERT\_NAV\_PACKETS (boolean)**

The CX2341X MPEG encoder can insert one empty MPEG-2 PES packet into the stream between every four video frames. The packet size is 2048 bytes, including the packet\_start\_code\_prefix and stream\_id fields. The stream\_id is 0xBF (private stream 2). The payload consists of 0x00 bytes, to be filled in by the application. 0 = do not insert, 1 = insert packets.

## VPX Control Reference

The VPX controls include controls for encoding parameters of VPx video codec.

### VPX Control IDs

#### **V4L2\_CID\_MPEG\_VIDEO\_VPX\_NUM\_PARTITIONS** (enum)

##### **enum v4l2\_vp8\_num\_partitions -**

The number of token partitions to use in VP8 encoder. Possible values are:

V4L2_CID_MPEG_VIDEO_VPX_1_PARTITION	1 coefficient partition
V4L2_CID_MPEG_VIDEO_VPX_2_PARTITIONS	2 coefficient partitions
V4L2_CID_MPEG_VIDEO_VPX_4_PARTITIONS	4 coefficient partitions
V4L2_CID_MPEG_VIDEO_VPX_8_PARTITIONS	8 coefficient partitions

#### **V4L2\_CID\_MPEG\_VIDEO\_VPX\_IMD\_DISABLE\_4X4 (boolean)**

Setting this prevents intra 4x4 mode in the intra mode decision.

#### **V4L2\_CID\_MPEG\_VIDEO\_VPX\_NUM\_REF\_FRAMES** (enum)

##### **enum v4l2\_vp8\_num\_ref\_frames -**

The number of reference pictures for encoding P frames. Possible values are:

V4L2_CID_MPEG_VIDEO_VPX_1_REF_FRAME	Last encoded frame will be searched
V4L2_CID_MPEG_VIDEO_VPX_2_REF_FRAME	Two frames will be searched among the last encoded frame, the golden frame and the alternate reference (altref) frame. The encoder implementation will decide which two are chosen.
V4L2_CID_MPEG_VIDEO_VPX_3_REF_FRAME	The last encoded frame, the golden frame and the altref frame will be searched.

#### **V4L2\_CID\_MPEG\_VIDEO\_VPX\_FILTER\_LEVEL (integer)**

Indicates the loop filter level. The adjustment of the loop filter level is done via a delta value against a baseline loop filter value.

#### **V4L2\_CID\_MPEG\_VIDEO\_VPX\_FILTER\_SHARPNESS (integer)**

This parameter affects the loop filter. Anything above zero weakens the deblocking effect on the loop filter.

#### **V4L2\_CID\_MPEG\_VIDEO\_VPX\_GOLDEN\_FRAME\_REF\_PERIOD (integer)**

Sets the refresh period for the golden frame. The period is defined in number of frames. For a value of 'n', every nth frame starting from the first key frame will be taken as a golden frame. For eg. for encoding sequence of 0, 1, 2, 3, 4, 5, 6, 7 where the golden frame refresh period is set as 4, the frames 0, 4, 8 etc will be taken as the golden frames as frame 0 is always a key frame.

#### **V4L2\_CID\_MPEG\_VIDEO\_VPX\_GOLDEN\_FRAME\_SEL** (enum)

**enum v4l2\_vp8\_golden\_frame\_sel -**

Selects the golden frame for encoding. Possible values are:

V4L2_CID_MPEG_VIDEO_VPX_GOLDEN_FRAME_USE_PREV	Use the (n-2)th frame as a golden frame, current frame index being 'n'.
V4L2_CID_MPEG_VIDEO_VPX_GOLDEN_FRAME_USE_REF_PERIOD	Use the previous specific frame indicated by V4L2_CID_MPEG_VIDEO_VPX_GOLDEN_FRAME_REF_PERIOD as a golden frame.

**V4L2\_CID\_MPEG\_VIDEO\_VPX\_MIN\_QP (integer)**

Minimum quantization parameter for VP8.

**V4L2\_CID\_MPEG\_VIDEO\_VPX\_MAX\_QP (integer)**

Maximum quantization parameter for VP8.

**V4L2\_CID\_MPEG\_VIDEO\_VPX\_I\_FRAME\_QP (integer)**

Quantization parameter for an I frame for VP8.

**V4L2\_CID\_MPEG\_VIDEO\_VPX\_P\_FRAME\_QP (integer)**

Quantization parameter for a P frame for VP8.

**V4L2\_CID\_MPEG\_VIDEO\_VP8\_PROFILE**

(enum)

**enum v4l2\_mpeg\_video\_vp8\_profile -**

This control allows selecting the profile for VP8 encoder. This is also used to enumerate supported profiles by VP8 encoder or decoder. Possible values are:

V4L2_MPEG_VIDEO_VP8_PROFILE_0	Profile 0
V4L2_MPEG_VIDEO_VP8_PROFILE_1	Profile 1
V4L2_MPEG_VIDEO_VP8_PROFILE_2	Profile 2
V4L2_MPEG_VIDEO_VP8_PROFILE_3	Profile 3

**V4L2\_CID\_MPEG\_VIDEO\_VP9\_PROFILE**

(enum)

**enum v4l2\_mpeg\_video\_vp9\_profile -**

This control allows selecting the profile for VP9 encoder. This is also used to enumerate supported profiles by VP9 encoder or decoder. Possible values are:

V4L2_MPEG_VIDEO_VP9_PROFILE_0	Profile 0
V4L2_MPEG_VIDEO_VP9_PROFILE_1	Profile 1
V4L2_MPEG_VIDEO_VP9_PROFILE_2	Profile 2
V4L2_MPEG_VIDEO_VP9_PROFILE_3	Profile 3

**V4L2\_CID\_MPEG\_VIDEO\_VP9\_LEVEL (enum)****enum v4l2\_mpeg\_video\_vp9\_level -**

This control allows selecting the level for VP9 encoder. This is also used to enumerate supported levels by VP9 encoder or decoder. More information can be found at [webmproject](#). Possible values are:

V4L2_MPEG_VIDEO_VP9_LEVEL_1_0	Level 1
V4L2_MPEG_VIDEO_VP9_LEVEL_1_1	Level 1.1
V4L2_MPEG_VIDEO_VP9_LEVEL_2_0	Level 2
V4L2_MPEG_VIDEO_VP9_LEVEL_2_1	Level 2.1
V4L2_MPEG_VIDEO_VP9_LEVEL_3_0	Level 3
V4L2_MPEG_VIDEO_VP9_LEVEL_3_1	Level 3.1
V4L2_MPEG_VIDEO_VP9_LEVEL_4_0	Level 4
V4L2_MPEG_VIDEO_VP9_LEVEL_4_1	Level 4.1
V4L2_MPEG_VIDEO_VP9_LEVEL_5_0	Level 5
V4L2_MPEG_VIDEO_VP9_LEVEL_5_1	Level 5.1
V4L2_MPEG_VIDEO_VP9_LEVEL_5_2	Level 5.2
V4L2_MPEG_VIDEO_VP9_LEVEL_6_0	Level 6
V4L2_MPEG_VIDEO_VP9_LEVEL_6_1	Level 6.1
V4L2_MPEG_VIDEO_VP9_LEVEL_6_2	Level 6.2

## High Efficiency Video Coding (HEVC/H.265) Control Reference

The HEVC/H.265 controls include controls for encoding parameters of HEVC/H.265 video codec.

### HEVC/H.265 Control IDs

#### **V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MIN\_QP (integer)**

Minimum quantization parameter for HEVC. Valid range: from 0 to 51 for 8 bit and from 0 to 63 for 10 bit.

#### **V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MAX\_QP (integer)**

Maximum quantization parameter for HEVC. Valid range: from 0 to 51 for 8 bit and from 0 to 63 for 10 bit.

#### **V4L2\_CID\_MPEG\_VIDEO\_HEVC\_I\_FRAME\_QP (integer)**

Quantization parameter for an I frame for HEVC. Valid range: [V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MIN\_QP, V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MAX\_QP].

#### **V4L2\_CID\_MPEG\_VIDEO\_HEVC\_P\_FRAME\_QP (integer)**

Quantization parameter for a P frame for HEVC. Valid range: [V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MIN\_QP, V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MAX\_QP].

#### **V4L2\_CID\_MPEG\_VIDEO\_HEVC\_B\_FRAME\_QP (integer)**

Quantization parameter for a B frame for HEVC. Valid range: [V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MIN\_QP, V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MAX\_QP].

#### **V4L2\_CID\_MPEG\_VIDEO\_HEVC\_I\_FRAME\_MIN\_QP (integer)**

Minimum quantization parameter for the HEVC I frame to limit I frame quality to a range. Valid range: from 0 to 51 for 8 bit and from 0 to 63 for 10 bit. If V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MIN\_QP is also set, the quantization parameter should be chosen to meet both requirements.

#### **V4L2\_CID\_MPEG\_VIDEO\_HEVC\_I\_FRAME\_MAX\_QP (integer)**

Maximum quantization parameter for the HEVC I frame to limit I frame quality to a range. Valid range: from 0 to 51 for 8 bit and from 0 to 63 for 10 bit. If

V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MAX\_QP is also set, the quantization parameter should be chosen to meet both requirements.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_P\_FRAME\_MIN\_QP (integer)**

Minimum quantization parameter for the HEVC P frame to limit P frame quality to a range. Valid range: from 0 to 51 for 8 bit and from 0 to 63 for 10 bit. If V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MIN\_QP is also set, the quantization parameter should be chosen to meet both requirements.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_P\_FRAME\_MAX\_QP (integer)**

Maximum quantization parameter for the HEVC P frame to limit P frame quality to a range. Valid range: from 0 to 51 for 8 bit and from 0 to 63 for 10 bit. If V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MAX\_QP is also set, the quantization parameter should be chosen to meet both requirements.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_B\_FRAME\_MIN\_QP (integer)**

Minimum quantization parameter for the HEVC B frame to limit B frame quality to a range. Valid range: from 0 to 51 for 8 bit and from 0 to 63 for 10 bit. If V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MIN\_QP is also set, the quantization parameter should be chosen to meet both requirements.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_B\_FRAME\_MAX\_QP (integer)**

Maximum quantization parameter for the HEVC B frame to limit B frame quality to a range. Valid range: from 0 to 51 for 8 bit and from 0 to 63 for 10 bit. If V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MAX\_QP is also set, the quantization parameter should be chosen to meet both requirements.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_HIER\_QP (boolean)**

HIERARCHICAL\_QP allows the host to specify the quantization parameter values for each temporal layer through HIERARCHICAL\_QP\_LAYER. This is valid only if HIERARCHICAL\_CODING\_LAYER is greater than 1. Setting the control value to 1 enables setting of the QP values for the layers.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_HIER\_CODING\_TYPE**

(enum)

**enum v4l2\_mpeg\_video\_hevc\_hier\_coding\_type -**

Selects the hierarchical coding type for encoding. Possible values are:

V4L2_MPEG_VIDEO_HEVC_HIERARCHICAL_CODING_B	Use the B frame for hierarchical coding.
V4L2_MPEG_VIDEO_HEVC_HIERARCHICAL_CODING_P	Use the P frame for hierarchical coding.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_HIER\_CODING\_LAYER (integer)**

Selects the hierarchical coding layer. In normal encoding (non-hierarchical coding), it should be zero. Possible values are [0, 6]. 0 indicates HIERARCHICAL CODING LAYER 0, 1 indicates HIERARCHICAL CODING LAYER 1 and so on.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_HIER\_CODING\_L0\_QP (integer)**

Indicates quantization parameter for hierarchical coding layer 0. Valid range: [V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MIN\_QP, V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MAX\_QP].

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_HIER\_CODING\_L1\_QP (integer)**

Indicates quantization parameter for hierarchical coding layer 1. Valid range: [V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MIN\_QP, V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MAX\_QP].

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_HIER\_CODING\_L2\_QP (integer)**

Indicates quantization parameter for hierarchical coding layer 2. Valid range:

[V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MIN\_QP, V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MAX\_QP].

#### **V4L2\_CID\_MPEG\_VIDEO\_HEVC\_HIER\_CODING\_L3\_QP (integer)**

Indicates quantization parameter for hierarchical coding layer 3. Valid range: [V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MIN\_QP, V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MAX\_QP].

#### **V4L2\_CID\_MPEG\_VIDEO\_HEVC\_HIER\_CODING\_L4\_QP (integer)**

Indicates quantization parameter for hierarchical coding layer 4. Valid range: [V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MIN\_QP, V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MAX\_QP].

#### **V4L2\_CID\_MPEG\_VIDEO\_HEVC\_HIER\_CODING\_L5\_QP (integer)**

Indicates quantization parameter for hierarchical coding layer 5. Valid range: [V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MIN\_QP, V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MAX\_QP].

#### **V4L2\_CID\_MPEG\_VIDEO\_HEVC\_HIER\_CODING\_L6\_QP (integer)**

Indicates quantization parameter for hierarchical coding layer 6. Valid range: [V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MIN\_QP, V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MAX\_QP].

#### **V4L2\_CID\_MPEG\_VIDEO\_HEVC\_PROFILE**

(enum)

##### **enum v4l2\_mpeg\_video\_hevc\_profile -**

Select the desired profile for HEVC encoder.

V4L2_MPEG_VIDEO_HEVC_PROFILE_MAIN	Main profile.
V4L2_MPEG_VIDEO_HEVC_PROFILE_MAIN_STILL_PICTURE	Main still picture profile.
V4L2_MPEG_VIDEO_HEVC_PROFILE_MAIN_10	Main 10 profile.

#### **V4L2\_CID\_MPEG\_VIDEO\_HEVC\_LEVEL**

(enum)

##### **enum v4l2\_mpeg\_video\_hevc\_level -**

Selects the desired level for HEVC encoder.

V4L2_MPEG_VIDEO_HEVC_LEVEL_1	Level 1.0
V4L2_MPEG_VIDEO_HEVC_LEVEL_2	Level 2.0
V4L2_MPEG_VIDEO_HEVC_LEVEL_2_1	Level 2.1
V4L2_MPEG_VIDEO_HEVC_LEVEL_3	Level 3.0
V4L2_MPEG_VIDEO_HEVC_LEVEL_3_1	Level 3.1
V4L2_MPEG_VIDEO_HEVC_LEVEL_4	Level 4.0
V4L2_MPEG_VIDEO_HEVC_LEVEL_4_1	Level 4.1
V4L2_MPEG_VIDEO_HEVC_LEVEL_5	Level 5.0
V4L2_MPEG_VIDEO_HEVC_LEVEL_5_1	Level 5.1
V4L2_MPEG_VIDEO_HEVC_LEVEL_5_2	Level 5.2
V4L2_MPEG_VIDEO_HEVC_LEVEL_6	Level 6.0
V4L2_MPEG_VIDEO_HEVC_LEVEL_6_1	Level 6.1
V4L2_MPEG_VIDEO_HEVC_LEVEL_6_2	Level 6.2

#### **V4L2\_CID\_MPEG\_VIDEO\_HEVC\_FRAME\_RATE\_RESOLUTION (integer)**

Indicates the number of evenly spaced subintervals, called ticks, within one second. This is a 16 bit unsigned integer and has a maximum value up to 0xffff and a minimum value of 1.

#### **V4L2\_CID\_MPEG\_VIDEO\_HEVC\_TIER**

(enum)

**enum v4l2\_mpeg\_video\_hevc\_tier -**

TIER\_FLAG specifies tiers information of the HEVC encoded picture. Tier were made to deal with applications that differ in terms of maximum bit rate. Setting the flag to 0 selects HEVC tier as Main tier and setting this flag to 1 indicates High tier. High tier is for applications requiring high bit rates.

V4L2_MPEG_VIDEO_HEVC_TIER_MAIN	Main tier.
V4L2_MPEG_VIDEO_HEVC_TIER_HIGH	High tier.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MAX\_PARTITION\_DEPTH (integer)**

Selects HEVC maximum coding unit depth.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_LOOP\_FILTER\_MODE**

(enum)

**enum v4l2\_mpeg\_video\_hevc\_loop\_filter\_mode -**

Loop filter mode for HEVC encoder. Possible values are:

V4L2_MPEG_VIDEO_HEVC_LOOP_FILTER_MODE_DISABLED	Loop filter is disabled.
V4L2_MPEG_VIDEO_HEVC_LOOP_FILTER_MODE_ENABLED	Loop filter is enabled.
V4L2_MPEG_VIDEO_HEVC_LOOP_FILTER_MODE_DISABLED_AT_SLICE_BOUNDARY	Loop filter is disabled at the slice boundary.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_LF\_BETA\_OFFSET\_DIV2 (integer)**

Selects HEVC loop filter beta offset. The valid range is [-6, +6].

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_LF\_TC\_OFFSET\_DIV2 (integer)**

Selects HEVC loop filter tc offset. The valid range is [-6, +6].

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_REFRESH\_TYPE**

(enum)

**enum v4l2\_mpeg\_video\_hevc\_hier\_refresh\_type -**

Selects refresh type for HEVC encoder. Host has to specify the period into V4L2\_CID\_MPEG\_VIDEO\_HEVC\_REFRESH\_PERIOD.

V4L2_MPEG_VIDEO_HEVC_REFRESH_NONE	Use the B frame for hierarchical coding.
V4L2_MPEG_VIDEO_HEVC_REFRESH_CRA	Use CRA (Clean Random Access Unit) picture encoding.
V4L2_MPEG_VIDEO_HEVC_REFRESH_IDR	Use IDR (Instantaneous Decoding Refresh) picture encoding.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_REFRESH\_PERIOD (integer)**

Selects the refresh period for HEVC encoder. This specifies the number of I pictures between two CRA/IDR pictures. This is valid only if REFRESH\_TYPE is not 0.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_LOSSLESS CU (boolean)**

Indicates HEVC lossless encoding. Setting it to 0 disables lossless encoding. Setting it to 1 enables lossless encoding.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_CONST\_INTRA\_PRED (boolean)**

Indicates constant intra prediction for HEVC encoder. Specifies the constrained intra prediction in which intra largest coding unit (LCU) prediction is performed by using residual data and decoded samples of neighboring intra LCU only. Setting the value to 1 enables constant intra prediction and setting the value to 0 disables constant intra prediction.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_WAVEFRONT (boolean)**

Indicates waveform parallel processing for HEVC encoder. Setting it to 0 disables the feature and setting it to 1 enables the waveform parallel processing.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_GENERAL\_PB (boolean)**

Setting the value to 1 enables combination of P and B frame for HEVC encoder.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_TEMPORAL\_ID (boolean)**

Indicates temporal identifier for HEVC encoder which is enabled by setting the value to 1.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_STRONG\_SMOOTHING (boolean)**

Indicates bi-linear interpolation is conditionally used in the intra prediction filtering process in the CVS when set to 1. Indicates bi-linear interpolation is not used in the CVS when set to 0.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_MAX\_NUM\_MERGE\_MV\_MINUS1 (integer)**

Indicates maximum number of merge candidate motion vectors. Values are from 0 to 4.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_TMV\_PREDICTION (boolean)**

Indicates temporal motion vector prediction for HEVC encoder. Setting it to 1 enables the prediction. Setting it to 0 disables the prediction.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_WITHOUT\_STARTCODE (boolean)**

Specifies if HEVC generates a stream with a size of the length field instead of start code pattern. The size of the length field is configurable through the V4L2\_CID\_MPEG\_VIDEO\_HEVC\_SIZE\_OF\_LENGTH\_FIELD control. Setting the value to 0 disables encoding without startcode pattern. Setting the value to 1 will enable encoding without startcode pattern.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_SIZE\_OF\_LENGTH\_FIELD (enum)****enum v4l2\_mpeg\_video\_hevc\_size\_of\_length\_field -**

Indicates the size of length field. This is valid when encoding WITHOUT\_STARTCODE\_ENABLE is enabled.

V4L2_MPEG_VIDEO_HEVC_SIZE_0	Generate start code pattern (Normal).
V4L2_MPEG_VIDEO_HEVC_SIZE_1	Generate size of length field instead of start code pattern and length is 1.
V4L2_MPEG_VIDEO_HEVC_SIZE_2	Generate size of length field instead of start code pattern and length is 2.
V4L2_MPEG_VIDEO_HEVC_SIZE_4	Generate size of length field instead of start code pattern and length is 4.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_HIER\_CODING\_L0\_BR (integer)**

Indicates bit rate for hierarchical coding layer 0 for HEVC encoder.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_HIER\_CODING\_L1\_BR (integer)**

Indicates bit rate for hierarchical coding layer 1 for HEVC encoder.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_HIER\_CODING\_L2\_BR (integer)**

Indicates bit rate for hierarchical coding layer 2 for HEVC encoder.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_HIER\_CODING\_L3\_BR (integer)**

Indicates bit rate for hierarchical coding layer 3 for HEVC encoder.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_HIER\_CODING\_L4\_BR (integer)**

Indicates bit rate for hierarchical coding layer 4 for HEVC encoder.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_HIER\_CODING\_L5\_BR (integer)**

Indicates bit rate for hierarchical coding layer 5 for HEVC encoder.

**V4L2\_CID\_MPEG\_VIDEO\_HEVC\_HIER\_CODING\_L6\_BR (integer)**

Indicates bit rate for hierarchical coding layer 6 for HEVC encoder.

**V4L2\_CID\_MPEG\_VIDEO\_REF\_NUMBER\_FOR\_PFRAMES (integer)**

Selects number of P reference pictures required for HEVC encoder. P-Frame can use 1 or

2 frames for reference.

### V4L2\_CID\_MPEG\_VIDEO\_PREPEND\_SPSPPS\_TO\_IDR (integer)

Indicates whether to generate SPS and PPS at every IDR. Setting it to 0 disables generating SPS and PPS at every IDR. Setting it to one enables generating SPS and PPS at every IDR.

## Stateless Codec Control Reference

The Stateless Codec control class is intended to support stateless decoder and encoders (i.e. hardware accelerators).

These drivers are typically supported by the *Memory-to-memory Stateless Video Decoder Interface*, and deal with parsed pixel formats such as V4L2\_PIX\_FMT\_H264\_SLICE.

### Stateless Codec Control ID

#### V4L2\_CID\_CODEC\_STATELESS\_CLASS (class)

The Stateless Codec class descriptor.

#### V4L2\_CID\_STATELESS\_H264\_SPS (struct)

Specifies the sequence parameter set (as extracted from the bitstream) for the associated H264 slice data. This includes the necessary parameters for configuring a stateless hardware decoding pipeline for H264. The bitstream parameters are defined according to *ITU-T Rec. H.264 Specification (04/2017 Edition)*, section 7.4.2.1.1 "Sequence Parameter Set Data Semantics". For further documentation, refer to the above specification, unless there is an explicit comment stating otherwise.

type **v4l2\_ctrl\_h264\_sps**

Table 3: struct v4l2\_ctrl\_h264\_sps

<code>__u8</code>	<code>profile_idc</code>	
<code>__u8</code>	<code>constraint_set_flags</code>	See <i>Sequence Parameter Set Constraints Set Flags</i>
<code>__u8</code>	<code>level_idc</code>	
<code>__u8</code>	<code>seq_parameter_set_id</code>	
<code>__u8</code>	<code>chroma_format_idc</code>	
<code>__u8</code>	<code>bit_depth_luma_minus8</code>	
<code>__u8</code>	<code>bit_depth_chroma_minus8</code>	
<code>__u8</code>	<code>log2_max_frame_num_minus4</code>	
<code>__u8</code>	<code>pic_order_cnt_type</code>	
<code>__u8</code>	<code>log2_max_pic_order_cnt_lsb_minus4</code>	
<code>__u8</code>	<code>max_num_ref_frames</code>	
<code>__u8</code>	<code>num_ref_frames_in_pic_order_cnt_cycle</code>	
<code>s32</code>	<code>offset_for_ref_frame[255]</code>	
<code>s32</code>	<code>offset_for_non_ref_pic</code>	
<code>s32</code>	<code>offset_for_top_to_bottom_field</code>	
<code>__u16</code>	<code>pic_width_in_mbs_minus1</code>	
<code>__u16</code>	<code>pic_height_in_map_units_minus1</code>	
<code>__u32</code>	<code>flags</code>	See <i>Sequence Parameter Set Flags</i>

Sequence Parameter Set Constraints Set Flags

V4L2_H264_SPS_CONSTRAINT_SET0_FLAG	0x00000001
V4L2_H264_SPS_CONSTRAINT_SET1_FLAG	0x00000002
V4L2_H264_SPS_CONSTRAINT_SET2_FLAG	0x00000004
V4L2_H264_SPS_CONSTRAINT_SET3_FLAG	0x00000008
V4L2_H264_SPS_CONSTRAINT_SET4_FLAG	0x00000010
V4L2_H264_SPS_CONSTRAINT_SET5_FLAG	0x00000020

### Sequence Parameter Set Flags

V4L2_H264_SPS_FLAG_SEPARATE_COLOUR_PLANE	0x00000001
V4L2_H264_SPS_FLAG_QPPRIME_Y_ZERO_TRANSFORM_BYPASS	0x00000002
V4L2_H264_SPS_FLAG_DELTA_PIC_ORDER_ALWAYS_ZERO	0x00000004
V4L2_H264_SPS_FLAG_GAPS_IN_FRAME_NUM_VALUE_ALLOWED	0x00000008
V4L2_H264_SPS_FLAG_FRAME_MBS_ONLY	0x00000010
V4L2_H264_SPS_FLAG_MB_ADAPTIVE_FRAME_FIELD	0x00000020
V4L2_H264_SPS_FLAG_DIRECT_8X8_INFERENCE	0x00000040

### V4L2\_CID\_STATELESS\_H264\_PPS (struct)

Specifies the picture parameter set (as extracted from the bitstream) for the associated H264 slice data. This includes the necessary parameters for configuring a stateless hardware decoding pipeline for H264. The bitstream parameters are defined according to [ITU-T Rec. H.264 Specification \(04/2017 Edition\)](#), section 7.4.2.2 "Picture Parameter Set RBSP Semantics". For further documentation, refer to the above specification, unless there is an explicit comment stating otherwise.

type **v4l2\_ctrl\_h264\_pps**

Table 6: struct v4l2\_ctrl\_h264\_pps

__u8	pic_parameter_set_id	
__u8	seq_parameter_set_id	
__u8	num_slice_groups_minus1	
__u8	num_ref_idx_l0_default_active_minus1	
__u8	num_ref_idx_l1_default_active_minus1	
__u8	weighted_bipred_idc	
__s8	pic_init_qp_minus26	
__s8	pic_init_qs_minus26	
__s8	chroma_qp_index_offset	
__s8	second_chroma_qp_index_offset	
__u16	flags	See <a href="#">Picture Parameter Set Flags</a>

### Picture Parameter Set Flags

V4L2_H264_PPS_FLAG_ENTROPY_CODING_MODE	0x0001
V4L2_H264_PPS_FLAG_BOTTOM_FIELD_PIC_ORDER_IN_FRAME_PRESENT	0x0002
V4L2_H264_PPS_FLAG_WEIGHTED_PRED	0x0004
V4L2_H264_PPS_FLAG_DEBLOCKING_FILTER_CONTROL_PRESENT	0x0008
V4L2_H264_PPS_FLAG_CONSTRAINED_INTRA_PRED	0x0010
V4L2_H264_PPS_FLAG_REDUNDANT_PIC_CNT_PRESENT	0x0020
V4L2_H264_PPS_FLAG_TRANSFORM_8X8_MODE	0x0040
V4L2_H264_PPS_FLAG_SCALING_MATRIX_PRESENT	0x0080

V4L2\_CID\_STATELESS\_H264\_SCALING\_MATRIX must be used for this picture.

### V4L2\_CID\_STATELESS\_H264\_SCALING\_MATRIX (struct)

Specifies the scaling matrix (as extracted from the bitstream) for the associated H264

slice data. The bitstream parameters are defined according to *ITU-T Rec. H.264 Specification (04/2017 Edition)*, section 7.4.2.1.1.1 "Scaling List Semantics". For further documentation, refer to the above specification, unless there is an explicit comment stating otherwise.

type **v4l2\_ctrl\_h264\_scaling\_matrix**

Table 7: struct v4l2\_ctrl\_h264\_scaling\_matrix

__u8	scaling_list_4x4[6][16]	Scaling matrix after applying the inverse scanning process. Expected list order is Intra Y, Intra Cb, Intra Cr, Inter Y, Inter Cb, Inter Cr. The values on each scaling list are expected in raster scan order.
__u8	scaling_list_8x8[6][64]	Scaling matrix after applying the inverse scanning process. Expected list order is Intra Y, Inter Y, Intra Cb, Inter Cb, Intra Cr, Inter Cr. The values on each scaling list are expected in raster scan order.

#### V4L2\_CID\_STATELESS\_H264\_SLICE\_PARAMS (struct)

Specifies the slice parameters (as extracted from the bitstream) for the associated H264 slice data. This includes the necessary parameters for configuring a stateless hardware decoding pipeline for H264. The bitstream parameters are defined according to *ITU-T Rec. H.264 Specification (04/2017 Edition)*, section 7.4.3 "Slice Header Semantics". For further documentation, refer to the above specification, unless there is an explicit comment stating otherwise.

type **v4l2\_ctrl\_h264\_slice\_params**

Table 8: struct v4l2\_ctrl\_h264\_slice\_params

__u32	header_bit_size	Offset in bits to slice_data() from the beginning of this slice.
__u32	first_mb_in_slice	
__u8	slice_type	
__u8	colour_plane_id	
__u8	redundant_pic_cnt	
__u8	cabac_init_idc	
s8	slice_qp_delta	
s8	slice_qs_delta	
__u8	disable_deblocking_filter_idc	
s8	slice_alpha_c0_offset_div2	
s8	slice_beta_offset_div2	
__u8	num_ref_idx_l0_active_minus1	If num_ref_idx_active_override_flag is not set, this field must be set to the value of num_ref_idx_l0_default_active_minus1
__u8	num_ref_idx_l1_active_minus1	If num_ref_idx_active_override_flag is not set, this field must be set to the value of num_ref_idx_l1_default_active_minus1
__u8	reserved	Applications and drivers must set this to zero.
struct <i>v4l2_h264_reference</i>	ref_pic_list0[32]	Reference picture list after applying the per-slice modifications
struct <i>v4l2_h264_reference</i>	ref_pic_list1[32]	Reference picture list after applying the per-slice modifications
__u32	flags	See <i>Slice Parameter Flags</i>

#### Slice Parameter Set Flags

V4L2_H264_SLICE_FLAG_DIRECT_SPATIAL_MV_PRED	0x00000001	
V4L2_H264_SLICE_FLAG_SP_FOR_SWITCH	0x00000002	

**V4L2\_CID\_STATELESS\_H264\_PRED\_WEIGHTS (struct)**

Prediction weight table defined according to [ITU-T Rec. H.264 Specification \(04/2017 Edition\)](#), section 7.4.3.2 "Prediction Weight Table Semantics". The prediction weight table must be passed by applications under the conditions explained in section 7.3.3 "Slice header syntax".

type **v4l2\_ctrl\_h264\_pred\_weights**

Table 10: struct v4l2\_ctrl\_h264\_pred\_weights

__u16	luma_log2_weight_denom	
__u16	chroma_log2_weight_denom	
struct v4l2_h264_weight_factors	weight_factors[2]	The weight factors at index 0 are the weight factors for the reference list 0, the one at index 1 for the reference list 1.

type **v4l2\_h264\_weight\_factors**

Table 11: struct v4l2\_h264\_weight\_factors

s16	luma_weight[32]	
s16	luma_offset[32]	
s16	chroma_weight[32][2]	
s16	chroma_offset[32][2]	

## Picture Reference

type **v4l2\_h264\_reference**

Table 12: struct v4l2\_h264\_reference

__u8	fields	Specifies how the picture is referenced. See <a href="#">Reference Fields</a>
__u8	index	Index into the <a href="#">v4l2_ctrl_h264_decode_params.dpb</a> array.

## Reference Fields

V4L2_H264_TOP_FIELD_REF	0x1	The top field in field pair is used for short-term reference.
V4L2_H264_BOTTOM_FIELD_REF	0x2	The bottom field in field pair is used for short-term reference.
V4L2_H264_FRAME_REF	0x3	The frame (or the top/bottom fields, if it's a field pair) is used for short-term reference.

**V4L2\_CID\_STATELESS\_H264\_DECODE\_PARAMS (struct)**

Specifies the decode parameters (as extracted from the bitstream) for the associated H264 slice data. This includes the necessary parameters for configuring a stateless hardware decoding pipeline for H264. The bitstream parameters are defined according to [ITU-T Rec. H.264 Specification \(04/2017 Edition\)](#). For further documentation, refer to the above specification, unless there is an explicit comment stating otherwise.

type **v4l2\_ctrl\_h264\_decode\_params**

Table 13: struct v4l2\_ctrl\_h264\_decode\_params

struct <i>v4l2_h264_dpb_entry</i>	dpb[16]	
__u16	nal_ref_idc	NAL reference ID value coming from the NAL Unit header
__u16	frame_num	
__s32	top_field_order_cnt	Picture Order Count for the coded top field
__s32	bottom_field_order_cnt	Picture Order Count for the coded bottom field
__u16	idr_pic_id	
__u16	pic_order_cnt_lsb	
__s32	delta_pic_order_cnt_bottom	
__s32	delta_pic_order_cnt0	
__s32	delta_pic_order_cnt1	
__u32	dec_ref_pic_marking_bit_size	Size in bits of the dec_ref_pic_marking() syntax element.
__u32	pic_order_cnt_bit_size	Combined size in bits of the picture order count related syntax elements: pic_order_cnt_lsb, delta_pic_order_cnt_bottom, delta_pic_order_cnt0, and delta_pic_order_cnt1.
__u32	slice_group_change_cycle	
__u32	reserved	Applications and drivers must set this to zero.
__u32	flags	See <i>Decode Parameters Flags</i>

### Decode Parameters Flags

V4L2_H264_DECODE_PARAM_FLAG_IDR_PIC	0x00000001	That picture is an IDR picture
V4L2_H264_DECODE_PARAM_FLAG_FIELD_PIC	0x00000002	
V4L2_H264_DECODE_PARAM_FLAG_BOTTOM_FIELD	0x00000004	
V4L2_H264_DECODE_PARAM_FLAG_PFRAME	0x00000008	
V4L2_H264_DECODE_PARAM_FLAG_BFRAME	0x00000010	

type *v4l2\_h264\_dpb\_entry*

Table 14: struct v4l2\_h264\_dpb\_entry

<code>_u64</code>	<code>reference_ts</code>	Timestamp of the V4L2 capture buffer to use as reference, used with B-coded and P-coded frames. The timestamp refers to the <code>timestamp</code> field in struct <code>v4l2_buffer</code> . Use the <code>v4l2_timeval_to_ns()</code> function to convert the struct <code>timeval</code> in struct <code>v4l2_buffer</code> to a <code>_u64</code> .
<code>_u32</code>	<code>pic_num</code>	For short term references, this must match the derived value PicNum (8-28) and for long term references it must match the derived value LongTermPicNum (8-29). When decoding frames (as opposed to fields) <code>pic_num</code> is the same as FrameNumWrap.
<code>_u16</code>	<code>frame_num</code>	For short term references, this must match the <code>frame_num</code> value from the slice header syntax (the driver will wrap the value if needed). For long term references, this must be set to the value of <code>long_term_frame_idx</code> described in the <code>dec_ref_pic_marking()</code> syntax.
<code>_u8</code>	<code>fields</code>	Specifies how the DPB entry is referenced. See <a href="#">Reference Fields</a>
<code>_u8</code>	<code>reserved[5]</code>	Applications and drivers must set this to zero.
<code>s32</code>	<code>top_field_order_cnt</code>	
<code>s32</code>	<code>bottom_field_order_cnt</code>	
<code>_u32</code>	<code>flags</code>	See <a href="#">DPB Entry Flags</a>

## DPB Entries Flags

<code>V4L2_H264_DPB_ENTRY_FLAG_VALID</code>	0x00000001	The DPB entry is valid (non-empty) and should be considered.
<code>V4L2_H264_DPB_ENTRY_FLAG_ACTIVE</code>	0x00000002	The DPB entry is used for reference.
<code>V4L2_H264_DPB_ENTRY_FLAG_LONG_TERM</code>	0x00000004	The DPB entry is used for long-term reference.
<code>V4L2_H264_DPB_ENTRY_FLAG_FIELD</code>	0x00000008	The DPB entry is a single field or a complementary field pair.

## `V4L2_CID_STATELESS_H264_DECODE_MODE` (enum)

Specifies the decoding mode to use. Currently exposes slice-based and frame-based decoding but new modes might be added later on. This control is used as a modifier for `V4L2_PIX_FMT_H264_SLICE` pixel format. Applications that support `V4L2_PIX_FMT_H264_SLICE` are required to set this control in order to specify the decoding mode that is expected for the buffer. Drivers may expose a single or multiple decoding modes, depending on what they can support.

type `v4l2_stateless_h264_decode_mode`

<code>V4L2_STATELESS_H264_DECODE_MODE_SLICE_BASED</code>	0	Decoding is done at the slice granularity. The OUTPUT buffer must contain a single slice. When this mode is selected, the <code>V4L2_CID_STATELESS_H264_SLICE_PARAMS</code> control shall be set. When multiple slices compose a frame, use of <code>V4L2_BUF_CAP_SUPPORTS_M2M_HOLD_CAPTURE_BUF</code> flag is required.
<code>V4L2_STATELESS_H264_DECODE_MODE_FRAME_BASED</code>	1	Decoding is done at the frame granularity. The OUTPUT buffer must contain all slices needed to decode the frame. The OUTPUT buffer must also contain both fields. This mode will be supported by devices that parse the slice(s) header(s) in hardware. When this mode is selected, the <code>V4L2_CID_STATELESS_H264_SLICE_PARAMS</code> control shall not be set.

## `V4L2_CID_STATELESS_H264_START_CODE` (enum)

Specifies the H264 slice start code expected for each slice. This control is used as a modifier for `V4L2_PIX_FMT_H264_SLICE` pixel format. Applications that support `V4L2_PIX_FMT_H264_SLICE` are required to set this control in order to specify the start

code that is expected for the buffer. Drivers may expose a single or multiple start codes, depending on what they can support.

type **v4l2\_stateless\_h264\_start\_code**

V4L2_STATELESS_H264_START_CODE_NONE	0	Selecting this value specifies that H264 slices are passed to the driver without any start code. The bitstream data should be according to <a href="#">ITU-T Rec. H.264 Specification (04/2017 Edition)</a> 7.3.1 NAL unit syntax, hence contains emulation prevention bytes when required.
V4L2_STATELESS_H264_START_CODE_ANNEX_B	1	Selecting this value specifies that H264 slices are expected to be prefixed by Annex B start codes. According to <a href="#">ITU-T Rec. H.264 Specification (04/2017 Edition)</a> valid start codes can be 3-bytes 0x000001 or 4-bytes 0x00000001.

#### **V4L2\_CID\_STATELESS\_FWHT\_PARAMS (struct)**

Specifies the FWHT (Fast Walsh Hadamard Transform) parameters (as extracted from the bitstream) for the associated FWHT data. This includes the necessary parameters for configuring a stateless hardware decoding pipeline for FWHT. This codec is specific to the vicodec test driver.

type **v4l2\_ctrl\_fwht\_params**

Table 15: struct v4l2\_ctrl\_fwht\_params

__u64	backward_ref_ts	Timestamp of the V4L2 capture buffer to use as backward reference, used with P-coded frames. The timestamp refers to the timestamp field in struct v4l2_buffer. Use the v4l2_timeval_to_ns() function to convert the struct timeval in struct v4l2_buffer to a __u64.
__u32	version	The version of the codec. Set to V4L2_FWHT_VERSION.
__u32	width	The width of the frame.
__u32	height	The height of the frame.
__u32	flags	The flags of the frame, see <a href="#">FWHT Flags</a> .
__u32	colorspace	The colorspace of the frame, from enum <a href="#">v4l2_colorspace</a> .
__u32	xfer_func	The transfer function, from enum <a href="#">v4l2_xfer_func</a> .
__u32	ycbcr_enc	The Y'CbCr encoding, from enum <a href="#">v4l2_ycbcr_encoding</a> .
__u32	quantization	The quantization range, from enum <a href="#">v4l2_quantization</a> .

## FWHT Flags

V4L2_FWHT_FL_IS_INTERLACED	0x00000001	Set if this is an interlaced format.
V4L2_FWHT_FL_IS_BOTTOM_FIRST	0x00000002	Set if this is a bottom-first (NTSC) interlaced format.
V4L2_FWHT_FL_IS_ALTERNATE	0x00000004	Set if each 'frame' contains just one field.
V4L2_FWHT_FL_IS_BOTTOM_FIELD	0x00000008	If V4L2_FWHT_FL_IS_ALTERNATE was set, then this is set if this 'frame' is the bottom field, else it is the top field.
V4L2_FWHT_FL_LUMA_IS_UNCOMPRESSED	0x00000010	Set if the Y' (luma) plane is uncompressed.
V4L2_FWHT_FL_CB_IS_UNCOMPRESSED	0x00000020	Set if the Cb plane is uncompressed.
V4L2_FWHT_FL_CR_IS_UNCOMPRESSED	0x00000040	Set if the Cr plane is uncompressed.
V4L2_FWHT_FL_CHROMA_FULL_HEIGHT	0x00000080	Set if the chroma plane has the same height as the luma plane, else the chroma plane is half the height of the luma plane.
V4L2_FWHT_FL_CHROMA_FULL_WIDTH	0x00000100	Set if the chroma plane has the same width as the luma plane, else the chroma plane is half the width of the luma plane.
V4L2_FWHT_FL_ALPHA_IS_UNCOMPRESSED	0x00000200	Set if the alpha plane is uncompressed.
V4L2_FWHT_FL_I_FRAME	0x00000400	Set if this is an I-frame.
V4L2_FWHT_FL_COMPONENTS_NUM_MSK	0x00070000	The number of color components minus one.
V4L2_FWHT_FL_PIXENC_MSK	0x00180000	The mask for the pixel encoding.
V4L2_FWHT_FL_PIXENC_YUV	0x00080000	Set if the pixel encoding is YUV.
V4L2_FWHT_FL_PIXENC_RGB	0x00100000	Set if the pixel encoding is RGB.
V4L2_FWHT_FL_PIXENC_HSV	0x00180000	Set if the pixel encoding is HSV.

## V4L2\_CID\_STATELESS\_VP8\_FRAME (struct)

Specifies the frame parameters for the associated VP8 parsed frame data. This includes the necessary parameters for configuring a stateless hardware decoding pipeline for VP8. The bitstream parameters are defined according to [VP8](#).

type `v4l2_ctrl_vp8_frame`

Table 16: struct v4l2\_ctrl\_vp8\_frame

struct <code>v4l2_vp8_segment</code>	segment	Structure with segment-based adjustments metadata.
struct <code>v4l2_vp8_loop_filter</code>	lf	Structure with loop filter level adjustments metadata.
struct <code>v4l2_vp8_quantization</code>	quant	Structure with VP8 dequantization indices metadata.
struct <code>v4l2_vp8_entropy</code>	entropy	Structure with VP8 entropy coder probabilities metadata.
struct <code>v4l2_vp8_entropy_coder_state</code>	coder_state	Structure with VP8 entropy coder state.
<code>_u16</code>	width	The width of the frame. Must be set for all frames.
<code>_u16</code>	height	The height of the frame. Must be set for all frames.
<code>_u8</code>	horizontal_scale	Horizontal scaling factor.
<code>_u8</code>	vertical_scaling_factor	Vertical scale.
<code>_u8</code>	version	Bitstream version.

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<code>_u8</code>	<code>prob_skip_false</code>	Indicates the probability that the macroblock is not skipped.
<code>_u8</code>	<code>prob_intra</code>	Indicates the probability that a macroblock is intra-predicted.
<code>_u8</code>	<code>prob_last</code>	Indicates the probability that the last reference frame is used for inter-prediction
<code>_u8</code>	<code>prob_gf</code>	Indicates the probability that the golden reference frame is used for inter-prediction
<code>_u8</code>	<code>num_dct_parts</code>	Number of DCT coefficients partitions. Must be one of: 1, 2, 4, or 8.
<code>_u32</code>	<code>first_part_size</code>	Size of the first partition, i.e. the control partition.
<code>_u32</code>	<code>first_part_header_bits</code>	Size in bits of the first partition header portion.
<code>_u32</code>	<code>dct_part_sizes[8]</code>	DCT coefficients sizes.
<code>_u64</code>	<code>last_frame_ts</code>	Timestamp for the V4L2 capture buffer to use as last reference frame, used with inter-coded frames. The timestamp refers to the timestamp field in struct <code>v4l2_buffer</code> . Use the <code>v4l2_timeval_to_ns()</code> function to convert the struct <code>timeval</code> in struct <code>v4l2_buffer</code> to a <code>_u64</code> .
<code>_u64</code>	<code>golden_frame_ts</code>	Timestamp for the V4L2 capture buffer to use as last reference frame, used with inter-coded frames. The timestamp refers to the timestamp field in struct <code>v4l2_buffer</code> . Use the <code>v4l2_timeval_to_ns()</code> function to convert the struct <code>timeval</code> in struct <code>v4l2_buffer</code> to a <code>_u64</code> .
<code>_u64</code>	<code>alt_frame_ts</code>	Timestamp for the V4L2 capture buffer to use as alternate reference frame, used with inter-coded frames. The timestamp refers to the timestamp field in struct <code>v4l2_buffer</code> . Use the <code>v4l2_timeval_to_ns()</code> function to convert the struct <code>timeval</code> in struct <code>v4l2_buffer</code> to a <code>_u64</code> .
<code>_u64</code>	<code>flags</code>	See <a href="#">Frame Flags</a>

## Frame Flags

<code>V4L2_VP8_FRAME_FLAG_KEY_FRAME</code>	0x01	Indicates if the frame is a key frame.
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V4L2_VP8_FRAME_FLAG_EXPERIMENTAL	0x02	Experimental bitstream.
V4L2_VP8_FRAME_FLAG_SHOW_FRAME	0x04	Show frame flag, indicates if the frame is for display.
V4L2_VP8_FRAME_FLAG_MB_NO_SKIP_COEFF	0x08	Enable/disable skipping of macroblocks with no non-zero coefficients.
V4L2_VP8_FRAME_FLAG_SIGN_BIAS_GOLDEN	0x10	Sign of motion vectors when the golden frame is referenced.
V4L2_VP8_FRAME_FLAG_SIGN_BIAS_ALT	0x20	Sign of motion vectors when the alt frame is referenced.

type **v4l2\_vp8\_entropy\_coder\_state**

Table 18: struct v4l2\_vp8\_entropy\_coder\_state

__u8	range	coder state value for "Range"
__u8	value	coder state value for "Value"-
__u8	bit_count	number of bits left.
__u8	padding	Applications and drivers must set this to zero.

type **v4l2\_vp8\_segment**

Table 19: struct v4l2\_vp8\_segment

__s8	quant_update[4]	Signed quantizer value update.
__s8	lf_update[4]	Signed loop filter level value update.
__u8	segment_probs[3]	Segment probabilities.
__u8	padding	Applications and drivers must set this to zero.
__u32	flags	See <i>Segment Flags</i>

## Segment Flags

V4L2_VP8_SEGMENT_FLAG_ENABLED	0x01	Enable/disable segment-based adjustments.
V4L2_VP8_SEGMENT_FLAG_UPDATE_MAP	0x02	Indicates if the macroblock segmentation map is updated in this frame.
V4L2_VP8_SEGMENT_FLAG_UPDATE_FEATURE_DATA	0x04	Indicates if the segment feature data is updated in this frame.
V4L2_VP8_SEGMENT_FLAG_DELTA_VALUE_MODE	0x08	If is set, the segment feature data mode is delta-value. If cleared, it's absolute-value.

type **v4l2\_vp8\_loop\_filter**

Table 20: struct v4l2\_vp8\_loop\_filter

<code>_s8</code>	<code>ref_frm_delta[4]</code>	Reference adjustment (signed) delta value.
<code>_s8</code>	<code>mb_mode_delta[4]</code>	Macroblock prediction mode adjustment (signed) delta value.
<code>_u8</code>	<code>sharpness_level</code>	Sharpness level
<code>_u8</code>	<code>level</code>	Filter level
<code>_u16</code>	<code>padding</code>	Applications and drivers must set this to zero.
<code>_u32</code>	<code>flags</code>	See <a href="#">Loop Filter Flags</a>

### Loop Filter Flags

<code>V4L2_VP8_LF_ADJ_ENABLE</code>	0x01	Enable/disable macroblock-level loop filter adjustment.
<code>V4L2_VP8_LF_DELTA_UPDATE</code>	0x02	Indicates if the delta values used in an adjustment are updated.
<code>V4L2_VP8_LF_FILTER_TYPE_SIMPLE</code>	0x04	If set, indicates the filter type is simple. If cleared, the filter type is normal.

type **v4l2\_vp8\_quantization**

Table 21: struct v4l2\_vp8\_quantization

<code>_u8</code>	<code>y_ac_qi</code>	Luma AC coefficient table index.
<code>_s8</code>	<code>y_dc_delta</code>	Luma DC delta value.
<code>_s8</code>	<code>y2_dc_delta</code>	Y2 block DC delta value.
<code>_s8</code>	<code>y2_ac_delta</code>	Y2 block AC delta value.
<code>_s8</code>	<code>uv_dc_delta</code>	Chroma DC delta value.
<code>_s8</code>	<code>uv_ac_delta</code>	Chroma AC delta value.
<code>_u16</code>	<code>padding</code>	Applications and drivers must set this to zero.

type **v4l2\_vp8\_entropy**

Table 22: struct v4l2\_vp8\_entropy

<code>_u8</code>	<code>coeff_probs[4][8][3][11]</code>	Coefficient update probabilities.
<code>_u8</code>	<code>y_mode_probs[4]</code>	Luma mode update probabilities.
<code>_u8</code>	<code>uv_mode_probs[3]</code>	Chroma mode update probabilities.
<code>_u8</code>	<code>mv_probs[2][19]</code>	MV decoding update probabilities.
<code>_u8</code>	<code>padding[3]</code>	Applications and drivers must set this to zero.

### **V4L2\_CID\_STATELESS\_MPEG2\_SEQUENCE (struct)**

Specifies the sequence parameters (as extracted from the bitstream) for the associated MPEG-2 slice data. This includes fields matching the syntax elements from the sequence header and sequence extension parts of the bitstream as specified by [ISO 13818-2](#).

type **v4l2\_ctrl\_mpeg2\_sequence**

Table 23: struct v4l2\_ctrl\_mpeg2\_sequence

<code>_u16</code>	<code>horizontal_size</code>	The width of the displayable part of the frame's luminance component.
<code>_u16</code>	<code>vertical_size</code>	The height of the displayable part of the frame's luminance component.
<code>_u32</code>	<code>vbv_buffer_size</code>	Used to calculate the required size of the video buffering verifier, defined (in bits) as: $16 * 1024 * \text{vbv\_buffer\_size}$ .
<code>_u16</code>	<code>profile_and_level_indication</code>	The current profile and level indication as extracted from the bitstream.
<code>_u8</code>	<code>chroma_format</code>	The chrominance sub-sampling format (1: 4:2:0, 2: 4:2:2, 3: 4:4:4).
<code>_u8</code>	<code>flags</code>	See <a href="#">MPEG-2 Sequence Flags</a> .

### MPEG-2 Sequence Flags

<code>V4L2_MPEG2_SEQ_FLAG_PROGRESSIVE</code>	0x01	Indication that all the frames for the sequence are progressive.
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### **V4L2\_CID\_STATELESS\_MPEG2\_PICTURE (struct)**

Specifies the picture parameters (as extracted from the bitstream) for the associated MPEG-2 slice data. This includes fields matching the syntax elements from the picture header and picture coding extension parts of the bitstream as specified by [ISO 13818-2](#).

type **v4l2\_ctrl\_mpeg2\_picture**

Table 25: struct v4l2\_ctrl\_mpeg2\_picture

<code>_u64</code>	<code>backward_ref_ts</code>	Timestamp of the V4L2 capture buffer to use as backward reference, used with B-coded and P-coded frames. The timestamp refers to the timestamp field in struct <code>v4l2_buffer</code> . Use the <code>v4l2_timeval_to_ns()</code> function to convert the struct <code>timeval</code> in struct <code>v4l2_buffer</code> to a <code>_u64</code> .
<code>_u64</code>	<code>forward_ref_ts</code>	Timestamp for the V4L2 capture buffer to use as forward reference, used with B-coded frames. The timestamp refers to the timestamp field in struct <code>v4l2_buffer</code> . Use the <code>v4l2_timeval_to_ns()</code> function to convert the struct <code>timeval</code> in struct <code>v4l2_buffer</code> to a <code>_u64</code> .
<code>_u32</code>	<code>flags</code>	See <a href="#">MPEG-2 Picture Flags</a> .
<code>_u8</code>	<code>f_code[2][2]</code>	Motion vector codes.
<code>_u8</code>	<code>picture_coding_type</code>	Picture coding type for the frame covered by the current slice ( <code>V4L2_MPEG2_PIC_CODING_TYPE_I</code> , <code>V4L2_MPEG2_PIC_CODING_TYPE_P</code> or <code>V4L2_MPEG2_PIC_CODING_TYPE_B</code> ).
<code>_u8</code>	<code>picture_structure</code>	Picture structure (1: interlaced top field, 2: interlaced bottom field, 3: progressive frame).
<code>_u8</code>	<code>intra_dc_precision</code>	Precision of Discrete Cosine transform (0: 8 bits precision, 1: 9 bits precision, 2: 10 bits precision, 3: 11 bits precision).
<code>_u8</code>	<code>reserved[5]</code>	Applications and drivers must set this to zero.

### MPEG-2 Picture Flags

<code>V4L2_MPEG2_PIC_FLAG_TOP_FIELD_FIRST</code>	0x00000001	If set and it's an interlaced stream, top field is output first.
<code>V4L2_MPEG2_PIC_FLAG_FRAME_PRED_DCT</code>	0x00000002	If set only frame-DCT and frame prediction are used.
<code>V4L2_MPEG2_PIC_FLAG_CONCEALMENT_MV</code>	0x00000004	If set motion vectors are coded for intra macroblocks.

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V4L2_MPEG2_PIC_FLAG_Q_SCALE_TYPE	0x00000008	This flag affects the inverse quantization process.
V4L2_MPEG2_PIC_FLAG_INTRA_VLC	0x00000010	This flag affects the decoding of transform coefficients.
V4L2_MPEG2_PIC_FLAG_ALT_SCAN	0x00000020	This flag affects the decoding of transform coefficients.
V4L2_MPEG2_PIC_FLAG_REPEAT_FIRST	0x00000040	This flag affects the decoding process of progressive frames.
V4L2_MPEG2_PIC_FLAG_PROGRESSIVE	0x00000080	Indicates whether the current frame is progressive.

### V4L2\_CID\_STATELESS\_MPEG2\_QUANTISATION (struct)

Specifies quantisation matrices, in zigzag scanning order, for the associated MPEG-2 slice data. This control is initialized by the kernel to the matrices default values. If a bitstream transmits a user-defined quantisation matrices load, applications are expected to use this control. Applications are also expected to set the control loading the default values, if the quantisation matrices need to be reset, for instance on a sequence header. This process is specified by section 6.3.7. "Quant matrix extension" of the specification.

type **v4l2\_ctrl\_mpeg2\_quantisation**

Table 27: struct v4l2\_ctrl\_mpeg2\_quantisation

__u8	intra_quantiser_matrix[64]	The quantisation matrix coefficients for intra-coded frames, in zigzag scanning order. It is relevant for both luma and chroma components, although it can be superseded by the chroma-specific matrix for non-4:2:0 YUV formats.
__u8	non_intra_quantiser_matrix[64]	The quantisation matrix coefficients for non-intra-coded frames, in zigzag scanning order. It is relevant for both luma and chroma components, although it can be superseded by the chroma-specific matrix for non-4:2:0 YUV formats.
__u8	chroma_intra_quantiser_matrix[64]	The quantisation matrix coefficients for the chrominance component of intra-coded frames, in zigzag scanning order. Only relevant for non-4:2:0 YUV formats.
__u8	chroma_non_intra_quantiser_matrix[64]	The quantisation matrix coefficients for the chrominance component of non-intra-coded frames, in zigzag scanning order. Only relevant for non-4:2:0 YUV formats.

### V4L2\_CID\_STATELESS\_VP9\_COMPRESSED\_HDR (struct)

Stores VP9 probabilities updates as parsed from the current compressed frame header. A value of zero in an array element means no update of the relevant probability. Motion vector-related updates contain a new value or zero. All other updates contain values translated with inv\_map\_table[] (see 6.3.5 in [VP9](#)).

type **v4l2\_ctrl\_vp9\_compressed\_hdr**

Table 28: struct v4l2\_ctrl\_vp9\_compressed\_hdr

__u8	tx_mode	Specifies the TX mode. See <a href="#">TX Mode</a> for more details.
__u8	tx8[2][1]	TX 8x8 probabilities delta.
__u8	tx16[2][2]	TX 16x16 probabilities delta.
__u8	tx32[2][3]	TX 32x32 probabilities delta.
__u8	coef[4][2][2][6][6][3]	Coefficient probabilities delta.
__u8	skip[3]	Skip probabilities delta.

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<code>_u8</code>	<code>inter_mode[7][3]</code>	Inter prediction mode probabilities delta.
<code>_u8</code>	<code>interp_filter[4][2]</code>	Interpolation filter probabilities delta.
<code>_u8</code>	<code>is_inter[4]</code>	Is inter-block probabilities delta.
<code>_u8</code>	<code>comp_mode[5]</code>	Compound prediction mode probabilities delta.
<code>_u8</code>	<code>single_ref[5][2]</code>	Single reference probabilities delta.
<code>_u8</code>	<code>comp_ref[5]</code>	Compound reference probabilities delta.
<code>_u8</code>	<code>y_mode[4][9]</code>	Y prediction mode probabilities delta.
<code>_u8</code>	<code>uv_mode[10][9]</code>	UV prediction mode probabilities delta.
<code>_u8</code>	<code>partition[16][3]</code>	Partition probabilities delta.
<code>_u8</code>	<code>mv.joint[3]</code>	Motion vector joint probabilities delta.
<code>_u8</code>	<code>mv.sign[2]</code>	Motion vector sign probabilities delta.
<code>_u8</code>	<code>mv.classes[2][10]</code>	Motion vector class probabilities delta.
<code>_u8</code>	<code>mv.class0_bit[2]</code>	Motion vector class0 bit probabilities delta.
<code>_u8</code>	<code>mv.bits[2][10]</code>	Motion vector bits probabilities delta.
<code>_u8</code>	<code>mv.class0_fr[2][2][3]</code>	Motion vector class0 fractional bit probabilities delta.
<code>_u8</code>	<code>mv.fr[2][3]</code>	Motion vector fractional bit probabilities delta.
<code>_u8</code>	<code>mv.class0_hp[2]</code>	Motion vector class0 high precision fractional bit probabilities delta.
<code>_u8</code>	<code>mv.hp[2]</code>	Motion vector high precision fractional bit probabilities delta.

## TX Mode

<code>V4L2_VP9_TX_MODE_ONLY_4X4</code>	0	Transform size is 4x4.
<code>V4L2_VP9_TX_MODE_ALLOW_8X8</code>	1	Transform size can be up to 8x8.
<code>V4L2_VP9_TX_MODE_ALLOW_16X16</code>	2	Transform size can be up to 16x16.
<code>V4L2_VP9_TX_MODE_ALLOW_32X32</code>	3	transform size can be up to 32x32.
<code>V4L2_VP9_TX_MODE_SELECT</code>	4	Bitstream contains the transform size for each block.

See section '7.3.1 Tx mode semantics' of the [VP9](#) specification for more details.

**`V4L2_CID_STATELESS_VP9_FRAME` (struct)**

Specifies the frame parameters for the associated VP9 frame decode request. This includes the necessary parameters for configuring a stateless hardware decoding pipeline for VP9. The bitstream parameters are defined according to [VP9](#).

type `v4l2_ctrl_vp9_frame`

Table 29: struct `v4l2_ctrl_vp9_frame`

<code>struct v4l2_vp9_loop_filter</code>	<code>lf</code>	Loop filter parameters. See struct <code>v4l2_vp9_loop_filter</code> for more details.
<code>struct v4l2_vp9_quantization</code>	<code>quant</code>	Quantization parameters. See <code>v4l2_vp9_quantization</code> for more details.
<code>struct v4l2_vp9_segmentation</code>	<code>seg</code>	Segmentation parameters. See <code>v4l2_vp9_segmentation</code> for more details.

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<code>_u32</code>	<code>flags</code>	Combination of V4L2_VP9_FRAME_FLAG_* flags. See <a href="#">Frame Flags</a> .
<code>_u16</code>	<code>compressed_header_size</code>	Compressed header size in bytes.
<code>_u16</code>	<code>uncompressed_header_size</code>	Uncompressed header size in bytes.
<code>_u16</code>	<code>frame_width_minus_1</code>	Add 1 to get the frame width expressed in pixels. See section 7.2.3 in <a href="#">VP9</a> .
<code>_u16</code>	<code>frame_height_minus_1</code>	Add 1 to get the frame height expressed in pixels. See section 7.2.3 in <a href="#">VP9</a> .
<code>_u16</code>	<code>render_width_minus_1</code>	Add 1 to get the expected render width expressed in pixels. This is not used during the decoding process but might be used by HW scalers to prepare a frame that's ready for scanout. See section 7.2.4 in <a href="#">VP9</a> .
<code>_u16</code>	<code>render_height_minus_1</code>	Add 1 to get the expected render height expressed in pixels. This is not used during the decoding process but might be used by HW scalers to prepare a frame that's ready for scanout. See section 7.2.4 in <a href="#">VP9</a> .
<code>_u64</code>	<code>last_frame_ts</code>	"last" reference buffer timestamp. The timestamp refers to the timestamp field in struct <code>v4l2_buffer</code> . Use the <code>v4l2_timeval_to_ns()</code> function to convert the struct <code>timeval</code> in struct <code>v4l2_buffer</code> to a <code>_u64</code> .
<code>_u64</code>	<code>golden_frame_ts</code>	"golden" reference buffer timestamp. The timestamp refers to the timestamp field in struct <code>v4l2_buffer</code> . Use the <code>v4l2_timeval_to_ns()</code> function to convert the struct <code>timeval</code> in struct <code>v4l2_buffer</code> to a <code>_u64</code> .
<code>_u64</code>	<code>alt_frame_ts</code>	"alt" reference buffer timestamp. The timestamp refers to the timestamp field in struct <code>v4l2_buffer</code> . Use the <code>v4l2_timeval_to_ns()</code> function to convert the struct <code>timeval</code> in struct <code>v4l2_buffer</code> to a <code>_u64</code> .
<code>_u8</code>	<code>ref_frame_sign_bias</code>	a bitfield specifying whether the sign bias is set for a given reference frame. See <a href="#">Reference Frame Sign Bias</a> for more details.
<code>_u8</code>	<code>reset_frame_context</code>	specifies whether the frame context should be reset to default values. See <a href="#">Reset Frame Context</a> for more details.
<code>_u8</code>	<code>frame_context_idx</code>	Frame context that should be used/updated.
<code>_u8</code>	<code>profile</code>	VP9 profile. Can be 0, 1, 2 or 3.
<code>_u8</code>	<code>bit_depth</code>	Component depth in bits. Can be 8, 10 or 12. Note that not all profiles support 10 and/or 12 bits depths.
<code>_u8</code>	<code>interpolation_filter</code>	Specifies the filter selection used for performing inter prediction. See <a href="#">Interpolation Filter</a> for more details.

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<code>_u8</code>	<code>tile_cols_log2</code>	Specifies the base 2 logarithm of the width of each tile (where the width is measured in units of 8x8 blocks). Shall be less than or equal to 6.
<code>_u8</code>	<code>tile_rows_log2</code>	Specifies the base 2 logarithm of the height of each tile (where the height is measured in units of 8x8 blocks).
<code>_u8</code>	<code>reference_mode</code>	Specifies the type of inter prediction to be used. See <a href="#">Reference Mode</a> for more details. Note that this is derived as part of the compressed header parsing process and for this reason should have been part of :c:type: <code>v4l2_ctrl_vp9_compressed_hdr</code> optional control. It is safe to set this value to zero if the driver does not require compressed headers.
<code>_u8</code>	<code>reserved[7]</code>	Applications and drivers must set this to zero.

### Frame Flags

<code>V4L2_VP9_FRAME_FLAG_KEY_FRAME</code>	0x001	The frame is a key frame.
<code>V4L2_VP9_FRAME_FLAG_SHOW_FRAME</code>	0x002	The frame should be displayed.
<code>V4L2_VP9_FRAME_FLAG_ERROR_RESILIENT</code>	0x004	The decoding should be error resilient.
<code>V4L2_VP9_FRAME_FLAG_INTRA_ONLY</code>	0x008	The frame does not reference other frames.
<code>V4L2_VP9_FRAME_FLAG_ALLOW_HIGH_PREC_MV</code>	0x010	The frame can use high precision motion vectors.
<code>V4L2_VP9_FRAME_FLAG_REFRESH_FRAME_CTX</code>	0x020	Frame context should be updated after decoding.
<code>V4L2_VP9_FRAME_FLAG_PARALLEL_DEC_MODE</code>	0x040	Parallel decoding is used.
<code>V4L2_VP9_FRAME_FLAG_X_SUBSAMPLING</code>	0x080	Vertical subsampling is enabled.
<code>V4L2_VP9_FRAME_FLAG_Y_SUBSAMPLING</code>	0x100	Horizontal subsampling is enabled.
<code>V4L2_VP9_FRAME_FLAG_COLOR_RANGE_FULL_SWING</code>	0x200	The full UV range is used.

### Reference Frame Sign Bias

<code>V4L2_VP9_SIGN_BIAS_LAST</code>	0x1	Sign bias is set for the last reference frame.
<code>V4L2_VP9_SIGN_BIAS_GOLDEN</code>	0x2	Sign bias is set for the golden reference frame.
<code>V4L2_VP9_SIGN_BIAS_ALT</code>	0x2	Sign bias is set for the alt reference frame.

### Reset Frame Context

<code>V4L2_VP9_RESET_FRAME_CTX_NONE</code>	0	Do not reset any frame context.
<code>V4L2_VP9_RESET_FRAME_CTX_SPEC</code>	1	Reset the frame context pointed to by <code>v4l2_ctrl_vp9_frame.frame_context_idx</code> .
<code>V4L2_VP9_RESET_FRAME_CTX_ALL</code>	2	Reset all frame contexts.

See section '7.2 Uncompressed header semantics' of the [VP9](#) specification for more details.

### Interpolation Filter

V4L2_VP9_INTERP_FILTER_EIGHTTAP	0	Eight tap filter.
V4L2_VP9_INTERP_FILTER_EIGHTTAP_SMOOTH	1	Eight tap smooth filter.
V4L2_VP9_INTERP_FILTER_EIGHTTAP_SHARP	2	Eight tap sharp filter.
V4L2_VP9_INTERP_FILTER_BILINEAR	3	Bilinear filter.
V4L2_VP9_INTERP_FILTER_SWITCHABLE	4	Filter selection is signaled at the block level.

See section '7.2.7 Interpolation filter semantics' of the [VP9](#) specification for more details.

### Reference Mode

V4L2_VP9_REFERENCE_MODE_SINGLE_REFERENCE	0	Indicates that all the inter blocks use only a single reference frame to generate motion compensated prediction.
V4L2_VP9_REFERENCE_MODE_COMPOUND_REFERENCE	1	Requires all the inter blocks to use compound mode. Single reference frame prediction is not allowed.
V4L2_VP9_REFERENCE_MODE_SELECT	2	Allows each individual inter block to select between single and compound prediction modes.

See section '7.3.6 Frame reference mode semantics' of the [VP9](#) specification for more details.

### type `v4l2_vp9_segmentation`

Encodes the quantization parameters. See section '7.2.10 Segmentation params syntax' of the [VP9](#) specification for more details.

Table 30: struct `v4l2_vp9_segmentation`

<code>_u8 feature_data[8][4]</code>	Data attached to each feature. Data entry is only valid if the feature is enabled. The array shall be indexed with segment number as the first dimension (0..7) and one of V4L2_VP9_SEG_* as the second dimension. See <a href="#">Segment Feature IDs</a> .
<code>_u8 feature_enabled[8]</code>	Bitmask defining which features are enabled in each segment. The value for each segment is a combination of V4L2_VP9_SEGMENT_FEATURE_ENABLED(id) values where id is one of V4L2_VP9_SEG_*. See <a href="#">Segment Feature IDs</a> .
<code>_u8 tree_probs[7]</code>	Specifies the probability values to be used when decoding a Segment-ID. See '5.15 Segmentation map' section of <a href="#">VP9</a> for more details.
<code>_u8 pred_probs[3]</code>	Specifies the probability values to be used when decoding a Predicted-Segment-ID. See '6.4.14 Get segment id syntax' section of <a href="#">VP9</a> for more details.

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__u8	flags	Combination of V4L2_VP9_SEGMENTATION_FLAG_* flags. See <a href="#">Segmentation Flags</a> .
__u8	reserved[5]	Applications and drivers must set this to zero.

## Segment feature IDs

V4L2_VP9_SEG_LVL_ALT_Q	0	Quantizer segment feature.
V4L2_VP9_SEG_LVL_ALT_L	1	Loop filter segment feature.
V4L2_VP9_SEG_LVL_REF_FRAME	2	Reference frame segment feature.
V4L2_VP9_SEG_LVL_SKIP	3	Skip segment feature.
V4L2_VP9_SEG_LVL_MAX	4	Number of segment features.

## Segmentation Flags

V4L2_VP9_SEGMENTATION_FLAG_ENABLED	0x01	Indicates that this frame makes use of the segmentation tool.
V4L2_VP9_SEGMENTATION_FLAG_UPDATE_MAP	0x02	Indicates that the segmentation map should be updated during the decoding of this frame.
V4L2_VP9_SEGMENTATION_FLAG_TEMPORAL_UPDATE	0x04	Indicates that the updates to the segmentation map are coded relative to the existing segmentation map.
V4L2_VP9_SEGMENTATION_FLAG_UPDATE_DATA	0x08	Indicates that new parameters are about to be specified for each segment.
V4L2_VP9_SEGMENTATION_FLAG_ABS_OR_DELTA_UPDATE	0x10	Indicates that the segmentation parameters represent the actual values to be used.

type **v4l2\_vp9\_quantization**

Encodes the quantization parameters. See section '7.2.9 Quantization params syntax' of the VP9 specification for more details.

Table 31: struct v4l2\_vp9\_quantization

__u8	base_q_idx	Indicates the base frame qindex.
__s8	delta_q_y_dc	Indicates the Y DC quantizer relative to base_q_idx.
__s8	delta_q_uv_dc	Indicates the UV DC quantizer relative to base_q_idx.
__s8	delta_q_uv_ac	Indicates the UV AC quantizer relative to base_q_idx.
__u8	reserved[4]	Applications and drivers must set this to zero.

type **v4l2\_vp9\_loop\_filter**

This structure contains all loop filter related parameters. See sections '7.2.8 Loop filter semantics' of the [VP9](#) specification for more details.

Table 32: struct v4l2\_vp9\_loop\_filter

__s8	ref_deltas[4]	Contains the adjustment needed for the filter level based on the chosen reference frame.
__s8	mode_deltas[2]	Contains the adjustment needed for the filter level based on the chosen mode.
__u8	level	Indicates the loop filter strength.
__u8	sharpness	Indicates the sharpness level.
__u8	flags	Combination of V4L2_VP9_LOOP_FILTER_FLAG_* flags. See <a href="#">Loop Filter Flags</a> .
__u8	reserved[7]	Applications and drivers must set this to zero.

### Loop Filter Flags

V4L2_VP9_LOOP_FILTER_FLAG_DELTA_ENABLED	0x1	When set, the filter level depends on the mode and reference frame used to predict a block.
V4L2_VP9_LOOP_FILTER_FLAG_DELTA_UPDATE	0x2	When set, the bitstream contains additional syntax elements that specify which mode and reference frame deltas are to be updated.

### V4L2\_CID\_STATELESS\_HEVC\_SPS (struct)

Specifies the Sequence Parameter Set fields (as extracted from the bitstream) for the associated HEVC slice data. These bitstream parameters are defined according to [ITU H.265/HEVC](#). They are described in section 7.4.3.2 "Sequence parameter set RBSP semantics" of the specification.

type **v4l2\_ctrl\_hevc\_sps**

Table 33: struct v4l2\_ctrl\_hevc\_sps

__u8	video_parameter_set_id	Specifies the value of the vps_video_parameter_set_id of the active VPS as described in section "7.4.3.2.1 General sequence parameter set RBSP semantics" of H.265 specifications.
__u8	seq_parameter_set_id	Provides an identifier for the SPS for reference by other syntax elements as described in section "7.4.3.2.1 General sequence parameter set RBSP semantics" of H.265 specifications.
__u16	pic_width_in_luma_samples	Specifies the width of each decoded picture in units of luma samples.
__u16	pic_height_in_luma_samples	Specifies the height of each decoded picture in units of luma samples.
__u8	bit_depth_luma_minus8	This value plus 8 specifies the bit depth of the samples of the luma array.
__u8	bit_depth_chroma_minus8	This value plus 8 specifies the bit depth of the samples of the chroma arrays.
__u8	log2_max_pic_order_cnt_lsb_minus4	Specifies the value of the variable MaxPicOrderCntLsb.

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<code>_u8</code>	<code>sps_max_dec_pic_buffering_minus1</code>	This value plus 1 specifies the maximum required size of the decoded picture buffer for the coded video sequence (CVS).
<code>_u8</code>	<code>sps_max_num_reorder_pics</code>	Indicates the maximum allowed number of pictures.
<code>_u8</code>	<code>sps_max_latency_increase_plus1</code>	Used to signal MaxLatencyPictures, which indicates the maximum number of pictures that can precede any picture in output order and follow that picture in decoding order.
<code>_u8</code>	<code>log2_min_luma_coding_block_size_minus3</code>	This value plus 3 specifies the minimum luma coding block size.
<code>_u8</code>	<code>log2_diff_max_min_luma_coding_block_size</code>	Specifies the difference between the maximum and minimum luma coding block size.
<code>_u8</code>	<code>log2_min_luma_transform_block_size_minus2</code>	This value plus 2 specifies the minimum luma transform block size.
<code>_u8</code>	<code>log2_diff_max_min_luma_transform_block_size</code>	Specifies the difference between the maximum and minimum luma transform block size.
<code>_u8</code>	<code>max_transform_hierarchy_depth_inter</code>	Specifies the maximum hierarchy depth for transform units of coding units coded in inter prediction mode.
<code>_u8</code>	<code>max_transform_hierarchy_depth_intra</code>	Specifies the maximum hierarchy depth for transform units of coding units coded in intra prediction mode.
<code>_u8</code>	<code>pcm_sample_bit_depth_luma_minus1</code>	This value plus 1 specifies the number of bits used to represent each of PCM sample values of the luma component.
<code>_u8</code>	<code>pcm_sample_bit_depth_chroma_minus1</code>	Specifies the number of bits used to represent each of PCM sample values of the chroma components.
<code>_u8</code>	<code>log2_min_pcm_luma_coding_block_size_minus3</code>	Plus 3 specifies the minimum size of coding blocks.
<code>_u8</code>	<code>log2_diff_max_min_pcm_luma_coding_block_size</code>	Specifies the difference between the maximum and minimum size of coding blocks.
<code>_u8</code>	<code>num_short_term_ref_pic_sets</code>	Specifies the number of st_ref_pic_set() syntax structures included in the SPS.
<code>_u8</code>	<code>num_long_term_ref_pics_sps</code>	Specifies the number of candidate long-term reference pictures that are specified in the SPS.
<code>_u8</code>	<code>chroma_format_idc</code>	Specifies the chroma sampling.
<code>_u8</code>	<code>sps_max_sub_layers_minus1</code>	This value plus 1 specifies the maximum number of temporal sub-layers.
<code>_u64</code>	<code>flags</code>	See <a href="#">Sequence Parameter Set Flags</a>

### Sequence Parameter Set Flags

<code>V4L2_HEVC_SPS_FLAG_SEPARATE_COLOUR_PLANE</code>	0x00000001	
<code>V4L2_HEVC_SPS_FLAG_SCALING_LIST_ENABLED</code>	0x00000002	
<code>V4L2_HEVC_SPS_FLAG_AMP_ENABLED</code>	0x00000004	
<code>V4L2_HEVC_SPS_FLAG_SAMPLE_ADAPTIVE_OFFSET</code>	0x00000008	

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V4L2_HEVC_SPS_FLAG_PCM_ENABLED	0x00000010
V4L2_HEVC_SPS_FLAG_PCM_LOOP_FILTER_DISABLED	0x00000020
V4L2_HEVC_SPS_FLAG_LONG_TERM_REF_PICS_PRESENT	0x00000040
V4L2_HEVC_SPS_FLAG_SPS_TEMPORAL_MVP_ENABLED	0x00000080
V4L2_HEVC_SPS_FLAG_STRONG_INTRA_SMOOTHING_ENABLED	0x00000100

**V4L2\_CID\_STATELESS\_HEVC\_PPS (struct)**

Specifies the Picture Parameter Set fields (as extracted from the bitstream) for the associated HEVC slice data. These bitstream parameters are defined according to [ITU H.265/HEVC](#). They are described in section 7.4.3.3 "Picture parameter set RBSP semantics" of the specification.

type **v4l2\_ctrl\_hevc\_pps**

Table 35: struct v4l2\_ctrl\_hevc\_pps

__u8	pic_parameter_set_id	Identifies the PPS for reference by other syntax elements.
__u8	num_extra_slice_header_bits	Specifies the number of extra slice header bits that are present in the slice header RBSP for coded pictures referring to the PPS.
__u8	num_ref_idx_l0_default_active_minus1	This value plus 1 specifies the inferred value of num_ref_idx_l0_active_minus1.
__u8	num_ref_idx_l1_default_active_minus1	This value plus 1 specifies the inferred value of num_ref_idx_l1_active_minus1.
__s8	init_qp_minus26	This value plus 26 specifies the initial value of SliceQp Y for each slice referring to the PPS.
__u8	diff_cu_qp_delta_depth	Specifies the difference between the luma coding tree block size and the minimum luma coding block size of coding units that convey cu_qp_delta_abs and cu_qp_delta_sign_flag.
__s8	pps_cb_qp_offset	Specifies the offsets to the luma quantization parameter Cb.
__s8	pps_cr_qp_offset	Specifies the offsets to the luma quantization parameter Cr.
__u8	num_tile_columns_minus1	This value plus 1 specifies the number of tile columns partitioning the picture.
__u8	num_tile_rows_minus1	This value plus 1 specifies the number of tile rows partitioning the picture.
__u8	column_width_minus1[20]	This value plus 1 specifies the width of the i-th tile column in units of coding tree blocks.

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__u8	row_height_minus1[22]	This value plus 1 specifies the height of the i-th tile row in units of coding tree blocks.
__s8	pps_beta_offset_div2	Specifies the default deblocking parameter offsets for beta divided by 2.
__s8	pps_tc_offset_div2	Specifies the default deblocking parameter offsets for tC divided by 2.
__u8	log2_parallel_merge_level_minus2	This value plus 2 specifies the value of the variable Log2ParMrgLevel.
__u8	padding[4]	Applications and drivers must set this to zero.
__u64	flags	See <a href="#">Picture Parameter Set Flags</a>

### Picture Parameter Set Flags

V4L2_HEVC_PPS_FLAG_DEPENDENT	0x0000000000000000	SEGMENT_ENABLED
V4L2_HEVC_PPS_FLAG_OUTPUT_FLAG	0x0000000000000002	
V4L2_HEVC_PPS_FLAG_SIGN_DATA	0x0000000000000000	BIDDING_ENABLED
V4L2_HEVC_PPS_FLAG_CABAC_INIT	0x0000000000000008	TORBESSED08
V4L2_HEVC_PPS_FLAG_CONSTRAINED	0x0000000000000000	EDONTDRAOPRED
V4L2_HEVC_PPS_FLAG_TRANSFORM	0x0000000000000000	SKDPOOBABLED
V4L2_HEVC_PPS_FLAG_CU_QP_DELTA	0x0000000000000000	AxENABD010
V4L2_HEVC_PPS_FLAG_PPS_SLICE	0x0000000000000000	ONR000000000FFSETS_PRESENT
V4L2_HEVC_PPS_FLAG_WEIGHTED	0x0000000000000000	PRED00000100
V4L2_HEVC_PPS_FLAG_WEIGHTED	0x0000000000000000	BDRBBD00200
V4L2_HEVC_PPS_FLAG_TRANSQUANT	0x0000000000000000	TOR00ASS4ENABLED
V4L2_HEVC_PPS_FLAG_TILES_ENABLED	0x0000000000000000	BDE00000800
V4L2_HEVC_PPS_FLAG_ENTROPY_CODING_SYNC	0x0000000000000000	ENABLED
V4L2_HEVC_PPS_FLAG_LOOP_FILTER	0x0000000000000000	EBx0000000000000000
V4L2_HEVC_PPS_FLAG_PPS_LOOP	0x0000000000000000	F0k00000000000000
V4L2_HEVC_PPS_FLAG_DEBLOCKING	0x0000000000000000	G0R00000000000000
V4L2_HEVC_PPS_FLAG_PPS_DISABLE	0x0000000000000000	L0x00B1000000000000
V4L2_HEVC_PPS_FLAG_LISTS_MODIFIED	0x0000000000000000	I0x0000000000000000
V4L2_HEVC_PPS_FLAG_SLICE_SEGMENT_EXTENSION	0x0000000000000000	EXTENSION_PRESENT
V4L2_HEVC_PPS_FLAG_DEBLOCKING_CONTROL	0x0000000000000000	S_PRESENT
V4L2_HEVC_PPS_FLAG_UNIFORM_SPACING	0x0000000000000000	Specifies the presence of deblocking filter control syntax elements in the PPS
V4L2_HEVC_PPS_FLAG_UNIFORM_SPACING	0x0000000000000000	Specifies that tile column boundaries and likewise tile row boundaries are distributed uniformly across the picture

### V4L2\_CID\_STATELESS\_HEVC\_SLICE\_PARAMS (struct)

Specifies various slice-specific parameters, especially from the NAL unit header, general slice segment header and weighted prediction parameter parts of the bitstream. These bitstream parameters are defined according to [ITU H.265/HEVC](#). They are described in section 7.4.7 "General slice segment header semantics" of the specification. This control is a dynamically sized 1-dimensional array, V4L2\_CTRL\_FLAG\_DYNAMIC\_ARRAY flag must be set when using it.

type **v4l2\_ctrl\_hevc\_slice\_params**

Table 36: struct v4l2\_ctrl\_hevc\_slice\_params

<code>_u32</code>	<code>bit_size</code>	Size (in bits) of the current slice data.
<code>_u32</code>	<code>data_byte_offset</code>	Offset (in byte) to the video data in the current slice data.
<code>_u32</code>	<code>num_entry_point_offsets</code>	Specifies the number of entry point offset syntax elements in the slice header. When the driver supports it, the <code>V4L2_CID_STATELESS_HEVC_ENTRY_POINT_OF</code> must be set.
<code>_u8</code>	<code>nal_unit_type</code>	Specifies the coding type of the slice (B, P or I).
<code>_u8</code>	<code>nuh_temporal_id_plus1</code>	Minus 1 specifies a temporal identifier for the NAL unit.
<code>_u8</code>	<code>slice_type</code>	( <code>V4L2_HEVC_SLICE_TYPE_I</code> , <code>V4L2_HEVC_SLICE_TYPE_P</code> or <code>V4L2_HEVC_SLICE_TYPE_B</code> ).
<code>_u8</code>	<code>colour_plane_id</code>	Specifies the colour plane associated with the current slice.
<code>_s32</code>	<code>slice_pic_order_cnt</code>	Specifies the picture order count.
<code>_u8</code>	<code>num_ref_idx_l0_active_minus1</code>	This value plus 1 specifies the maximum reference index for reference picture list 0 that may be used to decode the slice.
<code>_u8</code>	<code>num_ref_idx_l1_active_minus1</code>	This value plus 1 specifies the maximum reference index for reference picture list 1 that may be used to decode the slice.
<code>_u8</code>	<code>collocated_ref_idx</code>	Specifies the reference index of the collocated picture used for temporal motion vector prediction.
<code>_u8</code>	<code>five_minus_max_num_merge_cand</code>	Specifies the maximum number of merging motion vector prediction candidates supported in the slice subtracted from 5.
<code>_s8</code>	<code>slice_qp_delta</code>	Specifies the initial value of QpY to be used for the coding blocks in the slice.
<code>_s8</code>	<code>slice_cb_qp_offset</code>	Specifies a difference to be added to the value of <code>pps_cb_qp_offset</code> .
<code>_s8</code>	<code>slice_cr_qp_offset</code>	Specifies a difference to be added to the value of <code>pps_cr_qp_offset</code> .
<code>_s8</code>	<code>slice_act_y_qp_offset</code>	Specifies the offset to the luma of quantization parameter qP derived in section 8.6.2
<code>_s8</code>	<code>slice_act_cb_qp_offset</code>	Specifies the offset to the cb of quantization parameter qP derived in section 8.6.2
<code>_s8</code>	<code>slice_act_cr_qp_offset</code>	Specifies the offset to the cr of quantization parameter qP derived in section 8.6.2
<code>_s8</code>	<code>slice_beta_offset_div2</code>	Specifies the deblocking parameter offsets for beta divided by 2.
<code>_s8</code>	<code>slice_tc_offset_div2</code>	Specifies the deblocking parameter offsets for tc divided by 2.
<code>_u8</code>	<code>pic_struct</code>	Indicates whether a picture should be displayed as a frame or as one or more fields.
<code>_u32</code>	<code>slice_segment_addr</code>	Specifies the address of the first coding tree block in the slice segment.
<code>_u8</code>	<code>ref_idx_l0[V4L2_HEVC_DPB_ENTRIES_NUM_MAX]</code>	The list of L0 reference elements as indices in the DPB.
<code>_u8</code>	<code>ref_idx_l1[V4L2_HEVC_DPB_ENTRIES_NUM_MAX]</code>	The list of L1 reference elements as indices in the DPB.
<code>_u16</code>	<code>short_term_ref_pic_set_size</code>	Specifies the size, in bits, of the short-term reference picture set, described as <code>st_ref_pic_set()</code> in the specification, included in the slice header or SPS (section 7.3.6.1).

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<code>_u16</code>	<code>long_term_ref_pic_set_size</code>	Specifies the size, in bits, of the long-term reference picture set include in the slice header or SPS. It is the number of bits in the conditional block if( <code>long_term_ref_pics_present_flag</code> ) in section 7.3.6.1 of the specification.
<code>_u8</code>	<code>padding</code>	Applications and drivers must set this to zero.
<code>struct v4l2_hevc_pred_weight_table</code>	<code>pred_weight_table</code>	The prediction weight coefficients for inter-picture prediction.
<code>_u64</code>	<code>flags</code>	See <a href="#">Slice Parameters Flags</a>

## Slice Parameters Flags

<code>V4L2_HEVC_SLICE_PARAMS_FLAG_SLICE_SAO_LUMA</code>	0x00000001	
<code>V4L2_HEVC_SLICE_PARAMS_FLAG_SLICE_SAO_CHROMA</code>	0x00000002	
<code>V4L2_HEVC_SLICE_PARAMS_FLAG_SLICE_TEMPORAL_MVP_ENABLED</code>	0x00000004	
<code>V4L2_HEVC_SLICE_PARAMS_FLAG_MVD_L1_ZERO</code>	0x00000008	
<code>V4L2_HEVC_SLICE_PARAMS_FLAG_CABAC_INIT</code>	0x00000010	
<code>V4L2_HEVC_SLICE_PARAMS_FLAG_COLLOCATED_FROM_L0</code>	0x00000020	
<code>V4L2_HEVC_SLICE_PARAMS_FLAG_USE_INTEGER_MV</code>	0x00000040	
<code>V4L2_HEVC_SLICE_PARAMS_FLAG_SLICE_DEBLOCKING_FILTER_DISABLED</code>	0x00000080	
<code>V4L2_HEVC_SLICE_PARAMS_FLAG_SLICE_LOOP_FILTER_ACROSS_SLICES_ENABLED</code>	0x00000100	
<code>V4L2_HEVC_SLICE_PARAMS_FLAG_DEPENDENT_SLICE_SEGMENT</code>	0x00000200	

## V4L2\_CID\_STATELESS\_HEVC\_ENTRY\_POINT\_OFFSETS (integer)

Specifies entry point offsets in bytes. This control is a dynamically sized array. The number of entry point offsets is reported by the `elems` field. This bitstream parameter is defined according to [ITU H.265/HEVC](#). They are described in section 7.4.7.1 "General slice segment header semantics" of the specification. When multiple slices are submitted in a request, the length of this array must be the sum of `num_entry_point_offsets` of all the slices in the request.

## V4L2\_CID\_STATELESS\_HEVC\_SCALING\_MATRIX (struct)

Specifies the HEVC scaling matrix parameters used for the scaling process for transform coefficients. These matrix and parameters are defined according to [ITU H.265/HEVC](#). They are described in section 7.4.5 "Scaling list data semantics" of the specification.

type `v4l2_ctrl_hevc_scaling_matrix`

Table 37: struct `v4l2_ctrl_hevc_scaling_matrix`

<code>_u8</code>	<code>scaling_list_4x4[6][16]</code>	Scaling list is used for the scaling process for transform coefficients. The values on each scaling list are expected in raster scan order.
<code>_u8</code>	<code>scaling_list_8x8[6][64]</code>	Scaling list is used for the scaling process for transform coefficients. The values on each scaling list are expected in raster scan order.
<code>_u8</code>	<code>scaling_list_16x16[6][64]</code>	Scaling list is used for the scaling process for transform coefficients. The values on each scaling list are expected in raster scan order.
<code>_u8</code>	<code>scaling_list_32x32[2][64]</code>	Scaling list is used for the scaling process for transform coefficients. The values on each scaling list are expected in raster scan order.
<code>_u8</code>	<code>scaling_list_dc_coef_16x16[6]</code>	Scaling list is used for the scaling process for transform coefficients. The values on each scaling list are expected in raster scan order.

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<code>_u8</code>	<code>scaling_list_dc_coef_32x32[2]</code>	Scaling list is used for the scaling process for transform coefficients. The values on each scaling list are expected in raster scan order.
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type `v4l2_hevc_dpb_entry`

Table 38: struct `v4l2_hevc_dpb_entry`

<code>_u64</code>	<code>timestamp</code>	Timestamp of the V4L2 capture buffer to use as reference, used with B-coded and P-coded frames. The timestamp refers to the <code>timestamp</code> field in struct <code>v4l2_buffer</code> . Use the <code>v4l2_timeval_to_ns()</code> function to convert the struct <code>timeval</code> in struct <code>v4l2_buffer</code> to a <code>_u64</code> .
<code>_u8</code>	<code>flags</code>	Long term flag for the reference frame (V4L2_HEVC_DPB_ENTRY_LONG_TERM_REFERENCE). The flag is set as described in the ITU HEVC specification chapter "8.3.2 Decoding process for reference picture set".
<code>_u8</code>	<code>field_pic</code>	Whether the reference is a field picture or a frame. See <a href="#">HEVC dpb field pic Flags</a>
<code>_s32</code>	<code>pic_order_cnt_val</code>	The picture order count of the current picture.
<code>_u8</code>	<code>padding[2]</code>	Applications and drivers must set this to zero.

HEVC dpb field pic Flags

<code>V4L2_HEVC_SEI_PIC_STRUCT_FRAME</code>	0	(progressive) Frame
<code>V4L2_HEVC_SEI_PIC_STRUCT_TOP_FIELD</code>	1	Top field
<code>V4L2_HEVC_SEI_PIC_STRUCT_BOTTOM_FIELD</code>	2	Bottom field
<code>V4L2_HEVC_SEI_PIC_STRUCT_TOP_BOTTOM</code>	3	Top field, bottom field, in that order
<code>V4L2_HEVC_SEI_PIC_STRUCT_BOTTOM_TOP</code>	4	Bottom field, top field, in that order
<code>V4L2_HEVC_SEI_PIC_STRUCT_TOP_BOTTOM_TOP</code>	5	Top field, bottom field, top field repeated, in that order
<code>V4L2_HEVC_SEI_PIC_STRUCT_BOTTOM_TOP_BOTTOM</code>	6	Bottom field, top field, bottom field repeated, in that order
<code>V4L2_HEVC_SEI_PIC_STRUCT_FRAME_DOUBLING</code>	7	Frame doubling
<code>V4L2_HEVC_SEI_PIC_STRUCT_FRAME_TRIPLING</code>	8	Frame tripling
<code>V4L2_HEVC_SEI_PIC_STRUCT_TOP_PAIREDF_PREVIOUS_BOTTOM</code>	9	Top field paired with previous bottom field in output order
<code>V4L2_HEVC_SEI_PIC_STRUCT_BOTTOM_PAIREDF_PREVIOUS_TOP</code>	10	Bottom field paired with previous top field in output order
<code>V4L2_HEVC_SEI_PIC_STRUCT_TOP_PAIREDF_NEXT_BOTTOM</code>	11	Top field paired with next bottom field in output order
<code>V4L2_HEVC_SEI_PIC_STRUCT_BOTTOM_PAIREDF_NEXT_TOP</code>	12	Bottom field paired with next top field in output order

type `v4l2_hevc_pred_weight_table`

Table 39: struct v4l2\_hevc\_pred\_weight\_table

__s8	delta_luma_weight_l0[V4L2_HEVC_DBP_ENTRIES_NUM_MAX]	The difference of the weighting factor applied to the luma prediction value for list 0.
__s8	luma_offset_l0[V4L2_HEVC_DBP_ENTRIES_NUM_MAX]	The additive offset applied to the luma prediction value for list 0.
__s8	delta_chroma_weight_l0[V4L2_HEVC_DBP_ENTRIES_NUM_MAX][2]	The difference of the weighting factor applied to the chroma prediction value for list 0.
__s8	chroma_offset_l0[V4L2_HEVC_DBP_ENTRIES_NUM_MAX][2]	The difference of the additive offset applied to the chroma prediction values for list 0.
__s8	delta_luma_weight_l1[V4L2_HEVC_DBP_ENTRIES_NUM_MAX]	The difference of the weighting factor applied to the luma prediction value for list 1.
__s8	luma_offset_l1[V4L2_HEVC_DBP_ENTRIES_NUM_MAX]	The additive offset applied to the luma prediction value for list 1.
__s8	delta_chroma_weight_l1[V4L2_HEVC_DBP_ENTRIES_NUM_MAX][2]	The difference of the weighting factor applied to the chroma prediction value for list 1.
__s8	chroma_offset_l1[V4L2_HEVC_DBP_ENTRIES_NUM_MAX][2]	The difference of the additive offset applied to the chroma prediction values for list 1.
__u8	luma_log2_weight_denom	The base 2 logarithm of the denominator for all luma weighting factors.
__s8	delta_chroma_log2_weight_denom	The difference of the base 2 logarithm of the denominator for all chroma weighting factors.
__u8	padding[6]	Applications and drivers must set this to zero.

**V4L2\_CID\_STATELESS\_HEVC\_DECODE\_MODE (enum)**

Specifies the decoding mode to use. Currently exposes slice-based and frame-based decoding but new modes might be added later on. This control is used as a modifier for V4L2\_PIX\_FMT\_HEVC\_SLICE pixel format. Applications that support V4L2\_PIX\_FMT\_HEVC\_SLICE are required to set this control in order to specify the decoding mode that is expected for the buffer. Drivers may expose a single or multiple decoding modes, depending on what they can support.

type **v4l2\_stateless\_hevc\_decode\_mode**

V4L2_STATELESS_HEVC_DECODE_MODE_SLICE_BASED	0	Decoding is done at the slice granularity. The OUTPUT buffer must contain a single slice.
V4L2_STATELESS_HEVC_DECODE_MODE_FRAME_BASED	1	Decoding is done at the frame granularity. The OUTPUT buffer must contain all slices needed to decode the frame.

**V4L2\_CID\_STATELESS\_HEVC\_START\_CODE (enum)**

Specifies the HEVC slice start code expected for each slice. This control is used as a modifier for V4L2\_PIX\_FMT\_HEVC\_SLICE pixel format. Applications that support V4L2\_PIX\_FMT\_HEVC\_SLICE are required to set this control in order to specify the start code that is expected for the buffer. Drivers may expose a single or multiple start codes, depending on what they can support.

type **v4l2\_stateless\_hevc\_start\_code**

V4L2_STATELESS_HEVC_START_CODE_NONE	0	Selecting this value specifies that HEVC slices are passed to the driver without any start code. The bit-stream data should be according to <a href="#">ITU H.265/HEVC</a> 7.3.1.1 General NAL unit syntax, hence contains emulation prevention bytes when required.
V4L2_STATELESS_HEVC_START_CODE_ANNEX_B	1	Selecting this value specifies that HEVC slices are expected to be prefixed by Annex B start codes. According to <a href="#">ITU H.265/HEVC</a> valid start codes can be 3-bytes 0x0000001 or 4-bytes 0x00000001.

**V4L2\_CID\_MPEG\_VIDEO\_BASELAYER\_PRIORITY\_ID (integer)**

Specifies a priority identifier for the NAL unit, which will be applied to the base layer. By default this value is set to 0 for the base layer, and the next layer will have the priority ID assigned as 1, 2, 3 and so on. The video encoder can't decide the priority id to be applied to a layer, so this has to come from client. This is applicable to H264 and valid Range is from 0 to 63. Source Rec. ITU-T H.264 (06/2019); G.7.4.1.1, G.8.8.1.

**V4L2\_CID\_MPEG\_VIDEO\_LTR\_COUNT (integer)**

Specifies the maximum number of Long Term Reference (LTR) frames at any given time that the encoder can keep. This is applicable to the H264 and HEVC encoders.

**V4L2\_CID\_MPEG\_VIDEO\_FRAME\_LTR\_INDEX (integer)**

After setting this control the frame that will be queued next will be marked as a Long Term Reference (LTR) frame and given this LTR index which ranges from 0 to LTR\_COUNT-1. This is applicable to the H264 and HEVC encoders. Source Rec. ITU-T H.264 (06/2019); Table 7.9

**V4L2\_CID\_MPEG\_VIDEO\_USE\_LTR\_FRAMES (bitmask)**

Specifies the Long Term Reference (LTR) frame(s) to be used for encoding the next frame queued after setting this control. This provides a bitmask which consists of bits [0, LTR\_COUNT-1]. This is applicable to the H264 and HEVC encoders.

**V4L2\_CID\_STATELESS\_HEVC\_DECODE\_PARAMS (struct)**

Specifies various decode parameters, especially the references picture order count (POC) for all the lists (short, long, before, current, after) and the number of entries for each of them. These parameters are defined according to [ITU H.265/HEVC](#). They are described in section 8.3 "Slice decoding process" of the specification.

type **v4l2\_ctrl\_hevc\_decode\_params**

<u>s32</u>	<u>pic_order_cnt_val</u>	PicOrder
<u>u16</u>	<u>short_term_ref_pic_set_size</u>	Specifies
<u>u16</u>	<u>long_term_ref_pic_set_size</u>	Specifies
<u>u8</u>	<u>num_active_dpb_entries</u>	The num
<u>u8</u>	<u>num_poc_st_curr_before</u>	The num
<u>u8</u>	<u>num_poc_st_curr_after</u>	The num

<code>_u8</code>	<code>num_poc_lt_curr</code>	The number of POCs in the current frame.
<code>_u8</code>	<code>poc_st_curr_before[V4L2_HEVC_DPB_ENTRIES_NUM_MAX]</code>	PocStCu
<code>_u8</code>	<code>poc_st_curr_after[V4L2_HEVC_DPB_ENTRIES_NUM_MAX]</code>	PocStCu
<code>_u8</code>	<code>poc_lt_curr[V4L2_HEVC_DPB_ENTRIES_NUM_MAX]</code>	PocLtCu
<code>_u8</code>	<code>num_delta_pocs_of_ref_rps_idx</code>	When the
<code>struct v4l2_hevc_dpb_entry</code>	<code>dpb[V4L2_HEVC_DPB_ENTRIES_NUM_MAX]</code>	The decode
<code>_u64</code>	<code>flags</code>	See <a href="#">Dec</a>

### Decode Parameters Flags

<code>V4L2_HEVC_DECODE_PARAM_FLAG_IRAP_PIC</code>	0x00000001	
<code>V4L2_HEVC_DECODE_PARAM_FLAG_IDR_PIC</code>	0x00000002	
<code>V4L2_HEVC_DECODE_PARAM_FLAG_NO_OUTPUT_OF_PRIOR</code>	0x00000004	

### `V4L2_CID_STATELESS_AV1_SEQUENCE` (struct)

Represents an AV1 Sequence OBU (Open Bitstream Unit). See section 5.5 "Sequence header OBU syntax" in [AV1](#) for more details.

type `v4l2_ctrl_av1_sequence`

Table 42: struct `v4l2_ctrl_av1_sequence`

<code>_u32</code>	<code>flags</code>	See <a href="#">AV1 Sequence Flags</a> .
<code>_u8</code>	<code>seq_profile</code>	Specifies the features that can be used in the coded video sequence.
<code>_u8</code>	<code>order_hint_bits</code>	Specifies the number of bits used for the <code>order_hint</code> field at each frame.
<code>_u8</code>	<code>bit_depth</code>	the bit depth to use for the sequence as described in section 5.5.2 "Color config syntax" in <a href="#">AV1</a> for more details.
<code>_u8</code>	<code>reserved</code>	Applications and drivers must set this to zero.
<code>_u16</code>	<code>max_frame_width_minus_1</code>	Specifies the maximum frame width minus 1 for the frames represented by this sequence header.

### AV1 Sequence Flags

<code>V4L2_AV1_SEQUENCE_FLAG_STILL_PICTURE</code>	0x00000001	If set, specifies that the
<code>V4L2_AV1_SEQUENCE_FLAG_USE_128X128_SUPERBLOCK</code>	0x00000002	If set, indicates that super
<code>V4L2_AV1_SEQUENCE_FLAG_ENABLE_FILTER_INTRA</code>	0x00000004	If set, specifies that the u
<code>V4L2_AV1_SEQUENCE_FLAG_ENABLE_INTRA_EDGE_FILTER</code>	0x00000008	Specifies whether the int
<code>V4L2_AV1_SEQUENCE_FLAG_ENABLE_INTERINTRA_COMPOUND</code>	0x00000010	If set, specifies that the r
<code>V4L2_AV1_SEQUENCE_FLAG_ENABLE_MASKED_COMPOUND</code>	0x00000020	If set, specifies that the r
<code>V4L2_AV1_SEQUENCE_FLAG_ENABLE_WARPED_MOTION</code>	0x00000040	If set, indicates that the a

V4L2_AV1_SEQUENCE_FLAG_ENABLE_DUAL_FILTER	0x00000080	If set, indicates that the sequence uses dual filter.
V4L2_AV1_SEQUENCE_FLAG_ENABLE_ORDER_HINT	0x00000100	If set, indicates that tools must use the specified order hint.
V4L2_AV1_SEQUENCE_FLAG_ENABLE_JNT_COMP	0x00000200	If set, indicates that the sequence uses joint component.
V4L2_AV1_SEQUENCE_FLAG_ENABLE_REF_FRAME_MVS	0x00000400	If set, indicates that the sequence uses multi view synthesis.
V4L2_AV1_SEQUENCE_FLAG_ENABLE_SUPERRES	0x00000800	If set, specifies that the sequence uses super resolution.
V4L2_AV1_SEQUENCE_FLAG_ENABLE_CDEF	0x00001000	If set, specifies that cdef is enabled.
V4L2_AV1_SEQUENCE_FLAG_ENABLE_RESTORATION	0x00002000	If set, specifies that loop restoration is enabled.
V4L2_AV1_SEQUENCE_FLAG_MONO_CHROME	0x00004000	If set, indicates that the sequence is mono chrome.
V4L2_AV1_SEQUENCE_FLAG_COLOR_RANGE	0x00008000	If set, signals full swing range.
V4L2_AV1_SEQUENCE_FLAG_SUBSAMPLING_X	0x00010000	Specify the chroma subsampling X.
V4L2_AV1_SEQUENCE_FLAG_SUBSAMPLING_Y	0x00020000	Specify the chroma subsampling Y.
V4L2_AV1_SEQUENCE_FLAG_FILM_GRAIN_PARAMS_PRESENT	0x00040000	Specifies whether film grain parameters are present.
V4L2_AV1_SEQUENCE_FLAG_SEPARATE_UV_DELTA_Q	0x00080000	If set, indicates that the sequence uses separate UV delta Q.

**V4L2\_CID\_STATELESS\_AV1\_TILE\_GROUP\_ENTRY (struct)**

Represents a single AV1 tile inside an AV1 Tile Group. Note that MiRowStart, MiRowEnd, MiColStart and MiColEnd can be retrieved from `struct v4l2_av1_tile_info` in `struct v4l2_ctrl_av1_frame` using tile\_row and tile\_col. See section 6.10.1 "General tile group OBU semantics" in [AV1](#) for more details.

type **v4l2\_ctrl\_av1\_tile\_group\_entry**

Table 44: struct v4l2\_ctrl\_av1\_tile\_group\_entry

<code>_u32</code>	<code>tile_offset</code>	Offset from the OBU data, i.e. where the coded tile data actually starts.
<code>_u32</code>	<code>tile_size</code>	Specifies the size in bytes of the coded tile. Equivalent to "Tile-Size" in <a href="#">AV1</a> .
<code>_u32</code>	<code>tile_row</code>	Specifies the row of the current tile. Equivalent to "TileRow" in <a href="#">AV1</a> .
<code>_u32</code>	<code>tile_col</code>	Specifies the column of the current tile. Equivalent to "TileColumn" in <a href="#">AV1</a> .

type **v4l2\_av1\_warp\_model**

AV1 Warp Model as described in section 3 "Symbols and abbreviated terms" of [AV1](#).

V4L2_AV1_WARP_MODEL_IDENTITY	0	Warp model is just an identity transform.
V4L2_AV1_WARP_MODEL_TRANSLATION	1	Warp model is a pure translation.
V4L2_AV1_WARP_MODEL_ROTZOOM	2	Warp model is a rotation + symmetric zoom + translation.
V4L2_AV1_WARP_MODEL_AFFINE	3	Warp model is a general affine transform.

type **v4l2\_av1\_reference\_frame**

AV1 Reference Frames as described in section 6.10.24 "Ref frames semantics" of [AV1](#).

V4L2_AV1_REF_INTRA_FRAME	0	Intra Frame Reference.
V4L2_AV1_REF_LAST_FRAME	1	Last Frame Reference.
V4L2_AV1_REF_LAST2_FRAME	2	Last2 Frame Reference.
V4L2_AV1_REF_LAST3_FRAME	3	Last3 Frame Reference.
V4L2_AV1_REF_GOLDEN_FRAME	4	Golden Frame Reference.
V4L2_AV1_REF_BWDREF_FRAME	5	BWD Frame Reference.
V4L2_AV1_REF_ALTREF2_FRAME	6	ALTREF2 Frame Reference.
V4L2_AV1_REF_ALTREF_FRAME	7	ALTREF Frame Reference.

type **v4l2\_av1\_global\_motion**

AV1 Global Motion parameters as described in section 6.8.17 "Global motion params semantics" of [AV1](#).

Table 45: struct v4l2\_av1\_global\_motion

__u8	flags[V4L2_AV1_TOTAL_REFS_PER_FRAME]	A bitfield containing the flags per reference frame. See <a href="#">AV1 Global Motion Flags</a> for more details.
enum <i>v4l2_av1_warp_model</i>	type[V4L2_AV1_TOTAL_REFS_PER_FRAME]	The type of global motion transform used.
s32	params[V4L2_AV1_TOTAL_REFS_PER_FRAME]	This field has the same meaning as "gm_params" in <a href="#">AV1</a> .
__u8	invalid	Bitfield indicating whether the global motion params are invalid for a given reference frame. See section 7.11.3.6 Setup shear process and the variable "warpValid". Use V4L2_AV1_GLOBAL_MOTION_IS_INVALID(ref) to create a suitable mask.
__u8	reserved[3]	Applications and drivers must set this to zero.

AV1 Global Motion Flags

V4L2_AV1_GLOBAL_MOTION_FLAG_IS_GLOBAL	0x00000001	Specifies whether global motion parameters are present for a particular reference frame.
V4L2_AV1_GLOBAL_MOTION_FLAG_IS_ROT_ZOOM	0x00000002	Specifies whether a particular reference frame uses rotation and zoom.
V4L2_AV1_GLOBAL_MOTION_FLAG_IS_TRANSLATION	0x00000004	Specifies whether a particular reference frame uses translation globally.

type **v4l2\_av1\_frame\_restoration\_type**

AV1 Frame Restoration Type.

V4L2_AV1_FRAME_RESTORE_NONE	0	No filtering is applied.
V4L2_AV1_FRAME_RESTORE_WIENER	1	Wiener filter process is invoked.
V4L2_AV1_FRAME_RESTORE_SGRPROJ	2	Self guided filter process is invoked.
V4L2_AV1_FRAME_RESTORE_SWITCHABLE	3	Restoration filter is switchable.

type **v4l2\_av1\_loop\_restoration**

AV1 Loop Restoration as described in section 6.10.15 "Loop restoration params semantics" of [AV1](#).

Table 47: struct v4l2\_av1\_loop\_restoration

__u8	flags	See <a href="#">AV1 Loop Restoration Flags</a> .
__u8	lr_unit_shift	Specifies if the luma restoration size should be halved.
__u8	lr_uv_shift	Specifies if the chroma size should be half the luma size.
__u8	reserved	Applications and drivers must set this to zero.
<i>v4l2_av1_frame_restoration_type</i> [V4L2_AV1_NUM_PLANES]	type[V4L2_AV1_NUM_PLANES]	The type of restoration used for each plane.
__u8	loop_restoration_size[V4L2_AV1_MAX_NUM_PLANES]	Specifies the size of loop restoration units in units of samples in the current plane.

AV1 Loop Restoration Flags

V4L2_AV1_LOOP_RESTORATION_FLAGUSES_LR	0x00000001	Retains the same meaning as UsesLr in <a href="#">AV1</a> .
V4L2_AV1_LOOP_RESTORATION_FLAGUSES_CHROMA_LR	0x00000002	Retains the same meaning as UsesChromaLr in <a href="#">AV1</a> .

type **v4l2\_av1\_cdef**

AV1 CDEF params semantics as described in section 6.10.14 "CDEF params semantics" of [AV1](#).

Table 49: struct v4l2\_av1\_cdef

<code>_u8</code>	<code>damping_minus_3</code>	Controls the amount of damping in the deringing filter.
<code>_u8</code>	<code>bits</code>	Specifies the number of bits needed to specify which CDEF filter to apply.
<code>_u8</code>	<code>y_pri_strength[V4L2_AV1_CDEF_MAX]</code>	Specifies the strength of the primary filter.
<code>_u8</code>	<code>y_sec_strength[V4L2_AV1_CDEF_MAX]</code>	Specifies the strength of the secondary filter.
<code>_u8</code>	<code>uv_pri_strength[V4L2_AV1_CDEF_MAX]</code>	Specifies the strength of the primary filter.
<code>_u8</code>	<code>uv_secondary_strength[V4L2_AV1_CDEF_MAX]</code>	Specifies the strength of the secondary filter.

type `v4l2_av1_segment_feature`

AV1 segment features as described in section 3 "Symbols and abbreviated terms" of [AV1](#).

<code>V4L2_AV1_SEG_LVL_ALT_Q</code>	0	Index for quantizer segment feature.
<code>V4L2_AV1_SEG_LVL_ALT_LF_Y_V</code>	1	Index for vertical luma loop filter segment feature.
<code>V4L2_AV1_SEG_LVL_REF_FRAME</code>	5	Index for reference frame segment feature.
<code>V4L2_AV1_SEG_LVL_REF_SKIP</code>	6	Index for skip segment feature.
<code>V4L2_AV1_SEG_LVL_REF_GLOBALMV</code>	7	Index for global mv feature.
<code>V4L2_AV1_SEG_LVL_MAX</code>	8	Number of segment features.

type `v4l2_av1_segmentation`

AV1 Segmentation params as defined in section 6.8.13 "Segmentation params semantics" of [AV1](#).

Table 50: struct v4l2\_av1\_segmentation

<code>_u8</code>	<code>flags</code>	See <a href="#">AV1 Segmentation Flags</a>
<code>_u8</code>	<code>last_active_seg_id</code>	Indicates the highest numbered segment id that has some enabled feature. This is used when decoding the segment id to only decode choices corresponding to used segments.
<code>_u8</code>	<code>feature_enabled[V4L2_AV1_MAX_SEGMENT]</code>	Bitmask defining which features are enabled in each segment. Use <code>V4L2_AV1_SEGMENT_FEATURE_ENABLED</code> to build a suitable mask.
<code>_u16</code>	<code>feature_data[V4L2_AV1_MAX_SEGMENTS]</code>	Data and the <code>SEG_ID_PRE_SKIP</code> entry. Data entry is only valid if the feature is enabled.

AV1 Segmentation Flags

<code>V4L2_AV1_SEGMENTATION_FLAG_ENABLED</code>	0x00000001	If set, indicates that this frame makes use of the segmentation tool.
<code>V4L2_AV1_SEGMENTATION_FLAG_UPDATE_MAP</code>	0x00000002	If set, indicates that the segmentation map are updated during the current frame.
<code>V4L2_AV1_SEGMENTATION_FLAG_TEMPORAL_UPDATE</code>	0x00000004	If set, indicates that the updates to the segmentation map are coded temporally.
<code>V4L2_AV1_SEGMENTATION_FLAG_UPDATE_DATA</code>	0x00000008	If set, indicates that the updates to the segmentation map are coded using data.
<code>V4L2_AV1_SEGMENTATION_FLAG_SEG_ID_PRE_SKIP</code>	0x00000010	If set, indicates that the segment id will be read before the skip syntax.

type `v4l2_av1_loop_filter`

AV1 Loop filter params as defined in section 6.8.10 "Loop filter semantics" of [AV1](#).

Table 52: struct v4l2\_av1\_global\_motion

<code>_u8</code>	<code>flags</code>	See <a href="#">AV1 Loop Filter flags</a> for more details.
<code>_u8</code>	<code>level[4]</code>	An array containing loop filter strength values. Different loop filter strength values from the array are used depending on the image plane being filtered, and the edge direction (vertical or horizontal) being filtered.
<code>_u8</code>	<code>sharpness</code>	indicates the sharpness level. The loop filter level and loop filter sharpness together determine when a block edge is filtered, and by how much the filtering can change the sample values. The loop filter process is described in section 7.14 of <a href="#">AV1</a> .
<code>_u8</code>	<code>ref_deltas[V4L2_AV1_TOTAL_REFS_PER_FRAME]</code>	Maintains the adjustment needed for the filter level based on the chosen reference frame. If this syntax element is not present, it maintains its previous value.
<code>_u8</code>	<code>mode_deltas[2]</code>	contains the adjustment needed for the filter level based on the chosen mode. If this syntax element is not present, it maintains its previous value.
<code>_u8</code>	<code>delta_lf_res</code>	specifies the left shift which should be applied to decoded loop filter delta values.

## AV1 Loop Filter Flags

V4L2_AV1_LOOP_FILTER_FLAG_DELTA_ENABLED	0x00000001	If set, means that the filter level depends on the mode and reference frame.
V4L2_AV1_LOOP_FILTER_FLAG_DELTA_UPDATE	0x00000002	If set, means that additional syntax elements are present that specify loop filter delta values.
V4L2_AV1_LOOP_FILTER_FLAG_DELTA_LF_PRESENT	0x00000004	Specifies whether loop filter delta values are present.
V4L2_AV1_LOOP_FILTER_FLAG_DELTA_LF_MULTI	0x00000008	A value equal to 1 specifies that separate loop filter deltas are sent for each frame.

type **v4l2\_av1\_quantization**

AV1 Quantization params as defined in section 6.8.11 "Quantization params semantics" of [AV1](#).

Table 54: struct v4l2\_av1\_quantization

__u8	flags	See <a href="#">AV1 Loop Filter flags</a> for more details.
__u8	base_q_idx	Indicates the base frame qindex. This is used for Y AC coefficients and as the base value for the other quantizers.
__u8	delta_q_y_dc	Indicates the Y DC quantizer relative to base_q_idx.
__u8	delta_q_u_dc	Indicates the U DC quantizer relative to base_q_idx.
__u8	delta_q_u_ac	Indicates the U AC quantizer relative to base_q_idx.
__u8	delta_q_v_dc	Indicates the V DC quantizer relative to base_q_idx.
__u8	delta_q_v_ac	Indicates the V AC quantizer relative to base_q_idx.
__u8	qm_y	Specifies the level in the quantizer matrix that should be used for luma plane decoding.
__u8	qm_u	Specifies the level in the quantizer matrix that should be used for chroma U plane decoding.
__u8	qm_v	Specifies the level in the quantizer matrix that should be used for chroma V plane decoding.
__u8	delta_q_res	Specifies the left shift which should be applied to decoded quantizer index delta values.

## AV1 Quantization Flags

V4L2_AV1_QUANTIZATION_FLAG_DIFF_UV_DELTA	0x00000001	If set, indicates that the U and V delta quantizer values are coded separately.
V4L2_AV1_QUANTIZATION_FLAG_USING_QMATRIX	0x00000002	If set, specifies that the quantizer matrix will be used to compute quantized values.
V4L2_AV1_QUANTIZATION_FLAG_DELTA_Q_PRESENT	0x00000004	Specifies whether quantizer index delta values are present.

type **v4l2\_av1\_tile\_info**

AV1 Tile info as defined in section 6.8.14 "Tile info semantics" of [ref:av1](#).

Table 56: struct v4l2\_av1\_tile\_info

__u8	flags	See <a href="#">AV1 Tile Info flags</a> for more details.
__u8	context_update_tile_id	Specifies which tile to use for the CDF update.
__u8	tile_cols	Specifies the number of tiles across the frame.
__u8	tile_rows	Specifies the number of tiles down the frame.
__u32	mi_col_starts[V4L2_AV1_MAX_TILE_COLS + 1]	An array specifying the start column (in units of 4x4 luma samples) for each tile across the image.
__u32	mi_row_starts[V4L2_AV1_MAX_TILE_ROWS + 1]	An array specifying the start row (in units of 4x4 luma samples) for each tile across the image.
__u32	width_in_sbs_minus_1[V4L2_AV1_MAX_TILE_ROWS]	The width of a tile minus 1 in units of superblocks.
__u32	height_in_sbs_minus_1[V4L2_AV1_MAX_TILE_COLS]	The height of a tile minus 1 in units of superblocks.
__u8	tile_size_bytes	Specifies the number of bytes needed to code each tile size.
__u8	reserved[3]	Applications and drivers must set this to zero.

## AV1 Tile Info Flags

V4L2_AV1_TILE_INFO_FLAG_UNIFORM_TILE_SPACING	0x00000001	If set, means that the tiles are uniformly spaced across the frame.
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type **v4l2\_av1\_frame\_type**

AV1 Frame Type

V4L2_AV1_KEY_FRAME	0	Key frame.
V4L2_AV1_INTER_FRAME	1	Inter frame.
V4L2_AV1_INTRA_ONLY_FRAME	2	Intra-only frame.
V4L2_AV1_SWITCH_FRAME	3	Switch frame.

type **v4l2\_av1\_interpolation\_filter**

AV1 Interpolation Filter

V4L2_AV1_INTERPOLATION_FILTER_EIGHTTAP	0	Eight tap filter.
V4L2_AV1_INTERPOLATION_FILTER_EIGHTTAP_SMOOTH	1	Eight tap smooth filter.
V4L2_AV1_INTERPOLATION_FILTER_EIGHTTAP_SHARP	2	Eight tap sharp filter.
V4L2_AV1_INTERPOLATION_FILTER_BILINEAR	3	Bilinear filter.
V4L2_AV1_INTERPOLATION_FILTER_SWITCHABLE	4	Filter selection is signaled at the block level.

type **v4l2\_av1\_tx\_mode**

AV1 Tx mode as described in section 6.8.21 “TX mode semantics” of [AV1](#).

V4L2_AV1_TX_MODE_ONLY_4X4	0	The inverse transform will use only 4x4 transforms.
V4L2_AV1_TX_MODE_LARGEST	1	The inverse transform will use the largest transform size that fits inside the block.
V4L2_AV1_TX_MODE_SELECT	2	The choice of transform size is specified explicitly for each block.

**V4L2\_CID\_STATELESS\_AV1\_FRAME (struct)**

Represents a Frame Header OBU. See 6.8 “Frame Header OBU semantics” of [AV1](#) for more details.

type **v4l2\_ctrl\_av1\_frame**

Table 58: struct v4l2\_ctrl\_av1\_frame

struct <code>v4l2_av1_tile_info</code>	<code>tile_info</code>	Tile info
struct <code>v4l2_av1_quantization</code>	<code>quantization</code>	Quantization parameters.
struct <code>v4l2_av1_segmentation</code>	<code>segmentation</code>	Segmentation parameters.
<code>_u8</code>	<code>superres_denom</code>	The denominator for the upscaling ratio.
struct <code>v4l2_av1_loop_filter</code>	<code>loop_filter</code>	Loop filter params
struct <code>v4l2_av1_cdef</code>	<code>cdef</code>	CDEF params
<code>_u8</code>	<code>skip_mode_frame[2]</code>	Specifies the frames to use for compound prediction when <code>skip_mode</code> is equal to 1.
<code>_u8</code>	<code>primary_ref_frame</code>	Specifies which reference frame contains the CDF values and other state that should be loaded at the start of the frame.
struct <code>v4l2_av1_loop_restoration</code>	<code>loop_restoration</code>	Loop restoration parameters.
struct <code>v4l2_av1_loop_global_motion</code>	<code>global_motion</code>	Global motion parameters.
<code>_u32</code>	<code>flags</code>	See <a href="#">AV1 Frame flags</a> for more details.
enum <code>v4l2_av1_frame_type</code>	<code>frame_type</code>	Specifies the AV1 frame type
<code>_u32</code>	<code>order_hint</code>	Specifies OrderHintBits least significant bits of the expected output order for this frame.
<code>_u32</code>	<code>upscaled_width</code>	The upscaled width.
enum <code>v4l2_av1_interpolation_filter</code>	<code>interpolation_filter</code>	Specifies the filter selection used for performing inter prediction.
enum <code>v4l2_av1_tx_mode</code>	<code>tx_mode</code>	Specifies how the transform size is determined.
<code>_u32</code>	<code>frame_width_minus_1</code>	Add 1 to get the frame's width.
<code>_u32</code>	<code>frame_height_minus_1</code>	Add 1 to get the frame's height.
<code>_u16</code>	<code>render_width_minus_1</code>	Add 1 to get the render width of the frame in luma samples.
<code>_u16</code>	<code>render_height_minus_1</code>	Add 1 to get the render height of the frame in luma samples.
<code>_u32</code>	<code>current_frame_id</code>	Specifies the frame id number for the current frame. Frame id numbers are additional information that do not affect the decoding process, but provide decoders with a way of detecting missing reference frames so that appropriate action can be taken.
<code>_u8</code>	<code>buffer_removal_time[V4L2_AV1_MAX_OPERATING_POINTS]</code>	Removal time in units of DecCT clock ticks counted from the removal time of the last random access point for operating point opNum.
<code>_u8</code>	<code>reserved[4]</code>	Applications and drivers must set this to zero.
<code>_u32</code>	<code>order_hints[V4L2_AV1_TOTAL_REFSS_PER_FRAME]</code>	expected output order hint for each reference frame. This field corresponds to the OrderHints variable from the specification (section 5.9.2 "Uncompressed header syntax"). As such, this is only used for non-intra frames and ignored otherwise. <code>order_hints[0]</code> is always ignored.
<code>_u64</code>	<code>reference_frame_ts[V4L2_AV1_TOTAL_REFSS_PER_FRAME]</code>	Timestamp for each of the reference frames enumerated in enum <code>v4l2_av1_reference_frame</code> starting at <code>V4L2_AV1_REF_LAST_FRAME</code> . This represents the state of reference slot as described in the spec and updated by userland through the "Reference frame update process" in section 7.20. The timestamp refers to the timestamp field in struct <code>v4l2_buffer</code> . Use the <code>v4l2_timeval_to_ns()</code> function to convert the struct <code>timeval</code> in struct <code>v4l2_buffer</code> to a <code>_u64</code> .
<code>_s8</code>	<code>ref_frame_idx[V4L2_AV1_REFSS_PER_FRAME]</code>	map into <code>reference_frame_ts</code> representing the ordered list of references used by inter-frame. Matches the bitstream syntax element of the same name.
<code>_u8</code>	<code>refresh_frame_flags</code>	Contains a bitmask that specifies which reference frame slots will be updated with the current frame after it is decoded.

AV1 Frame Flags

V4L2_AV1_FRAME_FLAG_SHOW_FRAME	0x00000001	If set, specifies that this frame should be immediately output
V4L2_AV1_FRAME_FLAG_SHOWABLE_FRAME	0x00000002	If set, specifies that the frame may be output using the show
V4L2_AV1_FRAME_FLAG_ERROR_RESILIENT_MODE	0x00000004	Specifies whether error resilient mode is enabled.
V4L2_AV1_FRAME_FLAG_DISABLE_CDF_UPDATE	0x00000008	Specifies whether the CDF update in the symbol decoding pr
V4L2_AV1_FRAME_FLAG_ALLOW_SCREEN_CONTENT_TOOLS	0x00000010	If set, indicates that intra blocks may use palette encoding. If
V4L2_AV1_FRAME_FLAG_FORCE_INTEGER_MV	0x00000020	If set, specifies that motion vectors will always be integers. If
V4L2_AV1_FRAME_FLAG_ALLOW_INTRABC	0x00000040	If set, indicates that intra block copy may be used in this fram
V4L2_AV1_FRAME_FLAG_USE_SUPERRES	0x00000080	If set, indicates that upscaling is needed.
V4L2_AV1_FRAME_FLAG_ALLOW_HIGH_PRECISION_MV	0x00000100	If set, specifies that motion vectors are specified to eighth pe
V4L2_AV1_FRAME_FLAG_IS_MOTION_MODE_SWITCHABLE	0x00000200	If not set, specifies that only the SIMPLE motion mode will be
V4L2_AV1_FRAME_FLAG_USE_REF_FRAME_MVS	0x00000400	If set specifies that motion vector information from a previous
V4L2_AV1_FRAME_FLAG_DISABLE_FRAME_END_UPDATE_CDF	0x00000800	If set indicates that the end of frame CDF update is disabled.
V4L2_AV1_FRAME_FLAG_ALLOW_WARPED_MOTION	0x00001000	If set, indicates that the syntax element motion_mode may be
V4L2_AV1_FRAME_FLAG_REFERENCE_SELECT	0x00002000	If set, specifies that the mode info for inter blocks contains the
V4L2_AV1_FRAME_FLAG_REDUCED_TX_SET	0x00004000	If set, specifies that the frame is restricted to a reduced subs
V4L2_AV1_FRAME_FLAG_SKIP_MODE_ALLOWED	0x00008000	This flag retains the same meaning as SkipModeAllowed in A
V4L2_AV1_FRAME_FLAG_SKIP_MODE_PRESENT	0x00010000	If set, specifies that the syntax element skip_mode will be pre
V4L2_AV1_FRAME_FLAG_FRAME_SIZE_OVERRIDE	0x00020000	If set, specifies that the frame size will either be specified as
V4L2_AV1_FRAME_FLAG_BUFFER_REMOVAL_TIME_PRESENT	0x00040000	If set, specifies that buffer_removal_time is present. If not set
V4L2_AV1_FRAME_FLAG_FRAME_REFS_SHORT_SIGNALING	0x00080000	If set, indicates that only two reference frames are explicitly

## **V4L2\_CID\_STATELESS\_AV1\_FILM\_GRAIN (struct)**

Represents the optional film grain parameters. See section 6.8.20 "Film grain params semantics" of [AV1](#) for more details.

type **v4l2\_ctrl\_av1\_film\_grain**

Table 60: struct v4l2\_ctrl\_av1\_film\_grain

<code>_u8</code>	<code>flags</code>	See <a href="#">AV1 Film Grain Flags</a> .
<code>_u8</code>	<code>cr_mult</code>	Represents a multiplier for the cr component used in derivation of the input index to the cr component scaling function.
<code>_u16</code>	<code>grain_seed</code>	Specifies the starting value for the pseudo-random numbers used during film grain synthesis.
<code>_u8</code>	<code>film_grain_params_ref_idx</code>	Indicates which reference frame contains the film grain parameters to be used for this frame.
<code>_u8</code>	<code>num_y_points</code>	Specifies the number of points for the piece-wise linear scaling function of the luma component.
<code>_u8</code>	<code>point_y_value[V4L2_AV1_MAX_NUM_Y_POINTS]</code>	Represents the x (luma value) coordinate for the i-th point of the piecewise linear scaling function for luma component. The values are signaled on the scale of 0..255. In case of 10 bit video, these values correspond to luma values divided by 4. In case of 12 bit video, these values correspond to luma values divided by 16.
<code>_u8</code>	<code>point_y_scaling[V4L2_AV1_MAX_NUM_Y_POINTS]</code>	Represents the scaling (output) value for the i-th point of the piecewise linear scaling function for luma component.
<code>_u8</code>	<code>num_cb_points</code>	Specifies the number of points for the piece-wise linear scaling function of the cb component.
<code>_u8</code>	<code>point_cb_value[V4L2_AV1_MAX_NUM_CB_POINTS]</code>	Represents the x coordinate for the i-th point of the piece-wise linear scaling function for cb component. The values are signaled on the scale of 0..255.
<code>_u8</code>	<code>point_cb_scaling[V4L2_AV1_MAX_NUM_CB_POINTS]</code>	Represents the scaling (output) value for the i-th point of the piecewise linear scaling function for cb component.
<code>_u8</code>	<code>num_cr_points</code>	Represents the number of points for the piece-wise linear scaling function of the cr component.
<code>_u8</code>	<code>point_cr_value[V4L2_AV1_MAX_NUM_CR_POINTS]</code>	Represents the x coordinate for the i-th point of the piece-wise linear scaling function for cr component. The values are signaled on the scale of 0..255.
<code>_u8</code>	<code>point_cr_scaling[V4L2_AV1_MAX_NUM_CR_POINTS]</code>	Represents the scaling (output) value for the i-th point of the piecewise linear scaling function for cr component.
<code>_u8</code>	<code>grain_scaling_minus_8</code>	Represents the shift - 8 applied to the values of the chroma component. The grain_scaling_minus_8 can take values of 0..3 and determines the range and quantization step of the standard deviation of film grain.
<code>_u8</code>	<code>ar_coeff_lag</code>	Specifies the number of auto-regressive coefficients for luma and chroma.
<code>_u8</code>	<code>ar_coeffs_y_plus_128[V4L2_AV1_AR_COEFFS_PLUS_128]</code>	auto-regressive coefficients used for the Y plane.
<code>_u8</code>	<code>ar_coeffs_cb_plus_128[V4L2_AV1_AR_COEFFS_PLUS_128]</code>	auto-regressive coefficients used for the U plane.
<code>_u8</code>	<code>ar_coeffs_cr_plus_128[V4L2_AV1_AR_COEFFS_PLUS_128]</code>	auto-regressive coefficients used for the V plane.
<code>_u8</code>	<code>ar_coeff_shift_minus_6</code>	Specifies the range of the auto-regressive coefficients. Values of 0, 1, 2, and 3 correspond to the ranges for auto-regressive coefficients of [-2, 2), [-1, 1), [-0.5, 0.5) and [-0.25, 0.25) respectively.
<code>_u8</code>	<code>grain_scale_shift</code>	Specifies how much the Gaussian random numbers should be scaled down during the grain synthesis process.
<code>_u8</code>	<code>cb_mult</code>	Represents a multiplier for the cb component used in derivation of the input index to the cb component scaling function.
<code>_u8</code>	<code>cb_luma_mult</code>	Represents a multiplier for the average luma component used in derivation of the input index to the cb component scaling function.
<code>_u8</code>	<code>cr_luma_mult</code>	Represents a multiplier for the average luma component used in derivation of the input index to the cr component scaling function.
<code>_u16</code>	<code>cb_offset</code>	Represents an offset used in derivation of the input index to the cb component scaling function.
<code>_u16</code>	<code>cr_offset</code>	Represents an offset used in derivation of the input index to the cr component scaling function.
<code>_u8</code>	<code>reserved[4]</code>	Applications and drivers must set this to zero.

## AV1 Film Grain Flags

<code>V4L2_AV1_FILM_GRAIN_FLAG_APPLY_GRAIN</code>	0x00000001	If set, specifies that film grain should be added to this frame.
<code>V4L2_AV1_FILM_GRAIN_FLAG_UPDATE_GRAIN</code>	0x00000002	If set, means that a new set of parameters should be sent. If
<code>V4L2_AV1_FILM_GRAIN_FLAG_CHROMA_SCALING_FROM_LUMA</code>	0x00000004	If set, specifies that the chroma scaling is inferred from the
<code>V4L2_AV1_FILM_GRAIN_FLAG_OVERLAP</code>	0x00000008	If set, indicates that the overlap between film grain blocks s
<code>V4L2_AV1_FILM_GRAIN_FLAG_CLIP_TO_RESTRICTED_RANGE</code>	0x00000010	If set, indicates that clipping to the restricted (studio, i.e. lin

## JPEG Control Reference

The JPEG class includes controls for common features of JPEG encoders and decoders. Currently it includes features for codecs implementing progressive baseline DCT compression process with Huffman entropy coding.

### JPEG Control IDs

#### V4L2\_CID\_JPEG\_CLASS (class)

The JPEG class descriptor. Calling `iocctl VIDIOC_QUERYCTRL`, `VIDIOC_QUERY_EXT_CTRL` and `VIDIOC_QUERYMENU` for this control will return a description of this control class.

#### V4L2\_CID\_JPEG\_CHROMA\_SUBSAMPLING (menu)

The chroma subsampling factors describe how each component of an input image is sampled, in respect to maximum sample rate in each spatial dimension. See [ITU-T.81](#), clause A.1.1. for more details. The V4L2\_CID\_JPEG\_CHROMA\_SUBSAMPLING control determines how Cb and Cr components are downsampled after converting an input image from RGB to Y'CbCr color space.

V4L2_JPEG_CHROMA_SUBSAMPLING_444	No chroma subsampling, each pixel has Y, Cr and Cb values.
V4L2_JPEG_CHROMA_SUBSAMPLING_422	Horizontally subsample Cr, Cb components by a factor of 2.
V4L2_JPEG_CHROMA_SUBSAMPLING_420	Subsample Cr, Cb components horizontally and vertically by 2.
V4L2_JPEG_CHROMA_SUBSAMPLING_411	Horizontally subsample Cr, Cb components by a factor of 4.
V4L2_JPEG_CHROMA_SUBSAMPLING_410	Subsample Cr, Cb components horizontally by 4 and vertically by 2.
V4L2_JPEG_CHROMA_SUBSAMPLING_GRAY	Use only luminance component.

#### V4L2\_CID\_JPEG\_RESTART\_INTERVAL (integer)

The restart interval determines an interval of inserting RSTm markers ( $m = 0..7$ ). The purpose of these markers is to additionally reinitialize the encoder process, in order to process blocks of an image independently. For the lossy compression processes the restart interval unit is MCU (Minimum Coded Unit) and its value is contained in DRI (Define Restart Interval) marker. If V4L2\_CID\_JPEG\_RESTART\_INTERVAL control is set to 0, DRI and RSTm markers will not be inserted.

#### V4L2\_CID\_JPEG\_COMPRESSION\_QUALITY (integer)

Determines trade-off between image quality and size. It provides simpler method for applications to control image quality, without a need for direct reconfiguration of luminance and chrominance quantization tables. In cases where a driver uses quantization tables configured directly by an application, using interfaces defined elsewhere, V4L2\_CID\_JPEG\_COMPRESSION\_QUALITY control should be set by driver to 0.

The value range of this control is driver-specific. Only positive, non-zero values are meaningful. The recommended range is 1 - 100, where larger values correspond to better image quality.

#### V4L2\_CID\_JPEG\_ACTIVE\_MARKER (bitmask)

Specify which JPEG markers are included in compressed stream. This control is valid only for encoders.

V4L2_JPEG_ACTIVE_MARKER_APP0	Application data segment APP <sub>0</sub> .
V4L2_JPEG_ACTIVE_MARKER_APP1	Application data segment APP <sub>1</sub> .
V4L2_JPEG_ACTIVE_MARKER_COM	Comment segment.
V4L2_JPEG_ACTIVE_MARKER_DQT	Quantization tables segment.
V4L2_JPEG_ACTIVE_MARKER_DHT	Huffman tables segment.

For more details about JPEG specification, refer to [ITU-T.81](#), [JFIF](#), [W3C JPEG JFIF](#).

## Digital Video Control Reference

The Digital Video control class is intended to control receivers and transmitters for [VGA](#), [DVI](#) (Digital Visual Interface), [HDMI](#) ([HDMI](#)) and [DisplayPort](#) ([DP](#)). These controls are generally expected to be private to the receiver or transmitter subdevice that implements them, so they are only exposed on the `/dev/v4l-subdev*` device node.

**Note:** Note that these devices can have multiple input or output pads which are hooked up to e.g. HDMI connectors. Even though the subdevice will receive or transmit video from/to only one of those pads, the other pads can still be active when it comes to EDID (Extended Display Identification Data, [EDID](#)) and HDCP (High-bandwidth Digital Content Protection System, [HDCP](#)) processing, allowing the device to do the fairly slow EDID/HDCP handling in advance. This allows for quick switching between connectors.

These pads appear in several of the controls in this section as bitmasks, one bit for each pad. Bit 0 corresponds to pad 0, bit 1 to pad 1, etc. The maximum value of the control is the set of valid pads.

**Digital Video Control IDs****V4L2\_CID\_DV\_CLASS (class)**

The Digital Video class descriptor.

**V4L2\_CID\_DV\_TX\_HOTPLUG (bitmask)**

Many connectors have a hotplug pin which is high if EDID information is available from the source. This control shows the state of the hotplug pin as seen by the transmitter. Each bit corresponds to an output pad on the transmitter. If an output pad does not have an associated hotplug pin, then the bit for that pad will be 0. This read-only control is applicable to DVI-D, HDMI and DisplayPort connectors.

**V4L2\_CID\_DV\_RX\_SENSE (bitmask)**

Rx Sense is the detection of pull-ups on the TMDS clock lines. This normally means that the sink has left/entered standby (i.e. the transmitter can sense that the receiver is ready to receive video). Each bit corresponds to an output pad on the transmitter. If an output pad does not have an associated Rx Sense, then the bit for that pad will be 0. This read-only control is applicable to DVI-D and HDMI devices.

**V4L2\_CID\_DV\_TX\_EDID\_PRESENT (bitmask)**

When the transmitter sees the hotplug signal from the receiver it will attempt to read the EDID. If set, then the transmitter has read at least the first block (= 128 bytes). Each bit corresponds to an output pad on the transmitter. If an output pad does not support EDIDs, then the bit for that pad will be 0. This read-only control is applicable to VGA, DVI-A/D, HDMI and DisplayPort connectors.

**V4L2\_CID\_DV\_TX\_MODE**

(enum)

**enum v4l2\_dv\_tx\_mode -**

HDMI transmitters can transmit in DVI-D mode (just video) or in HDMI mode (video + audio + auxiliary data). This control selects which mode to use: V4L2\_DV\_TX\_MODE\_DVI\_D or V4L2\_DV\_TX\_MODE\_HDMI. This control is applicable to HDMI connectors.

**V4L2\_CID\_DV\_TX\_RGB\_RANGE**

(enum)

**enum v4l2\_dv\_rgb\_range -**

Select the quantization range for RGB output. V4L2\_DV\_RANGE\_AUTO follows the RGB quantization range specified in the standard for the video interface (ie. [CEA-861-E](#) for HDMI). V4L2\_DV\_RANGE\_LIMITED and V4L2\_DV\_RANGE\_FULL override the standard to be compatible with sinks that have not implemented the standard correctly (unfortunately quite common for HDMI and DVI-D). Full range allows all possible values to be used whereas limited range sets the range to  $(16 << (N-8)) - (235 << (N-8))$  where N is the number of bits per component. This control is applicable to VGA, DVI-A/D, HDMI and DisplayPort connectors.

**V4L2\_CID\_DV\_TX\_IT\_CONTENT\_TYPE**

(enum)

**enum v4l2\_dv\_it\_content\_type -**

Configures the IT Content Type of the transmitted video. This information is sent over HDMI and DisplayPort connectors as part of the AVI InfoFrame. The term 'IT Content' is used for content that originates from a computer as opposed to content from a TV broadcast or an analog source. The enum v4l2\_dv\_it\_content\_type defines the possible content types:

V4L2_DV_IT_CONTENT_TYPE_GRAPHICS	Graphics content. Pixel data should be passed unfiltered and without analog reconstruction.
V4L2_DV_IT_CONTENT_TYPE_PHOTO	Photo content. The content is derived from digital still pictures. The content should be passed through with minimal scaling and picture enhancements.
V4L2_DV_IT_CONTENT_TYPE_CINEMA	Cinema content.
V4L2_DV_IT_CONTENT_TYPE_GAME	Game content. Audio and video latency should be minimized.
V4L2_DV_IT_CONTENT_TYPE_NO_ITC	No IT Content information is available and the ITC bit in the AVI InfoFrame is set to 0.

**V4L2\_CID\_DV\_RX\_POWER\_PRESENT (bitmask)**

Detects whether the receiver receives power from the source (e.g. HDMI carries 5V on one of the pins). This is often used to power an eeprom which contains EDID information, such that the source can read the EDID even if the sink is in standby/power off. Each bit corresponds to an input pad on the receiver. If an input pad cannot detect whether power is present, then the bit for that pad will be 0. This read-only control is applicable to DVI-D, HDMI and DisplayPort connectors.

**V4L2\_CID\_DV\_RX\_RGB\_RANGE**

(enum)

**enum v4l2\_dv\_rgb\_range -**

Select the quantization range for RGB input. V4L2\_DV\_RANGE\_AUTO follows the RGB quantization range specified in the standard for the video interface (ie. [CEA-861-E](#) for HDMI). V4L2\_DV\_RANGE\_LIMITED and V4L2\_DV\_RANGE\_FULL override the standard to be compatible with sources that have not implemented the standard correctly (unfortunately quite common for HDMI and DVI-D). Full range allows all possible values to be used whereas limited range sets the range to  $(16 << (N-8)) - (235 << (N-8))$  where N is the number of bits per component.

`<< (N-8)) - (235 << (N-8))` where N is the number of bits per component. This control is applicable to VGA, DVI-A/D, HDMI and DisplayPort connectors.

## V4L2\_CID\_DV\_RX\_IT\_CONTENT\_TYPE (enum)

### enum v4l2\_dv\_it\_content\_type -

Reads the IT Content Type of the received video. This information is sent over HDMI and DisplayPort connectors as part of the AVI InfoFrame. The term 'IT Content' is used for content that originates from a computer as opposed to content from a TV broadcast or an analog source. See V4L2\_CID\_DV\_TX\_IT\_CONTENT\_TYPE for the available content types.

## RF Tuner Control Reference

The RF Tuner (RF\_TUNER) class includes controls for common features of devices having RF tuner.

In this context, RF tuner is radio receiver circuit between antenna and demodulator. It receives radio frequency (RF) from the antenna and converts that received signal to lower intermediate frequency (IF) or baseband frequency (BB). Tuners that could do baseband output are often called Zero-IF tuners. Older tuners were typically simple PLL tuners inside a metal box, while newer ones are highly integrated chips without a metal box "silicon tuners". These controls are mostly applicable for new feature rich silicon tuners, just because older tuners does not have much adjustable features.

For more information about RF tuners see [Tuner \(radio\)](#) and [RF front end](#) from Wikipedia.

## RF\_TUNER Control IDs

### V4L2\_CID\_RF\_TUNER\_CLASS (class)

The RF\_TUNER class descriptor. Calling `ioctls VIDIOC_QUERYCTRL, VIDIOC_QUERY_EXT_CTRL and VIDIOC_QUERYMENU` for this control will return a description of this control class.

### V4L2\_CID\_RF\_TUNER\_BANDWIDTH\_AUTO (boolean)

Enables/disables tuner radio channel bandwidth configuration. In automatic mode bandwidth configuration is performed by the driver.

### V4L2\_CID\_RF\_TUNER\_BANDWIDTH (integer)

Filter(s) on tuner signal path are used to filter signal according to receiving party needs. Driver configures filters to fulfill desired bandwidth requirement. Used when V4L2\_CID\_RF\_TUNER\_BANDWIDTH\_AUTO is not set. Unit is in Hz. The range and step are driver-specific.

### V4L2\_CID\_RF\_TUNER\_LNA\_GAIN\_AUTO (boolean)

Enables/disables LNA automatic gain control (AGC)

### V4L2\_CID\_RF\_TUNER\_MIXER\_GAIN\_AUTO (boolean)

Enables/disables mixer automatic gain control (AGC)

### V4L2\_CID\_RF\_TUNER\_IF\_GAIN\_AUTO (boolean)

Enables/disables IF automatic gain control (AGC)

### V4L2\_CID\_RF\_TUNER\_RF\_GAIN (integer)

The RF amplifier is the very first amplifier on the receiver signal path, just right after the antenna input. The difference between the LNA gain and the RF gain in this document is that the LNA gain is integrated in the tuner chip while the RF gain is a separate chip. There may be both RF and LNA gain controls in the same device. The range and step are driver-specific.

### V4L2\_CID\_RF\_TUNER\_LNA\_GAIN (integer)

LNA (low noise amplifier) gain is first gain stage on the RF tuner signal path. It is located very close to tuner antenna input. Used when V4L2\_CID\_RF\_TUNER\_LNA\_GAIN\_AUTO is not set. See V4L2\_CID\_RF\_TUNER\_RF\_GAIN to understand how RF gain and LNA gain differs from the each others. The range and step are driver-specific.

### V4L2\_CID\_RF\_TUNER\_MIXER\_GAIN (integer)

Mixer gain is second gain stage on the RF tuner signal path. It is located inside mixer block, where RF signal is down-converted by the mixer. Used when V4L2\_CID\_RF\_TUNER\_MIXER\_GAIN\_AUTO is not set. The range and step are driver-specific.

### V4L2\_CID\_RF\_TUNER\_IF\_GAIN (integer)

IF gain is last gain stage on the RF tuner signal path. It is located on output of RF tuner. It controls signal level of intermediate frequency output or baseband output. Used when V4L2\_CID\_RF\_TUNER\_IF\_GAIN\_AUTO is not set. The range and step are driver-specific.

### V4L2\_CID\_RF\_TUNER\_PLL\_LOCK (boolean)

Is synthesizer PLL locked? RF tuner is receiving given frequency when that control is set. This is a read-only control.

## FM Transmitter Control Reference

The FM Transmitter (FM\_TX) class includes controls for common features of FM transmissions capable devices. Currently this class includes parameters for audio compression, pilot tone generation, audio deviation limiter, RDS transmission and tuning power features.

### FM\_TX Control IDs

#### **V4L2\_CID\_FM\_TX\_CLASS (class)**

The FM\_TX class descriptor. Calling `iocls VIDIOC_QUERYCTRL`, `VIDIOC_QUERY_EXT_CTRL` and `VIDIOC_QUERYMENU` for this control will return a description of this control class.

#### **V4L2\_CID\_RDS\_TX\_DEVIATION (integer)**

Configures RDS signal frequency deviation level in Hz. The range and step are driver-specific.

#### **V4L2\_CID\_RDS\_TX\_PI (integer)**

Sets the RDS Programme Identification field for transmission.

#### **V4L2\_CID\_RDS\_TX\_PTY (integer)**

Sets the RDS Programme Type field for transmission. This encodes up to 31 pre-defined programme types.

#### **V4L2\_CID\_RDS\_TX\_PS\_NAME (string)**

Sets the Programme Service name (PS\_NAME) for transmission. It is intended for static display on a receiver. It is the primary aid to listeners in programme service identification and selection. In Annex E of [IEC 62106](#), the RDS specification, there is a full description of the correct character encoding for Programme Service name strings. Also from RDS specification, PS is usually a single eight character text. However, it is also possible to find receivers which can scroll strings sized as 8 x N characters. So, this control must be configured with steps of 8 characters. The result is it must always contain a string with size multiple of 8.

#### **V4L2\_CID\_RDS\_TX\_RADIO\_TEXT (string)**

Sets the Radio Text info for transmission. It is a textual description of what is being broadcasted. RDS Radio Text can be applied when broadcaster wishes to transmit longer PS names, programme-related information or any other text. In these cases, RadioText should be used in addition to V4L2\_CID\_RDS\_TX\_PS\_NAME. The encoding for Radio Text strings is also fully described in Annex E of [IEC 62106](#). The length of Radio Text strings depends on which RDS Block is being used to transmit it, either 32 (2A block) or 64 (2B block). However, it is also possible to find receivers which can scroll strings sized as 32 x N or 64 x N characters. So, this control must be configured with steps of 32 or 64 characters. The result is it must always contain a string with size multiple of 32 or 64.

#### **V4L2\_CID\_RDS\_TX\_MONO\_STEREO (boolean)**

Sets the Mono/Stereo bit of the Decoder Identification code. If set, then the audio was recorded as stereo.

#### **V4L2\_CID\_RDS\_TX\_ARTIFICIAL\_HEAD (boolean)**

Sets the Artificial Head bit of the Decoder Identification code. If set, then the audio was recorded using an artificial head.

#### **V4L2\_CID\_RDS\_TX\_COMPRESSED (boolean)**

Sets the Compressed bit of the Decoder Identification code. If set, then the audio is compressed.

#### **V4L2\_CID\_RDS\_TX\_DYNAMIC\_PTY (boolean)**

Sets the Dynamic PTY bit of the Decoder Identification code. If set, then the PTY code is dynamically switched.

#### **V4L2\_CID\_RDS\_TX\_TRAFFIC\_ANNOUNCEMENT (boolean)**

If set, then a traffic announcement is in progress.

#### **V4L2\_CID\_RDS\_TX\_TRAFFIC\_PROGRAM (boolean)**

If set, then the tuned programme carries traffic announcements.

#### **V4L2\_CID\_RDS\_TX\_MUSIC\_SPEECH (boolean)**

If set, then this channel broadcasts music. If cleared, then it broadcasts speech. If the transmitter doesn't make this distinction, then it should be set.

#### **V4L2\_CID\_RDS\_TX\_ALT\_FREQS\_ENABLE (boolean)**

If set, then transmit alternate frequencies.

#### **V4L2\_CID\_RDS\_TX\_ALT\_FREQS (\_u32 array)**

The alternate frequencies in kHz units. The RDS standard allows for up to 25 frequencies to be defined. Drivers may support fewer frequencies so check the array size.

#### **V4L2\_CID\_AUDIO\_LIMITER\_ENABLED (boolean)**

Enables or disables the audio deviation limiter feature. The limiter is useful when trying to maximize the audio volume, minimize receiver-generated distortion and prevent overmodulation.

#### **V4L2\_CID\_AUDIO\_LIMITER\_RELEASE\_TIME (integer)**

Sets the audio deviation limiter feature release time. Unit is in microseconds. Step and range are driver-specific.

**V4L2\_CID\_AUDIO\_LIMITER\_DEVIATION (integer)**

Configures audio frequency deviation level in Hz. The range and step are driver-specific.

**V4L2\_CID\_AUDIO\_COMPRESSION\_ENABLED (boolean)**

Enables or disables the audio compression feature. This feature amplifies signals below the threshold by a fixed gain and compresses audio signals above the threshold by the ratio of Threshold/(Gain + Threshold).

**V4L2\_CID\_AUDIO\_COMPRESSION\_GAIN (integer)**

Sets the gain for audio compression feature. It is a dB value. The range and step are driver-specific.

**V4L2\_CID\_AUDIO\_COMPRESSION\_THRESHOLD (integer)**

Sets the threshold level for audio compression feature. It is a dB value. The range and step are driver-specific.

**V4L2\_CID\_AUDIO\_COMPRESSION\_ATTACK\_TIME (integer)**

Sets the attack time for audio compression feature. It is a useconds value. The range and step are driver-specific.

**V4L2\_CID\_AUDIO\_COMPRESSION\_RELEASE\_TIME (integer)**

Sets the release time for audio compression feature. It is a useconds value. The range and step are driver-specific.

**V4L2\_CID\_PILOT\_TONE\_ENABLED (boolean)**

Enables or disables the pilot tone generation feature.

**V4L2\_CID\_PILOT\_TONE\_DEVIATION (integer)**

Configures pilot tone frequency deviation level. Unit is in Hz. The range and step are driver-specific.

**V4L2\_CID\_PILOT\_TONE\_FREQUENCY (integer)**

Configures pilot tone frequency value. Unit is in Hz. The range and step are driver-specific.

**V4L2\_CID\_TUNE\_PREEMPHASIS (enum)****enum v4l2\_preemphasis -**

Configures the pre-emphasis value for broadcasting. A pre-emphasis filter is applied to the broadcast to accentuate the high audio frequencies. Depending on the region, a time constant of either 50 or 75 useconds is used. The enum v4l2\_preemphasis defines possible values for pre-emphasis. Here they are:

V4L2_PREEMPHASIS_DISABLED	No pre-emphasis is applied.
V4L2_PREEMPHASIS_50_uS	A pre-emphasis of 50 uS is used.
V4L2_PREEMPHASIS_75_uS	A pre-emphasis of 75 uS is used.

**V4L2\_CID\_TUNE\_POWER\_LEVEL (integer)**

Sets the output power level for signal transmission. Unit is in dBuV. Range and step are driver-specific.

**V4L2\_CID\_TUNE\_ANTENNA\_CAPACITOR (integer)**

This selects the value of antenna tuning capacitor manually or automatically if set to zero. Unit, range and step are driver-specific.

For more details about RDS specification, refer to [IEC 62106](#) document, from CENELEC.

## FM Receiver Control Reference

The FM Receiver (FM\_RX) class includes controls for common features of FM Reception capable devices.

### FM\_RX Control IDs

**V4L2\_CID\_FM\_RX\_CLASS (class)**

The FM\_RX class descriptor. Calling `iocctl VIDIOC_QUERYCTRL`, `VIDIOC_QUERY_EXT_CTRL` and `VIDIOC_QUERYMENU` for this control will return a description of this control class.

**V4L2\_CID\_RDS\_RECEPTION (boolean)**

Enables/disables RDS reception by the radio tuner

**V4L2\_CID\_RDS\_RX\_PTY (integer)**

Gets RDS Programme Type field. This encodes up to 31 pre-defined programme types.

**V4L2\_CID\_RDS\_RX\_PS\_NAME (string)**

Gets the Programme Service name (PS\_NAME). It is intended for static display on a receiver. It is the primary aid to listeners in programme service identification and selection. In Annex E of [IEC 62106](#), the RDS specification, there is a full description of the correct character encoding for Programme Service name strings. Also from RDS specification, PS is usually a single eight character text. However, it is also possible to find receivers which can scroll strings sized as 8 x N characters. So, this control must be configured with steps of 8 characters. The result is it must always contain a string with size multiple of 8.

**V4L2\_CID\_RDS\_RX\_RADIO\_TEXT (string)**

Gets the Radio Text info. It is a textual description of what is being broadcasted. RDS Radio Text can be applied when broadcaster wishes to transmit longer PS names, programme-related information or any other text. In these cases, Radio-Text can be used in addition to V4L2\_CID\_RDS\_RX\_PS\_NAME. The encoding for Radio Text strings is also fully described in Annex E of [IEC 62106](#). The length of Radio Text strings depends on which RDS Block is being used to transmit it, either 32 (2A block) or 64 (2B block). However, it is also possible to find receivers which can scroll strings sized as 32 x N or 64 x N characters. So, this control must be configured with steps of 32 or 64 characters. The result is it must always contain a string with size multiple of 32 or 64.

**V4L2\_CID\_RDS\_RX\_TRAFFIC\_ANNOUNCEMENT (boolean)**

If set, then a traffic announcement is in progress.

**V4L2\_CID\_RDS\_RX\_TRAFFIC\_PROGRAM (boolean)**

If set, then the tuned programme carries traffic announcements.

**V4L2\_CID\_RDS\_RX\_MUSIC\_SPEECH (boolean)**

If set, then this channel broadcasts music. If cleared, then it broadcasts speech. If the transmitter doesn't make this distinction, then it will be set.

**V4L2\_CID\_TUNE\_DEEMPHASIS**

(enum)

**enum v4l2\_deemphasis -**

Configures the de-emphasis value for reception. A de-emphasis filter is applied to the broadcast to accentuate the high audio frequencies. Depending on the region, a time constant of either 50 or 75 microseconds is used. The enum v4l2\_deemphasis defines possible values for de-emphasis. Here they are:

V4L2_DEEMPHASIS_DISABLED	No de-emphasis is applied.
V4L2_DEEMPHASIS_50_uS	A de-emphasis of 50 uS is used.
V4L2_DEEMPHASIS_75_uS	A de-emphasis of 75 uS is used.

**Detect Control Reference**

The Detect class includes controls for common features of various motion or object detection capable devices.

**Detect Control IDs****V4L2\_CID\_DETECT\_CLASS (class)**

The Detect class descriptor. Calling [ioctls VIDIOC\\_QUERYCTRL](#), [VIDIOC\\_QUERY\\_EXT\\_CTRL](#) and [VIDIOC\\_QUERYMENU](#) for this control will return a description of this control class.

**V4L2\_CID\_DETECT\_MD\_MODE (menu)**

Sets the motion detection mode.

V4L2_DETECT_MD_MODE_DISABLED	Disable motion detection.
V4L2_DETECT_MD_MODE_GLOBAL	Use a single motion detection threshold.
V4L2_DETECT_MD_MODE_THRESHOLD_GRID	The image is divided into a grid, each cell with its own motion detection threshold. These thresholds are set through the V4L2_CID_DETECT_MD_THRESHOLD_GRID matrix control.
V4L2_DETECT_MD_MODE_REGION_GRID	The image is divided into a grid, each cell with its own region value that specifies which per-region motion detection thresholds should be used. Each region has its own thresholds. How these per-region thresholds are set up is driver-specific. The region values for the grid are set through the V4L2_CID_DETECT_MD_REGION_GRID matrix control.

**V4L2\_CID\_DETECT\_MD\_GLOBAL\_THRESHOLD (integer)**

Sets the global motion detection threshold to be used with the V4L2\_DETECT\_MD\_MODE\_GLOBAL motion detection mode.

**V4L2\_CID\_DETECT\_MD\_THRESHOLD\_GRID ( \_\_u16 matrix )**

Sets the motion detection thresholds for each cell in the grid. To be used with the V4L2\_DETECT\_MD\_MODE\_THRESHOLD\_GRID motion detection mode. Matrix element (0, 0) represents the cell at the top-left of the grid.

**V4L2\_CID\_DETECT\_MD\_REGION\_GRID ( \_\_u8 matrix )**

Sets the motion detection region value for each cell in the grid. To be used with the V4L2\_DETECT\_MD\_MODE\_REGION\_GRID motion detection mode. Matrix element (0, 0) represents the cell at the top-left of the grid.

## Colorimetry Control Reference

The Colorimetry class includes controls for High Dynamic Range imaging for representing colors in digital images and video. The controls should be used for video and image encoding and decoding as well as in HDMI receivers and transmitters.

### Colorimetry Control IDs

#### `V4L2_CID_COLORIMETRY_CLASS` (`class`)

The Colorimetry class descriptor. Calling `ioctls VIDIOC_QUERYCTRL`, `VIDIOC_QUERY_EXT_CTRL` and `VIDIOC_QUERYMENU` for this control will return a description of this control class.

#### `V4L2_CID_COLORIMETRY_HDR10_CLL_INFO` (`struct`)

The Content Light Level defines upper bounds for the nominal target brightness light level of the pictures.

type `v4l2_ctrl_hdr10_cll_info`

Table 62: struct `v4l2_ctrl_hdr10_cll_info`

<code>__u16</code>	<code>max_content_light_level</code>	The upper bound for the maximum light level among all individual samples for the pictures or frames.
<code>__u16</code>	<code>max_pic_average_light_level</code>	The upper bound for the maximum average light level among the samples for any individual picture or frame.

#### `V4L2_CID_COLORIMETRY_HDR10_MASTERING_DISPLAY` (`struct`)

The mastering display defines the color volume (the color primaries, white point and luminance range) of a display considered to be the mastering display for the current video content.

type `v4l2_ctrl_hdr10_mastering_display`

<code>__u16</code>	<code>display_primaries_x[3]</code>	Specifies the normalized x chromaticity coordinate of the color primary component c of the master display.
<code>__u16</code>	<code>display_primaries_y[3]</code>	Specifies the normalized y chromaticity coordinate of the color primary component c of the master display.
<code>__u16</code>	<code>white_point_x</code>	Specifies the normalized x chromaticity coordinate of the white point of the mastering display in its native color space.
<code>__u16</code>	<code>white_point_y</code>	Specifies the normalized y chromaticity coordinate of the white point of the mastering display in its native color space.
<code>u32</code>	<code>max_luminance</code>	Specifies the nominal maximum display luminance of the mastering display in units of 0.0001 cd/m².
<code>u32</code>	<code>min_luminance</code>	Specifies the nominal minimum display luminance of the mastering display in units of 0.0001 cd/m².

## Guidelines for Video4Linux pixel format 4CCs

Guidelines for Video4Linux 4CC codes defined using `v4l2_fourcc()` are specified in this document. First of the characters defines the nature of the pixel format, compression and colour space. The interpretation of the other three characters depends on the first one.

Existing 4CCs may not obey these guidelines.

### Raw bayer

The following first characters are used by raw bayer formats:

- B: raw bayer, uncompressed
- b: raw bayer, DPCM compressed
- a: A-law compressed
- u: u-law compressed

2nd character: pixel order

- B: BGGR
- G: GBRG
- g: GRBG
- R: RGGB

3rd character: uncompressed bits-per-pixel 0--9, A--

4th character: compressed bits-per-pixel 0--9, A--

## Data Formats

### Data Format Negotiation

Different devices exchange different kinds of data with applications, for example video images, raw or sliced VBI data, RDS datagrams. Even within one kind many different formats are possible, in particular there is an abundance of image formats. Although drivers must provide a default and the selection persists across closing and reopening a device, applications should always negotiate a data format before engaging in data exchange. Negotiation means the application asks for a particular format and the driver selects and reports the best the hardware can do to satisfy the request. Of course applications can also just query the current selection.

A single mechanism exists to negotiate all data formats using the aggregate struct `v4l2_format` and the `VIDIOC_G_FMT` and `VIDIOC_S_FMT` ioctls. Additionally the `VIDIOC_TRY_FMT` ioctl can be used to examine what the hardware *could* do, without actually selecting a new data format. The data formats supported by the V4L2 API are covered in the respective device section in *Interfaces*. For a closer look at image formats see *Image Formats*.

The `VIDIOC_S_FMT` ioctl is a major turning-point in the initialization sequence. Prior to this point multiple panel applications can access the same device concurrently to select the current input, change controls or modify other properties. The first `VIDIOC_S_FMT` assigns a logical stream (video data, VBI data etc.) exclusively to one file descriptor.

Exclusive means no other application, more precisely no other file descriptor, can grab this stream or change device properties inconsistent with the negotiated parameters. A video standard change for example, when the new standard uses a different number of scan lines, can invalidate the selected image format. Therefore only the file descriptor owning the stream can make invalidating changes. Accordingly multiple file descriptors which grabbed different logical streams prevent each other from interfering with their settings. When for example video overlay is about to start or already in progress, simultaneous video capturing may be restricted to the same cropping and image size.

When applications omit the `VIDIOC_S_FMT` ioctl its locking side effects are implied by the next step, the selection of an I/O method with the `ioctl VIDIOC_REQBUFS` ioctl or implicit with the first `read()` or `write()` call.

Generally only one logical stream can be assigned to a file descriptor, the exception being drivers permitting simultaneous video capturing and overlay using the same file descriptor for compatibility with V4L and earlier versions of V4L2. Switching the logical stream or returning into "panel mode" is possible by closing and reopening the device. Drivers *may* support a switch using `VIDIOC_S_FMT`.

All drivers exchanging data with applications must support the `VIDIOC_G_FMT` and `VIDIOC_S_FMT` ioctl. Implementation of the `VIDIOC_TRY_FMT` is highly recommended but optional.

### Image Format Enumeration

Apart of the generic format negotiation functions a special ioctl to enumerate all image formats supported by video capture, overlay or output devices is available.<sup>1</sup>

The ioctl `VIDIOC_ENUM_FMT` ioctl must be supported by all drivers exchanging image data with applications.

---

**Important:** Drivers are not supposed to convert image formats in kernel space. They must enumerate only formats directly supported by the hardware. If necessary driver writers should publish an example conversion routine or library for integration into applications.

---

### Single- and multi-planar APIs

Some devices require data for each input or output video frame to be placed in discontiguous memory buffers. In such cases, one video frame has to be addressed using more than one memory address, i.e. one pointer per "plane". A plane is a sub-buffer of the current frame. For examples of such formats see *Image Formats*.

Initially, V4L2 API did not support multi-planar buffers and a set of extensions has been introduced to handle them. Those extensions constitute what is being referred to as the "multi-planar API".

Some of the V4L2 API calls and structures are interpreted differently, depending on whether single- or multi-planar API is being used. An application can choose whether to use one or the other by passing a corresponding buffer type to its ioctl calls. Multi-planar versions of buffer types are suffixed with an `_MPLANE` string. For a list of available multi-planar buffer types see enum `v4l2_buf_type`.

---

<sup>1</sup> Enumerating formats an application has no a-priori knowledge of (otherwise it could explicitly ask for them and need not enumerate) seems useless, but there are applications serving as proxy between drivers and the actual video applications for which this is useful.

## Multi-planar formats

Multi-planar API introduces new multi-planar formats. Those formats use a separate set of FourCC codes. It is important to distinguish between the multi-planar API and a multi-planar format. Multi-planar API calls can handle all single-planar formats as well (as long as they are passed in multi-planar API structures), while the single-planar API cannot handle multi-planar formats.

## Calls that distinguish between single and multi-planar APIs

### **`VIDIOC_QUERYCAP`**

Two additional multi-planar capabilities are added. They can be set together with non-multi-planar ones for devices that handle both single- and multi-planar formats.

### **`VIDIOC_G_FMT`, `VIDIOC_S_FMT`, `VIDIOC_TRY_FMT`**

New structures for describing multi-planar formats are added: struct `v4l2_pix_format_mplane` and struct `v4l2_plane_pix_format`. Drivers may define new multi-planar formats, which have distinct FourCC codes from the existing single-planar ones.

### **`VIDIOC_QBUF`, `VIDIOC_DQBUF`, `VIDIOC_QUERYBUF`**

A new struct `v4l2_plane` structure for describing planes is added. Arrays of this structure are passed in the new `m.planes` field of struct `v4l2_buffer`.

### **`VIDIOC_REQBUFS`**

Will allocate multi-planar buffers as requested.

## Cropping, composing and scaling -- the SELECTION API

### Introduction

Some video capture devices can sample a subsection of a picture and shrink or enlarge it to an image of arbitrary size. Next, the devices can insert the image into larger one. Some video output devices can crop part of an input image, scale it up or down and insert it at an arbitrary scan line and horizontal offset into a video signal. We call these abilities cropping, scaling and composing.

On a video *capture* device the source is a video signal, and the cropping target determine the area actually sampled. The sink is an image stored in a memory buffer. The composing area specifies which part of the buffer is actually written to by the hardware.

On a video *output* device the source is an image in a memory buffer, and the cropping target is a part of an image to be shown on a display. The sink is the display or the graphics screen. The application may select the part of display where the image should be displayed. The size and position of such a window is controlled by the compose target.

Rectangles for all cropping and composing targets are defined even if the device does supports neither cropping nor composing. Their size and position will be fixed in such a case. If the device does not support scaling then the cropping and composing rectangles have the same size.

### Selection targets

See *Selection targets* for more information.

### Configuration

Applications can use the *selection API* to select an area in a video signal or a buffer, and to query for default settings and hardware limits.

Video hardware can have various cropping, composing and scaling limitations. It may only scale up or down, support only discrete scaling factors, or have different scaling abilities in the horizontal and vertical directions. Also it may not support scaling at all. At the same time the cropping/composing rectangles may have to be aligned, and both the source and the sink may have arbitrary upper and lower size limits. Therefore, as usual, drivers are expected to adjust the requested parameters and return the actual values selected. An application can control the rounding behaviour using *constraint flags*.

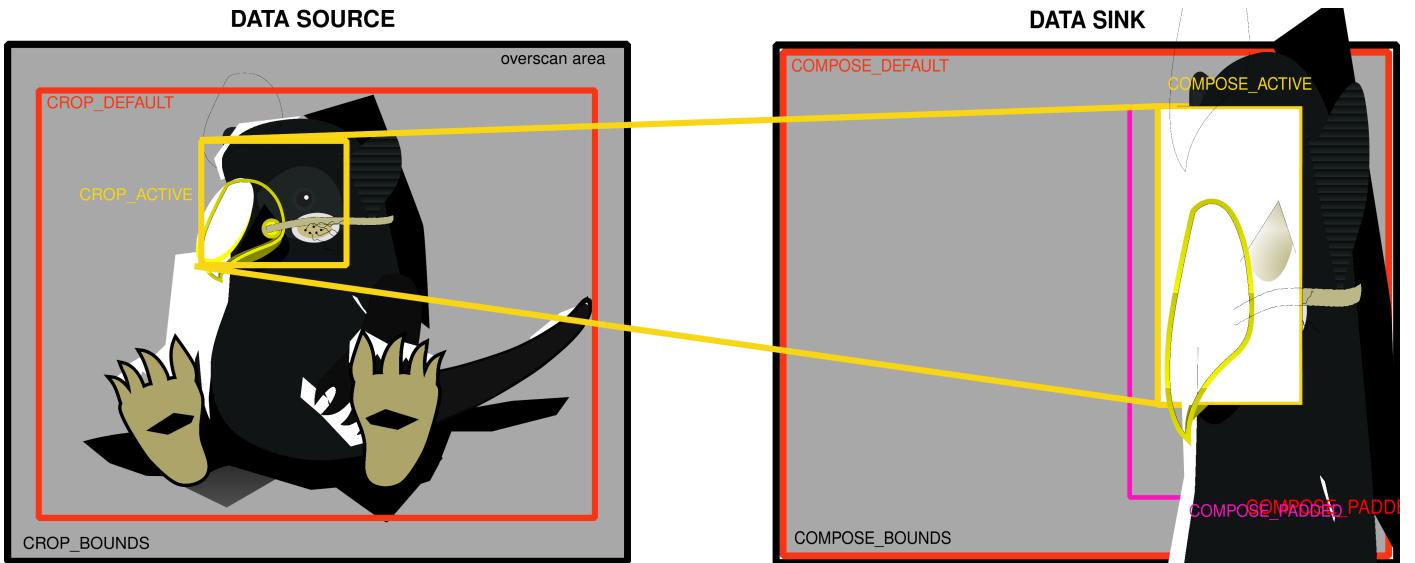


Fig. 2: Cropping and composing targets  
Targets used by a cropping, composing and scaling process

#### Configuration of video capture

See figure *Cropping and composing targets* for examples of the selection targets available for a video capture device. It is recommended to configure the cropping targets before to the composing targets.

The range of coordinates of the top left corner, width and height of areas that can be sampled is given by the V4L2\_SEL\_TGT\_CROP\_BOUNDS target. It is recommended for the driver developers to put the top/left corner at position  $(0,0)$ . The rectangle's coordinates are expressed in pixels.

The top left corner, width and height of the source rectangle, that is the area actually sampled, is given by the V4L2\_SEL\_TGT\_CROP target. It uses the same coordinate system as V4L2\_SEL\_TGT\_CROP\_BOUNDS. The active cropping area must lie completely inside the capture boundaries. The driver may further adjust the requested size and/or position according to hardware limitations.

Each capture device has a default source rectangle, given by the V4L2\_SEL\_TGT\_CROP\_DEFAULT target. This rectangle shall cover what the driver writer considers the complete picture. Drivers shall set the active crop rectangle to the default when the driver is first loaded, but not later.

The composing targets refer to a memory buffer. The limits of composing coordinates are obtained using V4L2\_SEL\_TGT\_COMPOSE\_BOUNDS. All coordinates are expressed in pixels. The rectangle's top/left corner must be located at position  $(0,0)$ . The width and height are equal to the image size set by VIDIOC\_S\_FMT.

The part of a buffer into which the image is inserted by the hardware is controlled by the V4L2\_SEL\_TGT\_COMPOSE target. The rectangle's coordinates are also expressed in the same coordinate system as the bounds rectangle. The composing rectangle must lie completely inside bounds rectangle. The driver must adjust the composing rectangle to fit to the bounding limits. Moreover, the driver can perform other adjustments according to hardware limitations. The application can control rounding behaviour using *constraint flags*.

For capture devices the default composing rectangle is queried using V4L2\_SEL\_TGT\_COMPOSE\_DEFAULT. It is usually equal to the bounding rectangle.

The part of a buffer that is modified by the hardware is given by V4L2\_SEL\_TGT\_COMPOSE\_PADDED. It contains all pixels defined using V4L2\_SEL\_TGT\_COMPOSE plus all padding data modified by hardware during insertion process. All pixels outside this rectangle *must not* be changed by the hardware. The content of pixels that lie inside the padded area but outside active area is undefined. The application can use the padded and active rectangles to detect where the rubbish pixels are located and remove them if needed.

## Configuration of video output

For output devices targets and ioctls are used similarly to the video capture case. The *composing* rectangle refers to the insertion of an image into a video signal. The cropping rectangles refer to a memory buffer. It is recommended to configure the composing targets before to the cropping targets.

The cropping targets refer to the memory buffer that contains an image to be inserted into a video signal or graphical screen. The limits of cropping coordinates are obtained using `V4L2_SEL_TGT_CROP_BOUNDS`. All coordinates are expressed in pixels. The top/left corner is always point  $(0, 0)$ . The width and height is equal to the image size specified using `VIDIOC_S_FMT` ioctl.

The top left corner, width and height of the source rectangle, that is the area from which image date are processed by the hardware, is given by the `V4L2_SEL_TGT_CROP`. Its coordinates are expressed in the same coordinate system as the bounds rectangle. The active cropping area must lie completely inside the crop boundaries and the driver may further adjust the requested size and/or position according to hardware limitations.

For output devices the default cropping rectangle is queried using `V4L2_SEL_TGT_CROP_DEFAULT`. It is usually equal to the bounding rectangle.

The part of a video signal or graphics display where the image is inserted by the hardware is controlled by `V4L2_SEL_TGT_COMPOSE` target. The rectangle's coordinates are expressed in pixels. The composing rectangle must lie completely inside the bounds rectangle. The driver must adjust the area to fit to the bounding limits. Moreover, the driver can perform other adjustments according to hardware limitations.

The device has a default composing rectangle, given by the `V4L2_SEL_TGT_COMPOSE_DEFAULT` target. This rectangle shall cover what the driver writer considers the complete picture. It is recommended for the driver developers to put the top/left corner at position  $(0, 0)$ . Drivers shall set the active composing rectangle to the default one when the driver is first loaded.

The devices may introduce additional content to video signal other than an image from memory buffers. It includes borders around an image. However, such a padded area is driver-dependent feature not covered by this document. Driver developers are encouraged to keep padded rectangle equal to active one. The padded target is accessed by the `V4L2_SEL_TGT_COMPOSE_PADDED` identifier. It must contain all pixels from the `V4L2_SEL_TGT_COMPOSE` target.

## Scaling control

An application can detect if scaling is performed by comparing the width and the height of rectangles obtained using `V4L2_SEL_TGT_CROP` and `V4L2_SEL_TGT_COMPOSE` targets. If these are not equal then the scaling is applied. The application can compute the scaling ratios using these values.

## Comparison with old cropping API

The selection API was introduced to cope with deficiencies of the older *CROP API*, that was designed to control simple capture devices. Later the cropping API was adopted by video output drivers. The ioctls are used to select a part of the display were the video signal is inserted. It should be considered as an API abuse because the described operation is actually the composing. The selection API makes a clear distinction between composing and cropping operations by setting the appropriate targets.

The CROP API lacks any support for composing to and cropping from an image inside a memory buffer. The application could configure a capture device to fill only a part of an image by abusing V4L2 API. Cropping a smaller image from a larger one is achieved by setting the field `bytesperline` at struct `v4l2_pix_format`. Introducing an image offsets could be done by modifying field `m_userptr` at struct `v4l2_buffer` before calling `VIDIOC_QBUF`. Those operations should be avoided because they are not portable (endianness), and do not work for macroblock and Bayer formats and mmap buffers.

The selection API deals with configuration of buffer cropping/composing in a clear, intuitive and portable way. Next, with the selection API the concepts of the padded target and constraints flags are introduced. Finally, struct `v4l2_crop` and struct `v4l2_croppcap` have no reserved fields. Therefore there is no way to extend their functionality. The new struct `v4l2_selection` provides a lot of place for future extensions.

Driver developers are encouraged to implement only selection API. The former cropping API would be simulated using the new one.

## Examples

(A video capture device is assumed; change V4L2\_BUF\_TYPE\_VIDEO\_CAPTURE for other devices; change target to V4L2\_SEL\_TGT\_COMPOSE\_\* family to configure composing area)

### Example: Resetting the cropping parameters

```
struct v4l2_selection sel = {
    .type = V4L2_BUF_TYPE_VIDEO_CAPTURE,
    .target = V4L2_SEL_TGT_CROP_DEFAULT,
};
ret = ioctl(fd, VIDIOC_G_SELECTION, &sel);
if (ret)
    exit(-1);
sel.target = V4L2_SEL_TGT_CROP;
ret = ioctl(fd, VIDIOC_S_SELECTION, &sel);
if (ret)
    exit(-1);
```

Setting a composing area on output of size of *at most* half of limit placed at a center of a display.

### Example: Simple downscaling

```
struct v4l2_selection sel = {
    .type = V4L2_BUF_TYPE_VIDEO_OUTPUT,
    .target = V4L2_SEL_TGT_COMPOSE_BOUNDS,
};
struct v4l2_rect r;

ret = ioctl(fd, VIDIOC_G_SELECTION, &sel);
if (ret)
    exit(-1);
/* setting smaller compose rectangle */
r.width = sel.r.width / 2;
r.height = sel.r.height / 2;
r.left = sel.r.width / 4;
r.top = sel.r.height / 4;
sel.r = r;
sel.target = V4L2_SEL_TGT_COMPOSE;
sel.flags = V4L2_SEL_FLAG_LE;
ret = ioctl(fd, VIDIOC_S_SELECTION, &sel);
if (ret)
    exit(-1);
```

A video output device is assumed; change V4L2\_BUF\_TYPE\_VIDEO\_OUTPUT for other devices

### Example: Querying for scaling factors

```
struct v4l2_selection compose = {
    .type = V4L2_BUF_TYPE_VIDEO_OUTPUT,
    .target = V4L2_SEL_TGT_COMPOSE,
};
struct v4l2_selection crop = {
    .type = V4L2_BUF_TYPE_VIDEO_OUTPUT,
    .target = V4L2_SEL_TGT_CROP,
};
double hscale, vscale;

ret = ioctl(fd, VIDIOC_G_SELECTION, &compose);
if (ret)
    exit(-1);
ret = ioctl(fd, VIDIOC_G_SELECTION, &crop);
if (ret)
    exit(-1);
```

```
/* computing scaling factors */
hscale = (double)compose.r.width / crop.r.width;
vscale = (double)compose.r.height / crop.r.height;
```

## Image Cropping, Insertion and Scaling -- the CROP API

**Note:** The CROP API is mostly superseded by the newer [SELECTION API](#). The new API should be preferred in most cases, with the exception of pixel aspect ratio detection, which is implemented by [VIDIOC\\_CROPCAP](#) and has no equivalent in the SELECTION API. See [Comparison with old cropping API](#) for a comparison of the two APIs.

Some video capture devices can sample a subsection of the picture and shrink or enlarge it to an image of arbitrary size. We call these abilities cropping and scaling. Some video output devices can scale an image up or down and insert it at an arbitrary scan line and horizontal offset into a video signal.

Applications can use the following API to select an area in the video signal, query the default area and the hardware limits.

**Note:** Despite their name, the [VIDIOC\\_CROPCAP](#), [VIDIOC\\_G\\_CROP](#) and [VIDIOC\\_S\\_CROP](#) ioctls apply to input as well as output devices.

Scaling requires a source and a target. On a video capture or overlay device the source is the video signal, and the cropping ioctls determine the area actually sampled. The target are images read by the application or overlaid onto the graphics screen. Their size (and position for an overlay) is negotiated with the [VIDIOC\\_G\\_FMT](#) and [VIDIOC\\_S\\_FMT](#) ioctls.

On a video output device the source are the images passed in by the application, and their size is again negotiated with the [VIDIOC\\_G\\_FMT](#) and [VIDIOC\\_S\\_FMT](#) ioctls, or may be encoded in a compressed video stream. The target is the video signal, and the cropping ioctls determine the area where the images are inserted.

Source and target rectangles are defined even if the device does not support scaling or the [VIDIOC\\_G\\_CROP](#) and [VIDIOC\\_S\\_CROP](#) ioctls. Their size (and position where applicable) will be fixed in this case.

**Note:** All capture and output devices that support the CROP or SELECTION API will also support the [VIDIOC\\_CROPCAP](#) ioctl.

## Cropping Structures

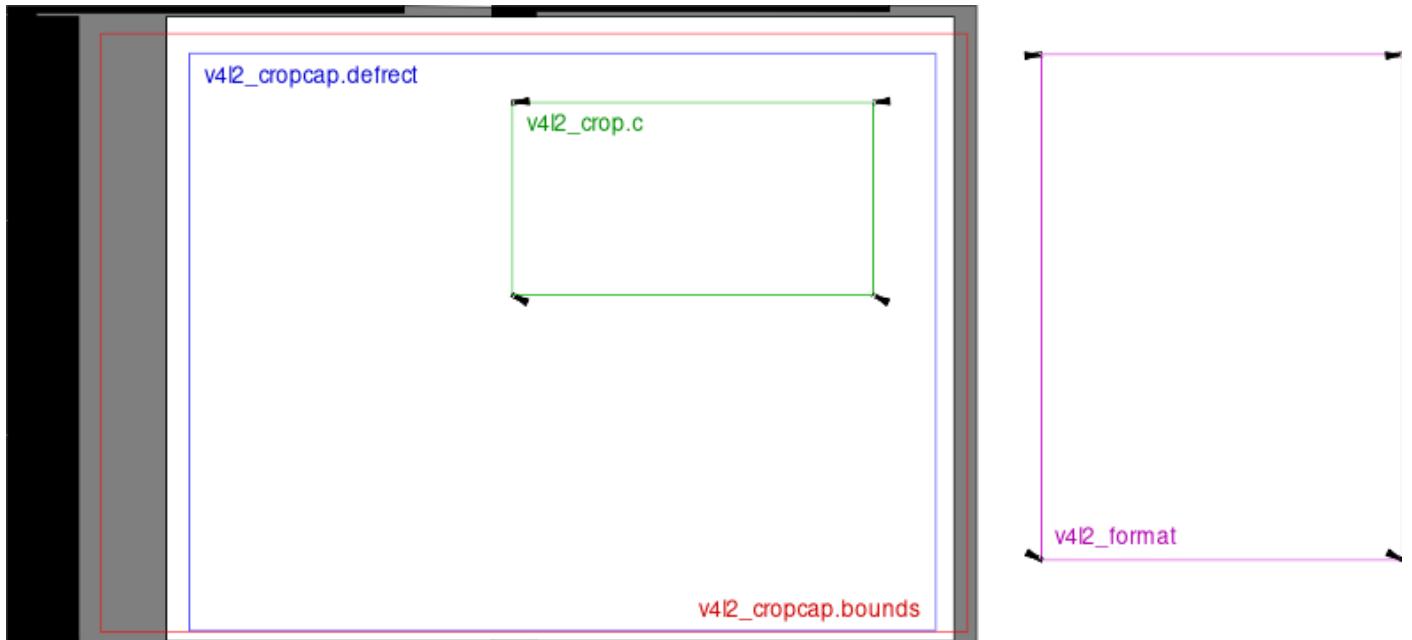


Fig. 3: Image Cropping, Insertion and Scaling  
The cropping, insertion and scaling process

For capture devices the coordinates of the top left corner, width and height of the area which can be sampled is given by the `bounds` substructure of the struct `v4l2_cropcap` returned by the `VIDIOC_CROPCAP` ioctl. To support a wide range of hardware this specification does not define an origin or units. However by convention drivers should horizontally count unscaled samples relative to 0H (the leading edge of the horizontal sync pulse, see *Figure 4.1. Line synchronization*). Vertically ITU-R line numbers of the first field (see ITU R-525 line numbering for 525 *lines* and for 625 *lines*), multiplied by two if the driver can capture both fields.

The top left corner, width and height of the source rectangle, that is the area actually sampled, is given by struct `v4l2_crop` using the same coordinate system as struct `v4l2_cropcap`. Applications can use the `VIDIOC_G_CROP` and `VIDIOC_S_CROP` ioctls to get and set this rectangle. It must lie completely within the capture boundaries and the driver may further adjust the requested size and/or position according to hardware limitations.

Each capture device has a default source rectangle, given by the `defrect` substructure of struct `v4l2_cropcap`. The center of this rectangle shall align with the center of the active picture area of the video signal, and cover what the driver writer considers the complete picture. Drivers shall reset the source rectangle to the default when the driver is first loaded, but not later.

For output devices these structures and ioctls are used accordingly, defining the *target* rectangle where the images will be inserted into the video signal.

## Scaling Adjustments

Video hardware can have various cropping, insertion and scaling limitations. It may only scale up or down, support only discrete scaling factors, or have different scaling abilities in horizontal and vertical direction. Also it may not support scaling at all. At the same time the struct `v4l2_crop` rectangle may have to be aligned, and both the source and target rectangles may have arbitrary upper and lower size limits. In particular the maximum width and height in struct `v4l2_crop` may be smaller than the struct `v4l2_cropcap`. `bounds` area. Therefore, as usual, drivers are expected to adjust the requested parameters and return the actual values selected.

Applications can change the source or the target rectangle first, as they may prefer a particular image size or a certain area in the video signal. If the driver has to adjust both to satisfy hardware limitations, the last requested rectangle shall take priority, and the driver should preferably adjust the opposite one. The `VIDIOC_TRY_FMT` ioctl however shall not change the driver state and therefore only adjust the requested rectangle.

Suppose scaling on a video capture device is restricted to a factor 1:1 or 2:1 in either direction and the target image size must be a multiple of  $16 \times 16$  pixels. The source cropping rectangle is set to defaults, which are also the upper limit in this example, of  $640 \times 400$  pixels at offset 0, 0. An application requests an image size of  $300 \times 225$  pixels, assuming video will be scaled down from the "full picture" accordingly. The driver sets the image size to the closest possible values  $304 \times 224$ , then chooses the cropping rectangle closest to the requested size, that is  $608 \times 224$  ( $224 \times 2:1$  would exceed the limit 400). The offset 0, 0 is still valid, thus unmodified. Given the default cropping rectangle reported by `VIDIOC_CROPCAP` the application can easily propose another offset to center the cropping rectangle.

Now the application may insist on covering an area using a picture aspect ratio closer to the original request, so it asks for a cropping rectangle of  $608 \times 456$  pixels. The present scaling factors limit cropping to  $640 \times 384$ , so the driver returns the cropping size  $608 \times 384$  and adjusts the image size to closest possible  $304 \times 192$ .

## Examples

Source and target rectangles shall remain unchanged across closing and reopening a device, such that piping data into or out of a device will work without special preparations. More advanced applications should ensure the parameters are suitable before starting I/O.

---

**Note:** On the next two examples, a video capture device is assumed; change `V4L2_BUF_TYPE_VIDEO_CAPTURE` for other types of device.

---

### Example: Resetting the cropping parameters

```
struct v4l2_cropcap cropcap;
struct v4l2_crop crop;

memset (&cropcap, 0, sizeof (cropcap));
cropcap.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;

if (-1 == ioctl (fd, VIDIOC_CROPCAP, &cropcap)) {
    perror ("VIDIOC_CROPCAP");
    exit (EXIT_FAILURE);
}
```

```
memset (&crop, 0, sizeof (crop));
crop.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
crop.c = cropcap.defrect;

/* Ignore if cropping is not supported (EINVAL). */

if (-1 == ioctl (fd, VIDIOC_S_CROP, &crop)
    && errno != EINVAL) {
    perror ("VIDIOC_S_CROP");
    exit (EXIT_FAILURE);
}
```

## Example: Simple downscaling

```
struct v4l2_cropcap cropcap;
struct v4l2_format format;

reset_cropping_parameters ();

/* Scale down to 1/4 size of full picture. */

memset (&format, 0, sizeof (format)); /* defaults */

format.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;

format.fmt.pix.width = cropcap.defrect.width >> 1;
format.fmt.pix.height = cropcap.defrect.height >> 1;
format.fmt.pix.pixelformat = V4L2_PIX_FMT_YUYV;

if (-1 == ioctl (fd, VIDIOC_S_FMT, &format)) {
    perror ("VIDIOC_S_FMT");
    exit (EXIT_FAILURE);
}

/* We could check the actual image size now, the actual scaling factor
   or if the driver can scale at all. */
```

## Example: Selecting an output area

---

**Note:** This example assumes an output device.

---

```
struct v4l2_cropcap cropcap;
struct v4l2_crop crop;

memset (&cropcap, 0, sizeof (cropcap));
cropcap.type = V4L2_BUF_TYPE_VIDEO_OUTPUT;

if (-1 == ioctl (fd, VIDIOC_CROPCAP, &cropcap)) {
    perror ("VIDIOC_CROPCAP");
    exit (EXIT_FAILURE);
}

memset (&crop, 0, sizeof (crop));

crop.type = V4L2_BUF_TYPE_VIDEO_OUTPUT;
crop.c = cropcap.defrect;

/* Scale the width and height to 50 % of their original size
   and center the output. */

crop.c.width /= 2;
crop.c.height /= 2;
crop.c.left += crop.c.width / 2;
crop.c.top += crop.c.height / 2;
```

```
/* Ignore if cropping is not supported (EINVAL). */

if (-1 == ioctl (fd, VIDIOC_S_CROP, &crop)
    && errno != EINVAL) {
    perror ("VIDIOC_S_CROP");
    exit (EXIT_FAILURE);
}
```

**Example: Current scaling factor and pixel aspect**

**Note:** This example assumes a video capture device.

```
struct v4l2_cropcap cropcap;
struct v4l2_crop crop;
struct v4l2_format format;
double hscale, vscale;
double aspect;
int dwidth, dheight;

memset (&cropcap, 0, sizeof (cropcap));
cropcap.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;

if (-1 == ioctl (fd, VIDIOC_CROPCAP, &cropcap)) {
    perror ("VIDIOC_CROPCAP");
    exit (EXIT_FAILURE);
}

memset (&crop, 0, sizeof (crop));
crop.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;

if (-1 == ioctl (fd, VIDIOC_G_CROP, &crop)) {
    if (errno != EINVAL) {
        perror ("VIDIOC_G_CROP");
        exit (EXIT_FAILURE);
    }

    /* Cropping not supported. */
    crop.c = cropcap.defrect;
}

memset (&format, 0, sizeof (format));
format.fmt.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;

if (-1 == ioctl (fd, VIDIOC_G_FMT, &format)) {
    perror ("VIDIOC_G_FMT");
    exit (EXIT_FAILURE);
}

/* The scaling applied by the driver. */

hscale = format.fmt.pix.width / (double) crop.c.width;
vscale = format.fmt.pix.height / (double) crop.c.height;

aspect = cropcap.pixelaspect.numerator /
    (double) cropcap.pixelaspect.denominator;
aspect = aspect * hscale / vscale;

/* Devices following ITU-R BT.601 do not capture
   square pixels. For playback on a computer monitor
   we should scale the images to this size. */

dwidth = format.fmt.pix.width / aspect;
dheight = format.fmt.pix.height;
```

## Streaming Parameters

Streaming parameters are intended to optimize the video capture process as well as I/O. Presently applications can request a high quality capture mode with the `VIDIOC_S_PARM` ioctl.

The current video standard determines a nominal number of frames per second. If less than this number of frames is to be captured or output, applications can request frame skipping or duplicating on the driver side. This is especially useful when using the `read()` or `write()`, which are not augmented by timestamps or sequence counters, and to avoid unnecessary data copying.

Finally these ioctls can be used to determine the number of buffers used internally by a driver in read/write mode. For implications see the section discussing the `read()` function.

To get and set the streaming parameters applications call the `VIDIOC_G_PARM` and `VIDIOC_S_PARM` ioctl, respectively. They take a pointer to a struct `v4l2_streamparm`, which contains a union holding separate parameters for input and output devices.

These ioctls are optional, drivers need not implement them. If so, they return the `EINVAL` error code.

## 13.2.2 Image Formats

The V4L2 API was primarily designed for devices exchanging image data with applications. The struct `v4l2_pix_format` and struct `v4l2_pix_format_mplane` structures define the format and layout of an image in memory. The former is used with the single-planar API, while the latter is used with the multi-planar version (see [Single- and multi-planar APIs](#)). Image formats are negotiated with the `VIDIOC_S_FMT` ioctl. (The explanations here focus on video capturing and output, for overlay frame buffer formats see also `VIDIOC_G_FBUF`.)

### Single-planar format structure

type `v4l2_pix_format`

Table 64: struct `v4l2_pix_format`

<code>__u32</code>	<code>width</code>	Image width in pixels.
<code>__u32</code>	<code>height</code>	Image height in pixels. If <code>field</code> is one of <code>V4L2_FIELD_TOP</code> , <code>V4L2_FIELD_BOTTOM</code> or <code>V4L2_FIELD_ALTERNATE</code> then <code>height</code> refers to the number of lines in the field, otherwise it refers to the number of lines in the frame (which is twice the field height for interlaced formats).

Applications set these fields to request an image size, drivers return the closest possible values. In case of planar formats the `width` and `height` applies to the largest plane. To avoid ambiguities drivers must return values rounded up to a multiple of the scale factor of any smaller planes. For example when the image format is YUV 4:2:0, `width` and `height` must be multiples of two.

For compressed formats that contain the resolution information encoded inside the stream, when fed to a stateful mem2mem decoder, the fields may be zero to rely on the decoder to detect the right values. For more details see [Memory-to-Memory Stateful Video Decoder Interface](#) and format descriptions.

For compressed formats on the CAPTURE side of a stateful mem2mem encoder, the fields must be zero, since the coded size is expected to be calculated internally by the encoder itself, based on the OUTPUT side. For more details see [Memory-to-Memory Stateful Video Encoder Interface](#) and format descriptions.

<code>__u32</code>	<code>pixelformat</code>	The pixel format or type of compression, set by the application. This is a little endian <a href="#">four character code</a> . V4L2 defines standard RGB formats in <a href="#">RGB Formats</a> , YUV formats in <a href="#">YUV Formats</a> , and reserved codes in <a href="#">Reserved Image Formats</a> .
<code>__u32</code>	<code>field</code>	Field order, from enum <code>v4l2_field</code> . Video images are typically interlaced. Applications can request to capture or output only the top or bottom field, or both fields interlaced or sequentially stored in one buffer or alternating in separate buffers. Drivers return the actual field order selected. For more details on fields see <a href="#">Field Order</a> .
<code>__u32</code>	<code>bytesperline</code>	Distance in bytes between the leftmost pixels in two adjacent lines.

Both applications and drivers can set this field to request padding bytes at the end of each line. Drivers however may ignore the value requested by the application, returning `width` times bytes per pixel or a larger value required by the hardware. That implies applications can just set this field to zero to get a reasonable default.

Video hardware may access padding bytes, therefore they must reside in accessible memory. Consider cases where padding bytes after the last line of an image cross a system page boundary. Input devices may write padding bytes, the value is undefined. Output devices ignore the contents of padding bytes.

When the image format is planar the `bytesperline` value applies to the first plane and is divided by the same factor as the `width` field for the other planes. For example the Cb and Cr planes of a YUV 4:2:0 image have half as many padding bytes following each line as the Y plane. To avoid ambiguities drivers must return a `bytesperline` value rounded up to a multiple of the scale factor.

For compressed formats the `bytesperline` value makes no sense. Applications and drivers must set this to 0 in that case.

continues on next page

Table 64 – continued from previous page

<code>_u32</code>	<code>sizeimage</code>	Size in bytes of the buffer to hold a complete image, set by the driver. Usually this is <code>bytesperline</code> times height. When the image consists of variable length compressed data this is the number of bytes required by the codec to support the worst-case compression scenario. The driver will set the value for uncompressed images. Clients are allowed to set the <code>sizeimage</code> field for variable length compressed data flagged with <code>V4L2_FMT_FLAG_COMPRESSED</code> at <code>ioctl VIDIOC_ENUM_FMT</code> , but the driver may ignore it and set the value itself, or it may modify the provided value based on alignment requirements or minimum/maximum size requirements. If the client wants to leave this to the driver, then it should set <code>sizeimage</code> to 0.
<code>_u32</code>	<code>colorspace</code>	Image colorspace, from enum <code>v4l2_colorspace</code> . This information supplements the <code>pixelformat</code> and must be set by the driver for capture streams and by the application for output streams, see <a href="#">Colorspaces</a> . If the application sets the flag <code>V4L2_PIX_FMT_FLAG_SET_CSC</code> then the application can set this field for a capture stream to request a specific colorspace for the captured image data. If the driver cannot handle requested conversion, it will return another supported colorspace. The driver indicates that colorspace conversion is supported by setting the flag <code>V4L2_FMT_FLAG_CSC_COLORSPACE</code> in the corresponding struct <code>v4l2_fmtdesc</code> during enumeration. See <a href="#">Image Format Description Flags</a> .
<code>_u32</code>	<code>priv</code>	This field indicates whether the remaining fields of the struct <code>v4l2_pix_format</code> , also called the extended fields, are valid. When set to <code>V4L2_PIX_FMT_PRIV_MAGIC</code> , it indicates that the extended fields have been correctly initialized. When set to any other value it indicates that the extended fields contain undefined values. Applications that wish to use the pixel format extended fields must first ensure that the feature is supported by querying the device for the <code>V4L2_CAP_EXT_PIX_FORMAT</code> capability. If the capability isn't set the pixel format extended fields are not supported and using the extended fields will lead to undefined results. To use the extended fields, applications must set the <code>priv</code> field to <code>V4L2_PIX_FMT_PRIV_MAGIC</code> , initialize all the extended fields and zero the unused bytes of the struct <code>v4l2_format raw_data</code> field. When the <code>priv</code> field isn't set to <code>V4L2_PIX_FMT_PRIV_MAGIC</code> drivers must act as if all the extended fields were set to zero. On return drivers must set the <code>priv</code> field to <code>V4L2_PIX_FMT_PRIV_MAGIC</code> and all the extended fields to applicable values.
<code>u32</code>	<code>flags</code>	Flags set by the application or driver, see <a href="#">Format Flags</a> .
<code>union {</code>	<code>(anonymous)</code>	
<code>_u32</code>	<code>ycbcr_enc</code>	Y'CbCr encoding, from enum <code>v4l2_ycbcr_encoding</code> . This information supplements the <code>colorspace</code> and must be set by the driver for capture streams and by the application for output streams, see <a href="#">Colorspaces</a> . If the application sets the flag <code>V4L2_PIX_FMT_FLAG_SET_CSC</code> then the application can set this field for a capture stream to request a specific Y'CbCr encoding for the captured image data. If the driver cannot handle requested conversion, it will return another supported encoding. This field is ignored for HSV pixelformats. The driver indicates that <code>ycbcr_enc</code> conversion is supported by setting the flag <code>V4L2_FMT_FLAG_CSC_YCBCR_ENC</code> in the corresponding struct <code>v4l2_fmtdesc</code> during enumeration. See <a href="#">Image Format Description Flags</a> .
<code>_u32</code>	<code>hsv_enc</code>	HSV encoding, from enum <code>v4l2_hsv_encoding</code> . This information supplements the <code>colorspace</code> and must be set by the driver for capture streams and by the application for output streams, see <a href="#">Colorspaces</a> . If the application sets the flag <code>V4L2_PIX_FMT_FLAG_SET_CSC</code> then the application can set this field for a capture stream to request a specific HSV encoding for the captured image data. If the driver cannot handle requested conversion, it will return another supported encoding. This field is ignored for non-HSV pixelformats. The driver indicates that <code>hsv_enc</code> conversion is supported by setting the flag <code>V4L2_FMT_FLAG_CSC_HSV_ENC</code> in the corresponding struct <code>v4l2_fmtdesc</code> during enumeration. See <a href="#">Image Format Description Flags</a> .
<code>}</code>		

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Table 64 – continued from previous page

__u32	quantization	Quantization range, from enum <a href="#">v4l2_quantization</a> . This information supplements the colorspace and must be set by the driver for capture streams and by the application for output streams, see <a href="#">Colorspaces</a> . If the application sets the flag V4L2_PIX_FMT_FLAG_SET_CSC then the application can set this field for a capture stream to request a specific quantization range for the captured image data. If the driver cannot handle requested conversion, it will return another supported quantization. The driver indicates that quantization conversion is supported by setting the flag V4L2_FMT_FLAG_CSC_QUANTIZATION in the corresponding struct <a href="#">v4l2_fmtdesc</a> during enumeration. See <a href="#">Image Format Description Flags</a> .
__u32	xfer_func	Transfer function, from enum <a href="#">v4l2_xfer_func</a> . This information supplements the colorspace and must be set by the driver for capture streams and by the application for output streams, see <a href="#">Colorspaces</a> . If the application sets the flag V4L2_PIX_FMT_FLAG_SET_CSC then the application can set this field for a capture stream to request a specific transfer function for the captured image data. If the driver cannot handle requested conversion, it will return another supported transfer function. The driver indicates that xfer_func conversion is supported by setting the flag V4L2_FMT_FLAG_CSC_XFER_FUNC in the corresponding struct <a href="#">v4l2_fmtdesc</a> during enumeration. See <a href="#">Image Format Description Flags</a> .

Table 65: Format Flags

V4L2_PIX_FMT_FLAG_PREMUL_ALPHA	0x00000001	The color values are premultiplied by the alpha channel value. For example, if a light blue pixel with 50% transparency was described by RGBA values (128, 192, 255, 128), the same pixel described with premultiplied colors would be described by RGBA values (64, 96, 128, 128)
V4L2_PIX_FMT_FLAG_SET_CSC	0x00000002	Set by the application. It is only used for capture and is ignored for output streams. If set, then request the device to do colorspace conversion from the received colorspace to the requested colorspace values. If the colorimetry field (colorspace, xfer_func, ycbr_enc, hsv_enc or quantization) is set to *_DEFAULT, then that colorimetry setting will remain unchanged from what was received. So in order to change the quantization, only the quantization field shall be set to non default value (V4L2_QUANTIZATION_FULL_RANGE or V4L2_QUANTIZATION_LIM_RANGE) and all other colorimetry fields shall be set to *_DEFAULT. To check which conversions are supported by the hardware for the current pixel format, see <a href="#">Image Format Description Flags</a> .

## Multi-planar format structures

The struct [v4l2\\_plane\\_pix\\_format](#) structures define size and layout for each of the planes in a multi-planar format. The struct [v4l2\\_pix\\_format\\_mplane](#) structure contains information common to all planes (such as image width and height) and an array of struct [v4l2\\_plane\\_pix\\_format](#) structures, describing all planes of that format.

type [v4l2\\_plane\\_pix\\_format](#)

Table 66: struct [v4l2\\_plane\\_pix\\_format](#)

__u32	sizeimage	Maximum size in bytes required for image data in this plane, set by the driver. When the image consists of variable length compressed data this is the number of bytes required by the codec to support the worst-case compression scenario. The driver will set the value for uncompressed images. Clients are allowed to set the sizeimage field for variable length compressed data flagged with V4L2_FMT_FLAG_COMPRESSED at <a href="#">ioctl VIDIOC_ENUM_FMT</a> , but the driver may ignore it and set the value itself, or it may modify the provided value based on alignment requirements or minimum/maximum size requirements. If the client wants to leave this to the driver, then it should set sizeimage to 0.
__u32	bytesperline	Distance in bytes between the leftmost pixels in two adjacent lines. See struct <a href="#">v4l2_pix_format</a> .
__u16	reserved[6]	Reserved for future extensions. Should be zeroed by drivers and applications.

type `v4l2_pix_format_mplane`

Table 67: struct `v4l2_pix_format_mplane`

<code>_u32</code>	<code>width</code>	Image width in pixels. See struct <code>v4l2_pix_format</code> .
<code>_u32</code>	<code>height</code>	Image height in pixels. See struct <code>v4l2_pix_format</code> .
<code>_u32</code>	<code>pixelformat</code>	The pixel format. Both single- and multi-planar four character codes can be used.
<code>_u32</code>	<code>field</code>	Field order, from enum <code>v4l2_field</code> . See struct <code>v4l2_pix_format</code> .
<code>_u32</code>	<code>colorspace</code>	Colorspace encoding, from enum <code>v4l2_colorspace</code> . See struct <code>v4l2_pix_format</code> .
<code>struct v4l2_plane_pix_format</code>	<code>plane_fmt[VIDEO_MAX_PLANES]</code>	An array of structures describing format of each plane this pixel format consists of. The number of valid entries in this array has to be put in the <code>num_planes</code> field.
<code>_u8</code>	<code>num_planes</code>	Number of planes (i.e. separate memory buffers) for this format and the number of valid entries in the <code>plane_fmt</code> array.
<code>_u8</code>	<code>flags</code>	Flags set by the application or driver, see <i>Format Flags</i> .
union {	(anonymous)	
<code>_u8</code>	<code>ycbcr_enc</code>	Y'CbCr encoding, from enum <code>v4l2_ycbcr_encoding</code> . See struct <code>v4l2_pix_format</code> .
<code>_u8</code>	<code>hsv_enc</code>	HSV encoding, from enum <code>v4l2_hsv_encoding</code> . See struct <code>v4l2_pix_format</code> .
}		
<code>_u8</code>	<code>quantization</code>	Quantization range, from enum <code>v4l2_quantization</code> . See struct <code>v4l2_pix_format</code> .
<code>_u8</code>	<code>xfer_func</code>	Transfer function, from enum <code>v4l2_xfer_func</code> . See struct <code>v4l2_pix_format</code> .
<code>_u8</code>	<code>reserved[7]</code>	Reserved for future extensions. Should be zeroed by drivers and applications.

## Standard Image Formats

In order to exchange images between drivers and applications, it is necessary to have standard image data formats which both sides will interpret the same way. V4L2 includes several such formats, and this section is intended to be an unambiguous specification of the standard image data formats in V4L2.

V4L2 drivers are not limited to these formats, however. Driver-specific formats are possible. In that case the application may depend on a codec to convert images to one of the standard formats when needed. But the data can still be stored and retrieved in the proprietary format. For example, a device may support a proprietary compressed format. Applications can still capture and save the data in the compressed format, saving much disk space, and later use a codec to convert the images to the X Windows screen format when the video is to be displayed.

Even so, ultimately, some standard formats are needed, so the V4L2 specification would not be

complete without well-defined standard formats.

The V4L2 standard formats are mainly uncompressed formats. The pixels are always arranged in memory from left to right, and from top to bottom. The first byte of data in the image buffer is always for the leftmost pixel of the topmost row. Following that is the pixel immediately to its right, and so on until the end of the top row of pixels. Following the rightmost pixel of the row there may be zero or more bytes of padding to guarantee that each row of pixel data has a certain alignment. Following the pad bytes, if any, is data for the leftmost pixel of the second row from the top, and so on. The last row has just as many pad bytes after it as the other rows.

In V4L2 each format has an identifier which looks like `PIX_FMT_XXX`, defined in the [videodev2.h](#) header file. These identifiers represent *four character (FourCC) codes* which are also listed below, however they are not the same as those used in the Windows world.

For some formats, data is stored in separate, discontiguous memory buffers. Those formats are identified by a separate set of FourCC codes and are referred to as "multi-planar formats". For example, a [YUV422](#) frame is normally stored in one memory buffer, but it can also be placed in two or three separate buffers, with Y component in one buffer and CbCr components in another in the 2-planar version or with each component in its own buffer in the 3-planar case. Those sub-buffers are referred to as "*planes*".

## Indexed Format

In this format each pixel is represented by an 8 bit index into a 256 entry ARGB palette. It is intended for [Video Output Overlays](#) only. There are no ioctls to access the palette, this must be done with ioctls of the Linux framebuffer API.

Table 68: Indexed Image Format

Identifier	Code	Bit	Byte 0							
			7	6	5	4	3	2	1	0
<code>V4L2_PIX_FMT_PAL8</code>	'PAL8'		i <sub>7</sub>	i <sub>6</sub>	i <sub>5</sub>	i <sub>4</sub>	i <sub>3</sub>	i <sub>2</sub>	i <sub>1</sub>	i <sub>0</sub>

## RGB Formats

These formats encode each pixel as a triplet of RGB values. They are packed formats, meaning that the RGB values for one pixel are stored consecutively in memory and each pixel consumes an integer number of bytes. When the number of bits required to store a pixel is not aligned to a byte boundary, the data is padded with additional bits to fill the remaining byte.

The formats differ by the number of bits per RGB component (typically but not always the same for all components), the order of components in memory, and the presence of an alpha component or additional padding bits.

The usage and value of the alpha bits in formats that support them (named ARGB or a permutation thereof, collectively referred to as alpha formats) depend on the device type and hardware operation. [Capture](#) devices (including capture queues of mem-to-mem devices) fill the alpha component in memory. When the device captures an alpha channel the alpha component will have a meaningful value. Otherwise, when the device doesn't capture an alpha channel but can set the alpha bit to a user-configurable value, the [V4L2\\_CID\\_ALPHA\\_COMPONENT](#) control is used to specify that alpha value, and the alpha component of all pixels will be set to the

value specified by that control. Otherwise a corresponding format without an alpha component (XRGB or XBGR) must be used instead of an alpha format.

*Output* devices (including output queues of mem-to-mem devices and *video output overlay* devices) read the alpha component from memory. When the device processes the alpha channel the alpha component must be filled with meaningful values by applications. Otherwise a corresponding format without an alpha component (XRGB or XBGR) must be used instead of an alpha format.

Formats that contain padding bits are named XRGB (or a permutation thereof). The padding bits contain undefined values and must be ignored by applications, devices and drivers, for both *Video Capture Interface* and *Video Output Interface* devices.

---

**Note:**

- In all the tables that follow, bit 7 is the most significant bit in a byte.
  - 'r', 'g' and 'b' denote bits of the red, green and blue components respectively. 'a' denotes bits of the alpha component (if supported by the format), and 'x' denotes padding bits.
- 

## Less Than 8 Bits Per Component

These formats store an RGB triplet in one, two or four bytes. They are named based on the order of the RGB components as seen in a 8-, 16- or 32-bit word, which is then stored in memory in little endian byte order (unless otherwise noted by the presence of bit 31 in the 4CC value), and on the number of bits for each component. For instance, the RGB565 format stores a pixel in a 16-bit word [15:0] laid out at as [R<sub>4</sub> R<sub>3</sub> R<sub>2</sub> R<sub>1</sub> R<sub>0</sub> G<sub>5</sub> G<sub>4</sub> G<sub>3</sub> G<sub>2</sub> G<sub>1</sub> G<sub>0</sub> B<sub>4</sub> B<sub>3</sub> B<sub>2</sub> B<sub>1</sub> B<sub>0</sub>], and stored in memory in two bytes, [R<sub>4</sub> R<sub>3</sub> R<sub>2</sub> R<sub>1</sub> R<sub>0</sub> G<sub>5</sub> G<sub>4</sub> G<sub>3</sub>] followed by [G<sub>2</sub> G<sub>1</sub> G<sub>0</sub> B<sub>4</sub> B<sub>3</sub> B<sub>2</sub> B<sub>1</sub> B<sub>0</sub>].

Table 69: RGB Formats With Less Than 8 Bits Per Component

## 8 Bits Per Component

These formats store an RGB triplet in three or four bytes. They are named based on the order of the RGB components as stored in memory, and on the total number of bits per pixel. For instance, RGB24 format stores a pixel with  $[R_7\ R_6\ R_5\ R_4\ R_3\ R_2\ R_1\ R_0]$  in the first byte,  $[G_7\ G_6\ G_5\ G_4\ G_3\ G_2\ G_1\ G_0]$  in the second byte and  $[B_7\ B_6\ B_5\ B_4\ B_3\ B_2\ B_1\ B_0]$  in the third byte. This differs from the DRM format nomenclature that instead use the order of components as seen in a 24- or 32-bit little endian word.

Table 70: RGB Formats With 8 Bits Per Component

Identifier	Code	Byte 0 in memory	Byte 1	Byte 2	Byte 3
V4L2_PIX_FMT_BGR24	'BGR3'	B <sub>7-0</sub>	G <sub>7-0</sub>	R <sub>7-0</sub>	
V4L2_PIX_FMT_RGB24	'RGB3'	R <sub>7-0</sub>	G <sub>7-0</sub>	B <sub>7-0</sub>	
V4L2_PIX_FMT_ABGR32	'AR24'	B <sub>7-0</sub>	G <sub>7-0</sub>	R <sub>7-0</sub>	A <sub>7-0</sub>
V4L2_PIX_FMT_XBGR32	'XR24'	B <sub>7-0</sub>	G <sub>7-0</sub>	R <sub>7-0</sub>	X <sub>7-0</sub>
V4L2_PIX_FMT_BGRA32	'RA24'	A <sub>7-0</sub>	B <sub>7-0</sub>	G <sub>7-0</sub>	R <sub>7-0</sub>
V4L2_PIX_FMT_BGRX32	'RX24'	X <sub>7-0</sub>	B <sub>7-0</sub>	G <sub>7-0</sub>	R <sub>7-0</sub>
V4L2_PIX_FMT_RGBA32	'AB24'	R <sub>7-0</sub>	G <sub>7-0</sub>	B <sub>7-0</sub>	A <sub>7-0</sub>
V4L2_PIX_FMT_RGBX32	'XB24'	R <sub>7-0</sub>	G <sub>7-0</sub>	B <sub>7-0</sub>	X <sub>7-0</sub>
V4L2_PIX_FMT_ARGB32	'BA24'	A <sub>7-0</sub>	R <sub>7-0</sub>	G <sub>7-0</sub>	B <sub>7-0</sub>
V4L2_PIX_FMT_XRGB32	'BX24'	X <sub>7-0</sub>	R <sub>7-0</sub>	G <sub>7-0</sub>	B <sub>7-0</sub>

## 10 Bits Per Component

These formats store a 30-bit RGB triplet with an optional 2 bit alpha in four bytes. They are named based on the order of the RGB components as seen in a 32-bit word, which is then stored in memory in little endian byte order (unless otherwise noted by the presence of bit 31 in the 4CC value), and on the number of bits for each component.

Table 71: RGB Formats 10 Bits Per Color Component

Identifier	Code	Byte 0 in memory										Byte 1										Byte 2										Byte 3									
		7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0								
V4L2_PIX_FMT_RGBX1010102	'RX30'	b <sub>5</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>	b <sub>0</sub>	x	x	g <sub>3</sub>	g <sub>2</sub>	g <sub>1</sub>	g <sub>0</sub>	b <sub>9</sub>	b <sub>8</sub>	b <sub>7</sub>	b <sub>6</sub>	r <sub>1</sub>	r <sub>0</sub>	g <sub>9</sub>	g <sub>8</sub>	g <sub>7</sub>	g <sub>6</sub>	g <sub>5</sub>	g <sub>4</sub>	r <sub>9</sub>	r <sub>8</sub>	r <sub>7</sub>	r <sub>6</sub>	r <sub>5</sub>	r <sub>4</sub>	r <sub>3</sub>	r <sub>2</sub>								
V4L2_PIX_FMT_RGBA1010102	'RA30'	b <sub>5</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>	b <sub>0</sub>	a <sub>1</sub>	a <sub>0</sub>	g <sub>3</sub>	g <sub>2</sub>	g <sub>1</sub>	g <sub>0</sub>	b <sub>9</sub>	b <sub>8</sub>	b <sub>7</sub>	b <sub>6</sub>	r <sub>1</sub>	r <sub>0</sub>	g <sub>9</sub>	g <sub>8</sub>	g <sub>7</sub>	g <sub>6</sub>	g <sub>5</sub>	g <sub>4</sub>	r <sub>9</sub>	r <sub>8</sub>	r <sub>7</sub>	r <sub>6</sub>	r <sub>5</sub>	r <sub>4</sub>	r <sub>3</sub>	r <sub>2</sub>								
V4L2_PIX_FMT_ARGB2101010	'AR30'	b <sub>7</sub>	b <sub>6</sub>	b <sub>5</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>	b <sub>0</sub>	g <sub>5</sub>	g <sub>4</sub>	g <sub>3</sub>	g <sub>2</sub>	g <sub>1</sub>	g <sub>0</sub>	b <sub>9</sub>	b <sub>8</sub>	r <sub>3</sub>	r <sub>2</sub>	r <sub>1</sub>	r <sub>0</sub>	g <sub>9</sub>	g <sub>8</sub>	g <sub>7</sub>	g <sub>6</sub>	a <sub>1</sub>	a <sub>0</sub>	r <sub>9</sub>	r <sub>8</sub>	r <sub>7</sub>	r <sub>6</sub>	r <sub>5</sub>	r <sub>4</sub>								

## 12 Bits Per Component

These formats store an RGB triplet in six or eight bytes, with 12 bits per component. Expand the bits per component to 16 bits, data in the high bits, zeros in the low bits, arranged in little endian order.

Table 72: RGB Formats With 12 Bits Per Component

Identifier	Code	Byte 1-0	Byte 3-2	Byte 5-4	Byte 7-6
V4L2_PIX_FMT_BGR48_12	'B312'	B <sub>15-4</sub>	G <sub>15-4</sub>	R <sub>15-4</sub>	
V4L2_PIX_FMT_ABGR64_12	'B412'	B <sub>15-4</sub>	G <sub>15-4</sub>	R <sub>15-4</sub>	A <sub>15-4</sub>

## Deprecated RGB Formats

Formats defined in *Deprecated Packed RGB Image Formats* are deprecated and must not be used by new drivers. They are documented here for reference. The meaning of their alpha bits (a) is ill-defined and they are interpreted as in either the corresponding ARGB or XRGB format, depending on the driver.

Table 73: Deprecated Packed RGB Image Formats

Identifier	Code	Byte 0 in memory										Byte 1										Byte 2										Byte 3									
		7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0								
V4L2_PIX_FMT_RGB444	'R444'	g <sub>3</sub>	g <sub>2</sub>	g <sub>1</sub>	g <sub>0</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>	b <sub>0</sub>	a <sub>3</sub>	a <sub>2</sub>	a <sub>1</sub>	a <sub>0</sub>	r <sub>3</sub>	r <sub>2</sub>	r <sub>1</sub>	r <sub>0</sub>																								
V4L2_PIX_FMT_RGB555	'RGBO'	g <sub>2</sub>	g <sub>1</sub>	g <sub>0</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>	b <sub>0</sub>	a	r <sub>4</sub>	r <sub>3</sub>	r <sub>2</sub>	r <sub>1</sub>	r <sub>0</sub>	g <sub>4</sub>	g <sub>3</sub>																								
V4L2_PIX_FMT_RGB555X	'RGBQ'	a	r <sub>4</sub>	r <sub>3</sub>	r <sub>2</sub>	r <sub>1</sub>	r <sub>0</sub>	g <sub>4</sub>	g <sub>3</sub>	g <sub>2</sub>	g <sub>1</sub>	g <sub>0</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>	b <sub>0</sub>																								
V4L2_PIX_FMT_BGR32	'BGR4'	b <sub>7</sub>	b <sub>6</sub>	b <sub>5</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>	b <sub>0</sub>	g <sub>7</sub>	g <sub>6</sub>	g <sub>5</sub>	g <sub>4</sub>	g <sub>3</sub>	g <sub>2</sub>	g <sub>1</sub>	g <sub>0</sub>	r <sub>7</sub>	r <sub>6</sub>	r <sub>5</sub>	r <sub>4</sub>	r <sub>3</sub>	r <sub>2</sub>	r <sub>1</sub>	r <sub>0</sub>	a <sub>7</sub>	a <sub>6</sub>	a <sub>5</sub>	a <sub>4</sub>	a <sub>3</sub>	a <sub>2</sub>	a <sub>1</sub>	a <sub>0</sub>								
V4L2_PIX_FMT_RGB32	'RGB4'	a <sub>7</sub>	a <sub>6</sub>	a <sub>5</sub>	a <sub>4</sub>	a <sub>3</sub>	a <sub>2</sub>	a <sub>1</sub>	a <sub>0</sub>	r <sub>7</sub>	r <sub>6</sub>	r <sub>5</sub>	r <sub>4</sub>	r <sub>3</sub>	r <sub>2</sub>	r <sub>1</sub>	r <sub>0</sub>	g <sub>7</sub>	g <sub>6</sub>	g <sub>5</sub>	g <sub>4</sub>	g <sub>3</sub>	g <sub>2</sub>	g <sub>1</sub>	g <sub>0</sub>	b <sub>7</sub>	b <sub>6</sub>	b <sub>5</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>	b <sub>0</sub>								

A test utility to determine which RGB formats a driver actually supports is available from the LinuxTV v4l-dvb repository. See <https://linuxtv.org/repo/> for access instructions.

## Raw Bayer Formats

### Description

The raw Bayer formats are used by image sensors before much if any processing is performed on the image. The formats contain green, red and blue components, with alternating lines of red and green, and blue and green pixels in different orders. See also the [Wikipedia article on Bayer filter](#).

**V4L2\_PIX\_FMT\_SRGG8** ('RGGB'), **V4L2\_PIX\_FMT\_SGRBG8** ('GRBG'),  
**V4L2\_PIX\_FMT\_SGBRG8** ('GBRG'), **V4L2\_PIX\_FMT\_SBGGR8** ('BA81'),

### 8-bit Bayer formats

#### Description

These four pixel formats are raw sRGB / Bayer formats with 8 bits per sample. Each sample is stored in a byte. Each n-pixel row contains n/2 green samples and n/2 blue or red samples, with alternating red and blue rows. They are conventionally described as GRGR... BGBG..., RGRG... GBGB..., etc. Below is an example of a small V4L2\_PIX\_FMT\_SBGGR8 image:

**Byte Order.** Each cell is one byte.

start + 0:	B <sub>00</sub>	G <sub>01</sub>	B <sub>02</sub>	G <sub>03</sub>
start + 4:	G <sub>10</sub>	R <sub>11</sub>	G <sub>12</sub>	R <sub>13</sub>
start + 8:	B <sub>20</sub>	G <sub>21</sub>	B <sub>22</sub>	G <sub>23</sub>
start + 12:	G <sub>30</sub>	R <sub>31</sub>	G <sub>32</sub>	R <sub>33</sub>

**V4L2\_PIX\_FMT\_SRGG10** ('RG10'), **V4L2\_PIX\_FMT\_SGRBG10** ('BA10'),  
**V4L2\_PIX\_FMT\_SGBRG10** ('GB10'), **V4L2\_PIX\_FMT\_SBGGR10** ('BG10'),

V4L2\_PIX\_FMT\_SGRBG10 V4L2\_PIX\_FMT\_SGBRG10 V4L2\_PIX\_FMT\_SBGGR10 10-bit Bayer formats expanded to 16 bits

#### Description

These four pixel formats are raw sRGB / Bayer formats with 10 bits per sample. Each sample is stored in a 16-bit word, with 6 unused high bits filled with zeros. Each n-pixel row contains n/2 green samples and n/2 blue or red samples, with alternating red and blue rows. Bytes are stored in memory in little endian order. They are conventionally described as GRGR... BGBG..., RGRG... GBGB..., etc. Below is an example of one of these formats:

**Byte Order.** Each cell is one byte, the 6 most significant bits in the high bytes are 0.

start + 0:	B <sub>00low</sub>	B <sub>00high</sub>	G <sub>01low</sub>	G <sub>01high</sub>	B <sub>02low</sub>	B <sub>02high</sub>	G <sub>03low</sub>	G <sub>03high</sub>
start + 8:	G <sub>10low</sub>	G <sub>10high</sub>	R <sub>11low</sub>	R <sub>11high</sub>	G <sub>12low</sub>	G <sub>12high</sub>	R <sub>13low</sub>	R <sub>13high</sub>
start + 16:	B <sub>20low</sub>	B <sub>20high</sub>	G <sub>21low</sub>	G <sub>21high</sub>	B <sub>22low</sub>	B <sub>22high</sub>	G <sub>23low</sub>	G <sub>23high</sub>
start + 24:	G <sub>30low</sub>	G <sub>30high</sub>	R <sub>31low</sub>	R <sub>31high</sub>	G <sub>32low</sub>	G <sub>32high</sub>	R <sub>33low</sub>	R <sub>33high</sub>

**V4L2\_PIX\_FMT\_SRGGB10P ('pRAA'), V4L2\_PIX\_FMT\_SGRBG10P ('pgAA'),  
V4L2\_PIX\_FMT\_SGBRG10P ('pGAA'), V4L2\_PIX\_FMT\_SBGGR10P ('pBAA'),**

V4L2\_PIX\_FMT\_SGRBG10P V4L2\_PIX\_FMT\_SGBRG10P V4L2\_PIX\_FMT\_SBGGR10P 10-bit packed Bayer formats

## Description

These four pixel formats are packed raw sRGB / Bayer formats with 10 bits per sample. Every four consecutive samples are packed into 5 bytes. Each of the first 4 bytes contain the 8 high order bits of the pixels, and the 5th byte contains the 2 least significant bits of each pixel, in the same order.

Each n-pixel row contains n/2 green samples and n/2 blue or red samples, with alternating green-red and green-blue rows. They are conventionally described as GRGR... BGBG..., RGRG... GBGB..., etc. Below is an example of a small V4L2\_PIX\_FMT\_SBGGR10P image:

**Byte Order.** Each cell is one byte.

start + 0:	B <sub>00</sub> high	G <sub>01</sub> high	B <sub>02</sub> high	G <sub>03</sub> high	G <sub>03</sub> low (bits 7--6) B <sub>02</sub> low (bits 5--4) G <sub>01</sub> low (bits 3--2) B <sub>00</sub> low (bits 1--0)
start + 5:	G <sub>10</sub> high	R <sub>11</sub> high	G <sub>12</sub> high	R <sub>13</sub> high	R <sub>13</sub> low (bits 7--6) G <sub>12</sub> low (bits 5--4) R <sub>11</sub> low (bits 3--2) G <sub>10</sub> low (bits 1--0)
start + 10:	B <sub>20</sub> high	G <sub>21</sub> high	B <sub>22</sub> high	G <sub>23</sub> high	G <sub>23</sub> low (bits 7--6) B <sub>22</sub> low (bits 5--4) G <sub>21</sub> low (bits 3--2) B <sub>20</sub> low (bits 1--0)
start + 15:	G <sub>30</sub> high	R <sub>31</sub> high	G <sub>32</sub> high	R <sub>33</sub> high	R <sub>33</sub> low (bits 7--6) G <sub>32</sub> low (bits 5--4) R <sub>31</sub> low (bits 3--2) G <sub>30</sub> low (bits 1--0)

**V4L2\_PIX\_FMT\_SBGGR10ALAW8 ('aBA8'), V4L2\_PIX\_FMT\_SGBRG10ALAW8 ('aGA8'),  
V4L2\_PIX\_FMT\_SGRBG10ALAW8 ('agA8'), V4L2\_PIX\_FMT\_SRGGB10ALAW8 ('aRA8'),**

V4L2\_PIX\_FMT\_SGBRG10ALAW8 V4L2\_PIX\_FMT\_SGRBG10ALAW8  
V4L2\_PIX\_FMT\_SRGGB10ALAW8 10-bit Bayer formats compressed to 8 bits

## Description

These four pixel formats are raw sRGB / Bayer formats with 10 bits per color compressed to 8 bits each, using the A-LAW algorithm. Each color component consumes 8 bits of memory. In other respects this format is similar to [V4L2\\_PIX\\_FMT\\_SRGGB8 \('RGGB'\)](#), [V4L2\\_PIX\\_FMT\\_SGRBG8 \('GRBG'\)](#), [V4L2\\_PIX\\_FMT\\_SGBRG8 \('GBRG'\)](#), [V4L2\\_PIX\\_FMT\\_SBGGR8 \('BA81'\)](#).

**V4L2\_PIX\_FMT\_SBGGR10DPCM8 ('bBA8'), V4L2\_PIX\_FMT\_SGBRG10DPCM8 ('bGA8'),  
V4L2\_PIX\_FMT\_SGRBG10DPCM8 ('BD10'), V4L2\_PIX\_FMT\_SRGGGB10DPCM8 ('bRA8'),**

man *V4L2\_PIX\_FMT\_SBGGR10DPCM8(2)*

V4L2\_PIX\_FMT\_SGBRG10DPCM8

V4L2\_PIX\_FMT\_SGRBG10DPCM8

V4L2\_PIX\_FMT\_SRGGGB10DPCM8 10-bit Bayer formats compressed to 8 bits

## Description

These four pixel formats are raw sRGB / Bayer formats with 10 bits per colour compressed to 8 bits each, using DPCM compression. DPCM, differential pulse-code modulation, is lossy. Each colour component consumes 8 bits of memory. In other respects this format is similar to *V4L2\_PIX\_FMT\_SRGGGB10 ('RG10')*, *V4L2\_PIX\_FMT\_SGRBG10 ('BA10')*, *V4L2\_PIX\_FMT\_SGBRG10 ('GB10')*, *V4L2\_PIX\_FMT\_SBGGR10 ('BG10')*.

**V4L2\_PIX\_FMT\_IPU3\_SBGGR10 ('ip3b'), V4L2\_PIX\_FMT\_IPU3\_SGBRG10 ('ip3g'),  
V4L2\_PIX\_FMT\_IPU3\_SGRBG10 ('ip3G'), V4L2\_PIX\_FMT\_IPU3\_SRGGGB10 ('ip3r')**

## 10-bit Bayer formats

### Description

These four pixel formats are used by Intel IPU3 driver, they are raw sRGB / Bayer formats with 10 bits per sample with every 25 pixels packed to 32 bytes leaving 6 most significant bits padding in the last byte. The format is little endian.

In other respects this format is similar to *V4L2\_PIX\_FMT\_SRGGGB10 ('RG10')*, *V4L2\_PIX\_FMT\_SGRBG10 ('BA10')*, *V4L2\_PIX\_FMT\_SGBRG10 ('GB10')*, *V4L2\_PIX\_FMT\_SBGGR10 ('BG10')*. Below is an example of a small image in *V4L2\_PIX\_FMT\_IPU3\_SBGGR10* format.

**Byte Order.** Each cell is one byte.

start + 0:	B <sub>0000</sub> low	G <sub>0001</sub> low (bits 7--2) B <sub>0000</sub> high (bits 1--0)	B <sub>0002</sub> low (bits 7--4) G <sub>0001</sub> high (bits 3--0)	G <sub>0003</sub> low (bits 7--6) B <sub>0002</sub> high (bits 5--0)
start + 4:	G <sub>0003</sub> high	B <sub>0004</sub> low	G <sub>0005</sub> low (bits 7--2) B <sub>0004</sub> high (bits 1--0)	B <sub>0006</sub> low (bits 7--4) G <sub>0005</sub> high (bits 3--0)
start + 8:	G <sub>0007</sub> low (bits 7--6) B <sub>0006</sub> high (bits 5--0)	G <sub>0007</sub> high	B <sub>0008</sub> low	G <sub>0009</sub> low (bits 7--2) B <sub>0008</sub> high (bits 1--0)
start + 12:	B <sub>0010</sub> low (bits 7--4) G <sub>0009</sub> high (bits 3--0)	G <sub>0011</sub> low (bits 7--6) B <sub>0010</sub> high (bits 5--0)	G <sub>0011</sub> high	B <sub>0012</sub> low
start + 16:	G <sub>0013</sub> low (bits 7--2) B <sub>0012</sub> high (bits 1--0)	B <sub>0014</sub> low (bits 7--4) G <sub>0013</sub> high (bits 3--0)	G <sub>0015</sub> low (bits 7--6) B <sub>0014</sub> high (bits 5--0)	G <sub>0015</sub> high
start + 20	B <sub>0016</sub> low	G <sub>0017</sub> low (bits 7--2) B <sub>0016</sub> high (bits 1--0)	B <sub>0018</sub> low (bits 7--4) G <sub>0017</sub> high (bits 3--0)	G <sub>0019</sub> low (bits 7--6) B <sub>0018</sub> high (bits 5--0)

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start + 24:	G <sub>0019</sub> high	B <sub>0020</sub> low	G <sub>0021</sub> low(bits 7--2) B <sub>0020</sub> high(bits 1--0)	B <sub>0022</sub> low(bits 7--4) G <sub>0021</sub> high(bits 3--0)
start + 28:	G <sub>0023</sub> low(bits 7--6) B <sub>0022</sub> high(bits 5--0)	G <sub>0023</sub> high	B <sub>0024</sub> low	B <sub>0024</sub> high(bits 1--0)
start + 32:	G <sub>0100</sub> low	R <sub>0101</sub> low(bits 7--2) G <sub>0100</sub> high(bits 1--0)	G <sub>0102</sub> low(bits 7--4) R <sub>0101</sub> high(bits 3--0)	R <sub>0103</sub> low(bits 7--6) G <sub>0102</sub> high(bits 5--0)
start + 36:	R <sub>0103</sub> high	G <sub>0104</sub> low	R <sub>0105</sub> low(bits 7--2) G <sub>0104</sub> high(bits 1--0)	G <sub>0106</sub> low(bits 7--4) R <sub>0105</sub> high(bits 3--0)
start + 40:	R <sub>0107</sub> low(bits 7--6) G <sub>0106</sub> high(bits 5--0)	R <sub>0107</sub> high	G <sub>0108</sub> low	R <sub>0109</sub> low(bits 7--2) G <sub>0108</sub> high(bits 1--0)
start + 44:	G <sub>0110</sub> low(bits 7--4) R <sub>0109</sub> high(bits 3--0)	R <sub>0111</sub> low(bits 7--6) G <sub>0110</sub> high(bits 5--0)	R <sub>0111</sub> high	G <sub>0112</sub> low
start + 48:	R <sub>0113</sub> low(bits 7--2) G <sub>0112</sub> high(bits 1--0)	G <sub>0114</sub> low(bits 7--4) R <sub>0113</sub> high(bits 3--0)	R <sub>0115</sub> low(bits 7--6) G <sub>0114</sub> high(bits 5--0)	R <sub>0115</sub> high
start + 52:	G <sub>0116</sub> low	R <sub>0117</sub> low(bits 7--2) G <sub>0116</sub> high(bits 1--0)	G <sub>0118</sub> low(bits 7--4) R <sub>0117</sub> high(bits 3--0)	R <sub>0119</sub> low(bits 7--6) G <sub>0118</sub> high(bits 5--0)
start + 56:	R <sub>0119</sub> high	G <sub>0120</sub> low	R <sub>0121</sub> low(bits 7--2) G <sub>0120</sub> high(bits 1--0)	G <sub>0122</sub> low(bits 7--4) R <sub>0121</sub> high(bits 3--0)
start + 60:	R <sub>0123</sub> low(bits 7--6) G <sub>0122</sub> high(bits 5--0)	R <sub>0123</sub> high	G <sub>0124</sub> low	G <sub>0124</sub> high(bits 1--0)
start + 64:	B <sub>0200</sub> low	G <sub>0201</sub> low(bits 7--2) B <sub>0200</sub> high(bits 1--0)	B <sub>0202</sub> low(bits 7--4) G <sub>0201</sub> high(bits 3--0)	G <sub>0203</sub> low(bits 7--6) B <sub>0202</sub> high(bits 5--0)
start + 68:	G <sub>0203</sub> high	B <sub>0204</sub> low	G <sub>0205</sub> low(bits 7--2) B <sub>0204</sub> high(bits 1--0)	B <sub>0206</sub> low(bits 7--4) G <sub>0205</sub> high(bits 3--0)
start + 72:	G <sub>0207</sub> low(bits 7--6) B <sub>0206</sub> high(bits 5--0)	G <sub>0207</sub> high	B <sub>0208</sub> low	G <sub>0209</sub> low(bits 7--2) B <sub>0208</sub> high(bits 1--0)
start + 76:	B <sub>0210</sub> low(bits 7--4) G <sub>0209</sub> high(bits 3--0)	G <sub>0211</sub> low(bits 7--6) B <sub>0210</sub> high(bits 5--0)	G <sub>0211</sub> high	B <sub>0212</sub> low
start + 80:	G <sub>0213</sub> low(bits 7--2) B <sub>0212</sub> high(bits 1--0)	B <sub>0214</sub> low(bits 7--4) G <sub>0213</sub> high(bits 3--0)	G <sub>0215</sub> low(bits 7--6) B <sub>0214</sub> high(bits 5--0)	G <sub>0215</sub> high
start + 84:	B <sub>0216</sub> low	G <sub>0217</sub> low(bits 7--2) B <sub>0216</sub> high(bits 1--0)	B <sub>0218</sub> low(bits 7--4) G <sub>0217</sub> high(bits 3--0)	G <sub>0219</sub> low(bits 7--6) B <sub>0218</sub> high(bits 5--0)
start + 88:	G <sub>0219</sub> high	B <sub>0220</sub> low	G <sub>0221</sub> low(bits 7--2) B <sub>0220</sub> high(bits 1--0)	B <sub>0222</sub> low(bits 7--4) G <sub>0221</sub> high(bits 3--0)
start + 92:	G <sub>0223</sub> low(bits 7--6) B <sub>0222</sub> high(bits 5--0)	G <sub>0223</sub> high	B <sub>0224</sub> low	B <sub>0224</sub> high(bits 1--0)

continues on next page

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start + 96:	G <sub>0300</sub> low	R <sub>0301</sub> low(bits 7--2) G <sub>0300</sub> high(bits 1--0)	G <sub>0302</sub> low(bits 7--4) R <sub>0301</sub> high(bits 3--0)	R <sub>0303</sub> low(bits 7--6) G <sub>0302</sub> high(bits 5--0)
start + 100:	R <sub>0303</sub> high	G <sub>0304</sub> low	R <sub>0305</sub> low(bits 7--2) G <sub>0304</sub> high(bits 1--0)	G <sub>0306</sub> low(bits 7--4) R <sub>0305</sub> high(bits 3--0)
start + 104:	R <sub>0307</sub> low(bits 7--6) G <sub>0306</sub> high(bits 5--0)	R <sub>0307</sub> high	G <sub>0308</sub> low	R <sub>0309</sub> low(bits 7--2) G <sub>0308</sub> high(bits 1--0)
start + 108:	G <sub>0310</sub> low(bits 7--4) R <sub>0309</sub> high(bits 3--0)	R <sub>0311</sub> low(bits 7--6) G <sub>0310</sub> high(bits 5--0)	R <sub>0311</sub> high	G <sub>0312</sub> low
start + 112:	R <sub>0313</sub> low(bits 7--2) G <sub>0312</sub> high(bits 1--0)	G <sub>0314</sub> low(bits 7--4) R <sub>0313</sub> high(bits 3--0)	R <sub>0315</sub> low(bits 7--6) G <sub>0314</sub> high(bits 5--0)	R <sub>0315</sub> high
start + 116:	G <sub>0316</sub> low	R <sub>0317</sub> low(bits 7--2) G <sub>0316</sub> high(bits 1--0)	G <sub>0318</sub> low(bits 7--4) R <sub>0317</sub> high(bits 3--0)	R <sub>0319</sub> low(bits 7--6) G <sub>0318</sub> high(bits 5--0)
start + 120:	R <sub>0319</sub> high	G <sub>0320</sub> low	R <sub>0321</sub> low(bits 7--2) G <sub>0320</sub> high(bits 1--0)	G <sub>0322</sub> low(bits 7--4) R <sub>0321</sub> high(bits 3--0)
start + 124:	R <sub>0323</sub> low(bits 7--6) G <sub>0322</sub> high(bits 5--0)	R <sub>0323</sub> high	G <sub>0324</sub> low	G <sub>0324</sub> high(bits 1--0)

**V4L2\_PIX\_FMT\_SRGGB12 ('RG12'), V4L2\_PIX\_FMT\_SGRBG12 ('BA12'),  
V4L2\_PIX\_FMT\_SGBRG12 ('GB12'), V4L2\_PIX\_FMT\_SBGGR12 ('BG12'),**

V4L2\_PIX\_FMT\_SGRBG12 V4L2\_PIX\_FMT\_SGBRG12 V4L2\_PIX\_FMT\_SBGGR12 12-bit Bayer formats expanded to 16 bits

## Description

These four pixel formats are raw sRGB / Bayer formats with 12 bits per colour. Each colour component is stored in a 16-bit word, with 4 unused high bits filled with zeros. Each n-pixel row contains n/2 green samples and n/2 blue or red samples, with alternating red and blue rows. Bytes are stored in memory in little endian order. They are conventionally described as GRGR... BGBG..., RGRG... GBGB..., etc. Below is an example of a small V4L2\_PIX\_FMT\_SBGGR12 image:

**Byte Order.** Each cell is one byte, the 4 most significant bits in the high bytes are 0.

start + 0:	B <sub>00</sub> low	B <sub>00</sub> high	G <sub>01</sub> low	G <sub>01</sub> high	B <sub>02</sub> low	B <sub>02</sub> high	G <sub>03</sub> low	G <sub>03</sub> high
start + 8:	G <sub>10</sub> low	G <sub>10</sub> high	R <sub>11</sub> low	R <sub>11</sub> high	G <sub>12</sub> low	G <sub>12</sub> high	R <sub>13</sub> low	R <sub>13</sub> high
start + 16:	B <sub>20</sub> low	B <sub>20</sub> high	G <sub>21</sub> low	G <sub>21</sub> high	B <sub>22</sub> low	B <sub>22</sub> high	G <sub>23</sub> low	G <sub>23</sub> high
start + 24:	G <sub>30</sub> low	G <sub>30</sub> high	R <sub>31</sub> low	R <sub>31</sub> high	G <sub>32</sub> low	G <sub>32</sub> high	R <sub>33</sub> low	R <sub>33</sub> high

**V4L2\_PIX\_FMT\_SRGG12P** ('pRCC'), **V4L2\_PIX\_FMT\_SGRBG12P** ('pgCC'),  
**V4L2\_PIX\_FMT\_SGBRG12P** ('pGCC'), **V4L2\_PIX\_FMT\_SBGGR12P** ('pBCC'),

## 12-bit packed Bayer formats

### Description

These four pixel formats are packed raw sRGB / Bayer formats with 12 bits per colour. Every two consecutive samples are packed into three bytes. Each of the first two bytes contain the 8 high order bits of the pixels, and the third byte contains the four least significant bits of each pixel, in the same order.

Each n-pixel row contains n/2 green samples and n/2 blue or red samples, with alternating green-red and green-blue rows. They are conventionally described as GRGR... BGBG..., RGRG... GBGB..., etc. Below is an example of a small V4L2\_PIX\_FMT\_SBGGR12P image:

**Byte Order.** Each cell is one byte.

start + 0:	B <sub>00</sub> high	G <sub>01</sub> high	G <sub>01</sub> low(bits 7--4) B <sub>00</sub> low(bits 3--0)	B <sub>02</sub> high	G <sub>03</sub> high	G <sub>03</sub> low(bits 7--4) B <sub>02</sub> low(bits 3--0)
start + 6:	G <sub>10</sub> high	R <sub>11</sub> high	R <sub>11</sub> low(bits 7--4) G <sub>10</sub> low(bits 3--0)	G <sub>12</sub> high	R <sub>13</sub> high	R <sub>13</sub> low(bits 7--4) G <sub>12</sub> low(bits 3--0)
start + 12:	B <sub>20</sub> high	G <sub>21</sub> high	G <sub>21</sub> low(bits 7--4) B <sub>20</sub> low(bits 3--0)	B <sub>22</sub> high	G <sub>23</sub> high	G <sub>23</sub> low(bits 7--4) B <sub>22</sub> low(bits 3--0)
start + 18:	G <sub>30</sub> high	R <sub>31</sub> high	R <sub>31</sub> low(bits 7--4) G <sub>30</sub> low(bits 3--0)	G <sub>32</sub> high	R <sub>33</sub> high	R <sub>33</sub> low(bits 7--4) G <sub>32</sub> low(bits 3--0)

**V4L2\_PIX\_FMT\_SRGG14** ('RG14'), **V4L2\_PIX\_FMT\_SGRBG14** ('GR14'),  
**V4L2\_PIX\_FMT\_SGBRG14** ('GB14'), **V4L2\_PIX\_FMT\_SBGGR14** ('BG14'),

## 14-bit Bayer formats expanded to 16 bits

### Description

These four pixel formats are raw sRGB / Bayer formats with 14 bits per colour. Each sample is stored in a 16-bit word, with two unused high bits filled with zeros. Each n-pixel row contains n/2 green samples and n/2 blue or red samples, with alternating red and blue rows. Bytes are stored in memory in little endian order. They are conventionally described as GRGR... BGBG..., RGRG... GBGB..., etc. Below is an example of a small V4L2\_PIX\_FMT\_SBGGR14 image:

**Byte Order.** Each cell is one byte, the two most significant bits in the high bytes are zero.

start + 0:	B <sub>00</sub> low	B <sub>00</sub> high	G <sub>01</sub> low	G <sub>01</sub> high	B <sub>02</sub> low	B <sub>02</sub> high	G <sub>03</sub> low	G <sub>03</sub> high
start + 8:	G <sub>10</sub> low	G <sub>10</sub> high	R <sub>11</sub> low	R <sub>11</sub> high	G <sub>12</sub> low	G <sub>12</sub> high	R <sub>13</sub> low	R <sub>13</sub> high
start + 16:	B <sub>20</sub> low	B <sub>20</sub> high	G <sub>21</sub> low	G <sub>21</sub> high	B <sub>22</sub> low	B <sub>22</sub> high	G <sub>23</sub> low	G <sub>23</sub> high
start + 24:	G <sub>30</sub> low	G <sub>30</sub> high	R <sub>31</sub> low	R <sub>31</sub> high	G <sub>32</sub> low	G <sub>32</sub> high	R <sub>33</sub> low	R <sub>33</sub> high

**V4L2\_PIX\_FMT\_SRGGGB14P ('pREE'), V4L2\_PIX\_FMT\_SGRBG14P ('pgEE'),**  
**V4L2\_PIX\_FMT\_SGBRG14P ('pGEE'), V4L2\_PIX\_FMT\_SBGGR14P ('pBEE'),**

man V4L2\_PIX\_FMT\_SRGGGB14P(2)

V4L2\_PIX\_FMT\_SGRBG14P V4L2\_PIX\_FMT\_SGBRG14P V4L2\_PIX\_FMT\_SBGGR14P 14-bit packed Bayer formats

## Description

These four pixel formats are packed raw sRGB / Bayer formats with 14 bits per colour. Every four consecutive samples are packed into seven bytes. Each of the first four bytes contain the eight high order bits of the pixels, and the three following bytes contains the six least significant bits of each pixel, in the same order.

Each n-pixel row contains n/2 green samples and n/2 blue or red samples, with alternating green-red and green-blue rows. They are conventionally described as GRGR... BGBG..., RGRG... GBGB..., etc. Below is an example of one of these formats:

**Byte Order.** Each cell is one byte.

start + 0	B <sub>00</sub> high	G <sub>01</sub> high	B <sub>02</sub> high	G <sub>03</sub> high	G <sub>01</sub> low bits 1--0(bits 7--6) B <sub>00</sub> low bits 5--0(bits 5--0)	B <sub>02</sub> low bits 3--0(bits 7--4) G <sub>01</sub> low bits 5--2(bits 3--0)	G <sub>03</sub> low bits 5--0(bits 7--2) B <sub>02</sub> low bits 5--4(bits 1--0)
start + 7	G <sub>10</sub> high	R <sub>11</sub> high	G <sub>12</sub> high	R <sub>13</sub> high	R <sub>11</sub> low bits 1--0(bits 7--6) G <sub>10</sub> low bits 5--0(bits 5--0)	G <sub>12</sub> low bits 3--0(bits 7--4) R <sub>11</sub> low bits 5--2(bits 3--0)	R <sub>13</sub> low bits 5--0(bits 7--2) G <sub>12</sub> low bits 5--4(bits 1--0)
start + 14	B <sub>20</sub> high	G <sub>21</sub> high	B <sub>22</sub> high	G <sub>23</sub> high	G <sub>21</sub> low bits 1--0(bits 7--6) B <sub>20</sub> low bits 5--0(bits 5--0)	B <sub>22</sub> low bits 3--0(bits 7--4) G <sub>21</sub> low bits 5--2(bits 3--0)	G <sub>23</sub> low bits 5--0(bits 7--2) B <sub>22</sub> low bits 5--4(bits 1--0)
start + 21	G <sub>30</sub> high	R <sub>31</sub> high	G <sub>32</sub> high	R <sub>33</sub> high	R <sub>31</sub> low bits 1--0(bits 7--6) G <sub>30</sub> low bits 5--0(bits 5--0)	G <sub>32</sub> low bits 3--0(bits 7--4) R <sub>31</sub> low bits 5--2(bits 3--0)	R <sub>33</sub> low bits 5--0(bits 7--2) G <sub>32</sub> low bits 5--4(bits 1--0)

**V4L2\_PIX\_FMT\_SRGGGB16 ('RG16'), V4L2\_PIX\_FMT\_SGRBG16 ('GR16'),**  
**V4L2\_PIX\_FMT\_SGBRG16 ('GB16'), V4L2\_PIX\_FMT\_SBGGR16 ('BYR2'),**

## 16-bit Bayer formats

### Description

These four pixel formats are raw sRGB / Bayer formats with 16 bits per sample. Each sample is stored in a 16-bit word. Each n-pixel row contains n/2 green samples and n/2 blue or red samples, with alternating red and blue rows. Bytes are stored in memory in little endian order. They are conventionally described as GRGR... BGBG..., RGRG... GBGB..., etc. Below is an example of a small V4L2\_PIX\_FMT\_SBGGR16 image:

**Byte Order.** Each cell is one byte.

start + 0:	B <sub>00</sub> low	B <sub>00</sub> high	G <sub>01</sub> low	G <sub>01</sub> high	B <sub>02</sub> low	B <sub>02</sub> high	G <sub>03</sub> low	G <sub>03</sub> high
start + 8:	G <sub>10</sub> low	G <sub>10</sub> high	R <sub>11</sub> low	R <sub>11</sub> high	G <sub>12</sub> low	G <sub>12</sub> high	R <sub>13</sub> low	R <sub>13</sub> high
start + 16:	B <sub>20</sub> low	B <sub>20</sub> high	G <sub>21</sub> low	G <sub>21</sub> high	B <sub>22</sub> low	B <sub>22</sub> high	G <sub>23</sub> low	G <sub>23</sub> high
start + 24:	G <sub>30</sub> low	G <sub>30</sub> high	R <sub>31</sub> low	R <sub>31</sub> high	G <sub>32</sub> low	G <sub>32</sub> high	R <sub>33</sub> low	R <sub>33</sub> high

## YUV Formats

YUV is the format native to TV broadcast and composite video signals. It separates the brightness information (Y) from the color information (U and V or Cb and Cr). The color information consists of red and blue *color difference* signals, this way the green component can be reconstructed by subtracting from the brightness component. See [Colorsaces](#) for conversion examples. YUV was chosen because early television would only transmit brightness information. To add color in a way compatible with existing receivers a new signal carrier was added to transmit the color difference signals.

## Subsampling

YUV formats commonly encode images with a lower resolution for the chroma components than for the luma component. This compression technique, taking advantage of the human eye being more sensitive to luminance than color differences, is called chroma subsampling.

While many combinations of subsampling factors in the horizontal and vertical direction are possible, common factors are 1 (no subsampling), 2 and 4, with horizontal subsampling always larger than or equal to vertical subsampling. Common combinations are named as follows.

- 4:4:4: No subsampling
- 4:2:2: Horizontal subsampling by 2, no vertical subsampling
- 4:2:0: Horizontal subsampling by 2, vertical subsampling by 2
- 4:1:1: Horizontal subsampling by 4, no vertical subsampling
- 4:1:0: Horizontal subsampling by 4, vertical subsampling by 4

Subsampling the chroma component effectively creates chroma values that can be located in different spatial locations:

- The subsampled chroma value may be calculated by simply averaging the chroma value of two consecutive pixels. It effectively models the chroma of a pixel sited between the two original pixels. This is referred to as centered or interstitially sited chroma.
- The other option is to subsample chroma values in a way that place them in the same spatial sites as the pixels. This may be performed by skipping every other chroma sample (creating aliasing artifacts), or with filters using an odd number of taps. This is referred to as co-sited chroma.

The following examples show different combination of chroma siting in a 4x4 image.

Table 75: 4:2:2 subsampling, interstitially sited

	0		1		2		3
0	Y	C	Y		Y	C	Y
1	Y	C	Y		Y	C	Y
2	Y	C	Y		Y	C	Y
3	Y	C	Y		Y	C	Y

Table 76: 4:2:2 subsampling, co-sited

	0	1	2	3
0	Y/C	Y	Y/C	Y
1	Y/C	Y	Y/C	Y
2	Y/C	Y	Y/C	Y
3	Y/C	Y	Y/C	Y

Table 77: 4:2:0 subsampling, horizontally interstitially sited, vertically co-sited

	0	1	2	3
0	Y	C	Y	Y
1	Y		Y	Y
2	Y	C	Y	Y
3	Y		Y	Y

Table 78: 4:1:0 subsampling, horizontally and vertically interstitially sited

	0	1	2	3
0	Y	Y	Y	Y
1	Y	Y	Y	Y
2			C	
3	Y	Y	Y	Y

## Packed YUV formats

Similarly to the packed RGB formats, the packed YUV formats store the Y, Cb and Cr components consecutively in memory. They may apply subsampling to the chroma components and thus differ in how they interlace the three components.

---

### Note:

- In all the tables that follow, bit 7 is the most significant bit in a byte.
  - 'Y', 'Cb' and 'Cr' denote bits of the luma, blue chroma (also known as 'U') and red chroma (also known as 'V') components respectively. 'A' denotes bits of the alpha component (if supported by the format), and 'X' denotes padding bits.
-

#### 4:4:4 Subsampling

These formats do not subsample the chroma components and store each pixels as a full triplet of Y, Cb and Cr values.

The next table lists the packed YUV 4:4:4 formats with less than 8 bits per component. They are named based on the order of the Y, Cb and Cr components as seen in a 16-bit word, which is then stored in memory in little endian byte order, and on the number of bits for each component. For instance the YUV565 format stores a pixel in a 16-bit word [15:0] laid out at as [Y'4-0 Cb5-0 Cr4-0], and stored in memory in two bytes, [Cb2-0 Cr4-0] followed by [Y'4-0 Cb5-3].

Table 79: Packed YUV 4:4:4 Image Formats (less than 8bpc)

Identifier	Code	Byte 0 in memory								Byte 1							
		7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
V4L2_PIX_FMT_YUV444	'Y444'	Cb <sub>3</sub>	Cb <sub>2</sub>	Cb <sub>1</sub>	Cb <sub>0</sub>	Cr <sub>3</sub>	Cr <sub>2</sub>	Cr <sub>1</sub>	Cr <sub>0</sub>	a <sub>3</sub>	a <sub>2</sub>	a <sub>1</sub>	a <sub>0</sub>	Y' <sub>3</sub>	Y' <sub>2</sub>	Y' <sub>1</sub>	Y' <sub>0</sub>
V4L2_PIX_FMT_YUV555	'YUVO'	Cb <sub>2</sub>	Cb <sub>1</sub>	Cb <sub>0</sub>	Cr <sub>4</sub>	Cr <sub>3</sub>	Cr <sub>2</sub>	Cr <sub>1</sub>	Cr <sub>0</sub>	a	Y' <sub>4</sub>	Y' <sub>3</sub>	Y' <sub>2</sub>	Y' <sub>1</sub>	Y' <sub>0</sub>	Cb <sub>4</sub>	Cb <sub>3</sub>
V4L2_PIX_FMT_YUV565	'YUVP'	Cb <sub>2</sub>	Cb <sub>1</sub>	Cb <sub>0</sub>	Cr <sub>4</sub>	Cr <sub>3</sub>	Cr <sub>2</sub>	Cr <sub>1</sub>	Cr <sub>0</sub>	Y' <sub>4</sub>	Y' <sub>3</sub>	Y' <sub>2</sub>	Y' <sub>1</sub>	Y' <sub>0</sub>	Cb <sub>5</sub>	Cb <sub>4</sub>	Cb <sub>3</sub>

---

**Note:** For the YUV444 and YUV555 formats, the value of alpha bits is undefined when reading from the driver, ignored when writing to the driver, except when alpha blending has been negotiated for a *Video Overlay* or *Video Output Overlay*.

The next table lists the packed YUV 4:4:4 formats with 8 bits per component. They are named based on the order of the Y, Cb and Cr components as stored in memory, and on the total number of bits per pixel. For instance, the VUYX32 format stores a pixel with Cr<sub>7-0</sub> in the first byte, Cb<sub>7-0</sub> in the second byte and Y'<sub>7-0</sub> in the third byte.

Table 80: Packed YUV Image Formats (8bpc)

Identifier	Code	Byte 0	Byte 1	Byte 2	Byte 3
V4L2_PIX_FMT_YUV32	'YUV4'	A <sub>7-0</sub>	Y' <sub>7-0</sub>	Cb <sub>7-0</sub>	Cr <sub>7-0</sub>
V4L2_PIX_FMT_AYUV32	'AYUV'	A <sub>7-0</sub>	Y' <sub>7-0</sub>	Cb <sub>7-0</sub>	Cr <sub>7-0</sub>
V4L2_PIX_FMT_XYUV32	'XYUV'	X <sub>7-0</sub>	Y' <sub>7-0</sub>	Cb <sub>7-0</sub>	Cr <sub>7-0</sub>
V4L2_PIX_FMT_VUYA32	'VUYA'	Cr <sub>7-0</sub>	Cb <sub>7-0</sub>	Y' <sub>7-0</sub>	A <sub>7-0</sub>
V4L2_PIX_FMT_VUYX32	'VUYX'	Cr <sub>7-0</sub>	Cb <sub>7-0</sub>	Y' <sub>7-0</sub>	X <sub>7-0</sub>
V4L2_PIX_FMT_YUVA32	'YUVA'	Y' <sub>7-0</sub>	Cb <sub>7-0</sub>	Cr <sub>7-0</sub>	A <sub>7-0</sub>
V4L2_PIX_FMT_YUVX32	'YUVX'	Y' <sub>7-0</sub>	Cb <sub>7-0</sub>	Cr <sub>7-0</sub>	X <sub>7-0</sub>
V4L2_PIX_FMT_YUV24	'YUV3'	Y' <sub>7-0</sub>	Cb <sub>7-0</sub>	Cr <sub>7-0</sub>	-

---

**Note:**

- The alpha component is expected to contain a meaningful value that can be used by drivers and applications.

- The padding bits contain undefined values that must be ignored by all applications and drivers.

The next table lists the packed YUV 4:4:4 formats with 12 bits per component. Expand the bits per component to 16 bits, data in the high bits, zeros in the low bits, arranged in little endian order, storing 1 pixel in 6 bytes.

Table 81: Packed YUV 4:4:4 Image Formats (12bpc)

Identifier	Code	Byte 1-0	Byte 3-2	Byte 5-4	Byte 7-6	Byte 9-8	Byte 11-10
V4L2_PIX_FMT_YUV48Y <del>3</del> <sup>2</sup> 2'	Y'0	Cb <sub>0</sub>	Cr <sub>0</sub>	Y'1	Cb <sub>1</sub>	Cr <sub>1</sub>	

## 4:2:2 Subsampling

These formats, commonly referred to as YUYV or YUY2, subsample the chroma components horizontally by 2, storing 2 pixels in a container. The container is 32-bits for 8-bit formats, and 64-bits for 10+-bit formats.

The packed YUYV formats with more than 8 bits per component are stored as four 16-bit little-endian words. Each word's most significant bits contain one component, and the least significant bits are zero padding.

Table 82: Packed YUV 4:2:2 Formats in 32-bit container

Identifier	Code	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7
V4L2_PIX_FMT_UYVY	'UYVY'	Cb <sub>0</sub>	Y'0	Cr <sub>0</sub>	Y'1	Cb <sub>2</sub>	Y'2	Cr <sub>2</sub>	Y'3
V4L2_PIX_FMT_VYUY	'VYUY'	Cr <sub>0</sub>	Y'0	Cb <sub>0</sub>	Y'1	Cr <sub>2</sub>	Y'2	Cb <sub>2</sub>	Y'3
V4L2_PIX_FMT_YUYV	'YUYV'	Y'0	Cb <sub>0</sub>	Y'1	Cr <sub>0</sub>	Y'2	Cb <sub>2</sub>	Y'3	Cr <sub>2</sub>
V4L2_PIX_FMT_VYYU	'VYYU'	Y'0	Cr <sub>0</sub>	Y'1	Cb <sub>0</sub>	Y'2	Cr <sub>2</sub>	Y'3	Cb <sub>2</sub>

Table 83: Packed YUV 4:2:2 Formats in 64-bit container

Identifier	Code	Word 0	Word 1	Word 2	Word 3
V4L2_PIX_FMT_Y210	'Y210'	Y'0 (bits 15-6)	Cb <sub>0</sub> (bits 15-6)	Y'1 (bits 15-6)	Cr <sub>0</sub> (bits 15-6)
V4L2_PIX_FMT_Y212	'Y212'	Y'0 (bits 15-4)	Cb <sub>0</sub> (bits 15-4)	Y'1 (bits 15-4)	Cr <sub>0</sub> (bits 15-4)
V4L2_PIX_FMT_Y216	'Y216'	Y'0 (bits 15-0)	Cb <sub>0</sub> (bits 15-0)	Y'1 (bits 15-0)	Cr <sub>0</sub> (bits 15-0)

**Color Sample Location:** Chroma samples are *interstitially sited* horizontally.

### 4:1:1 Subsampling

This format subsamples the chroma components horizontally by 4, storing 8 pixels in 12 bytes.

Table 84: Packed YUV 4:1:1 Formats

Identifier	Code	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte 7	Byte 8	Byte 9	Byte 10	Byte 11
V4L2_PIX_FMT_Y41P	'Y41P'	Cb <sub>0</sub>	Y' <sub>0</sub>	Cr <sub>0</sub>	Y' <sub>1</sub>	Cb <sub>4</sub>	Y' <sub>2</sub>	Cr <sub>4</sub>	Y' <sub>3</sub>	Y' <sub>4</sub>	Y' <sub>5</sub>	Y' <sub>6</sub>	Y' <sub>7</sub>

**Note:** Do not confuse V4L2\_PIX\_FMT\_Y41P with [V4L2\\_PIX\\_FMT\\_YUV411P](#). Y41P is derived from "YUV 4:1:1 **packed**", while YUV411P stands for "YUV 4:1:1 **planar**".

**Color Sample Location:** Chroma samples are *interstitially sited* horizontally.

### Planar YUV formats

Planar formats split luma and chroma data in separate memory regions. They exist in two variants:

- Semi-planar formats use two planes. The first plane is the luma plane and stores the Y components. The second plane is the chroma plane and stores the Cb and Cr components interleaved.
- Fully planar formats use three planes to store the Y, Cb and Cr components separately.

Within a plane, components are stored in pixel order, which may be linear or tiled. Padding may be supported at the end of the lines, and the line stride of the chroma planes may be constrained by the line stride of the luma plane.

Some planar formats allow planes to be placed in independent memory locations. They are identified by an 'M' suffix in their name (such as in V4L2\_PIX\_FMT\_NV12M). Those formats are intended to be used only in drivers and applications that support the multi-planar API, described in [Single- and multi-planar APIs](#). Unless explicitly documented as supporting non-contiguous planes, formats require the planes to follow each other immediately in memory.

### Semi-Planar YUV Formats

These formats are commonly referred to as NV formats (NV12, NV16, ...). They use two planes, and store the luma components in the first plane and the chroma components in the second plane. The Cb and Cr components are interleaved in the chroma plane, with Cb and Cr always stored in pairs. The chroma order is exposed as different formats.

For memory contiguous formats, the number of padding pixels at the end of the chroma lines is identical to the padding of the luma lines. Without horizontal subsampling, the chroma line stride (in bytes) is thus equal to twice the luma line stride. With horizontal subsampling by 2, the chroma line stride is equal to the luma line stride. Vertical subsampling doesn't affect the line stride.

For non-contiguous formats, no constraints are enforced by the format on the relationship between the luma and chroma line padding and stride.

All components are stored with the same number of bits per component.

Table 85: Overview of Semi-Planar YUV Formats

Identifier	Code	Bits per component	Subsampling	Chroma order <sup>1</sup>	Contiguous <sup>2</sup>	Tiling <sup>3</sup>
V4L2_PIX_FMT_NV12	'NV12'	8	4:2:0	Cb, Cr	Yes	Linear
V4L2_PIX_FMT_NV21	'NV21'	8	4:2:0	Cr, Cb	Yes	Linear
V4L2_PIX_FMT_NV12M	'NM12'	8	4:2:0	Cb, Cr	No	Linear
V4L2_PIX_FMT_NV21M	'NM21'	8	4:2:0	Cr, Cb	No	Linear
V4L2_PIX_FMT_NV12MT	'TM12'	8	4:2:0	Cb, Cr	No	64x32 tiles Horizontal Z order
V4L2_PIX_FMT_NV12MT_16X16	'VM12'	8	4:2:2	Cb, Cr	No	16x16 tiles
V4L2_PIX_FMT_P010	'P010'	10	4:2:0	Cb, Cr	Yes	Linear
V4L2_PIX_FMT_P010_4L4	'T010'	10	4:2:0	Cb, Cr	Yes	4x4 tiles
V4L2_PIX_FMT_P012	'P012'	12	4:2:0	Cb, Cr	Yes	Linear
V4L2_PIX_FMT_P012M	'PM12'	12	4:2:0	Cb, Cr	No	Linear
V4L2_PIX_FMT_NV15_4L4	'VT15'	15	4:2:0	Cb, Cr	Yes	4x4 tiles
V4L2_PIX_FMT_NV16	'NV16'	8	4:2:2	Cb, Cr	Yes	Linear
V4L2_PIX_FMT_NV61	'NV61'	8	4:2:2	Cr, Cb	Yes	Linear
V4L2_PIX_FMT_NV16M	'NM16'	8	4:2:2	Cb, Cr	No	Linear
V4L2_PIX_FMT_NV61M	'NM61'	8	4:2:2	Cr, Cb	No	Linear
V4L2_PIX_FMT_NV24	'NV24'	8	4:4:4	Cb, Cr	Yes	Linear
V4L2_PIX_FMT_NV42	'NV42'	8	4:4:4	Cr, Cb	Yes	Linear

**Color Sample Location:** Chroma samples are *interstitially sited* horizontally.

## NV12, NV21, NV12M and NV21M

Semi-planar YUV 4:2:0 formats. The chroma plane is subsampled by 2 in each direction. Chroma lines contain half the number of pixels and the same number of bytes as luma lines, and the chroma plane contains half the number of lines of the luma plane.

Table 86: Sample 4x4 NV12 Image

start + 0:	Y'00	Y'01	Y'02	Y'03
start + 4:	Y'10	Y'11	Y'12	Y'13
start + 8:	Y'20	Y'21	Y'22	Y'23
start + 12:	Y'30	Y'31	Y'32	Y'33
start + 16:	Cb <sub>00</sub>	Cr <sub>00</sub>	Cb <sub>01</sub>	Cr <sub>01</sub>
start + 20:	Cb <sub>10</sub>	Cr <sub>10</sub>	Cb <sub>11</sub>	Cr <sub>11</sub>

<sup>1</sup> Order of chroma samples in the second plane

<sup>2</sup> Indicates if planes have to be contiguous in memory or can be disjoint

<sup>3</sup> Macroblock size in pixels

Table 87: Sample 4x4 NV12M Image

start0 + 0:	Y'00	Y'01	Y'02	Y'03
start0 + 4:	Y'10	Y'11	Y'12	Y'13
start0 + 8:	Y'20	Y'21	Y'22	Y'23
start0 + 12:	Y'30	Y'31	Y'32	Y'33
start1 + 0:	Cb00	Cr00	Cb01	Cr01
start1 + 4:	Cb10	Cr10	Cb11	Cr11

## Tiled NV12

Semi-planar YUV 4:2:0 formats, using macroblock tiling. The chroma plane is subsampled by 2 in each direction. Chroma lines contain half the number of pixels and the same number of bytes as luma lines, and the chroma plane contains half the number of lines of the luma plane. Each tile follows the previous one linearly in memory (from left to right, top to bottom).

V4L2\_PIX\_FMT\_NV12MT\_16X16 is similar to V4L2\_PIX\_FMT\_NV12M but stores pixels in 2D 16x16 tiles, and stores tiles linearly in memory. The line stride and image height must be aligned to a multiple of 16. The layouts of the luma and chroma planes are identical.

V4L2\_PIX\_FMT\_NV12MT is similar to V4L2\_PIX\_FMT\_NV12M but stores pixels in 2D 64x32 tiles, and stores 2x2 groups of tiles in Z-order in memory, alternating Z and mirrored Z shapes horizontally. The line stride must be a multiple of 128 pixels to ensure an integer number of Z shapes. The image height must be a multiple of 32 pixels. If the vertical resolution is an odd number of tiles, the last row of tiles is stored in linear order. The layouts of the luma and chroma planes are identical.

V4L2\_PIX\_FMT\_NV12\_4L4 stores pixels in 4x4 tiles, and stores tiles linearly in memory. The line stride and image height must be aligned to a multiple of 4. The layouts of the luma and chroma planes are identical.

V4L2\_PIX\_FMT\_NV12\_16L16 stores pixels in 16x16 tiles, and stores tiles linearly in memory. The line stride and image height must be aligned to a multiple of 16. The layouts of the luma and chroma planes are identical.

V4L2\_PIX\_FMT\_NV12\_32L32 stores pixels in 32x32 tiles, and stores tiles linearly in memory. The line stride and image height must be aligned to a multiple of 32. The layouts of the luma and chroma planes are identical.

V4L2\_PIX\_FMT\_NV12M\_8L128 is similar to V4L2\_PIX\_FMT\_NV12M but stores pixels in 2D 8x128 tiles, and stores tiles linearly in memory. The image height must be aligned to a multiple of 128. The layouts of the luma and chroma planes are identical.

V4L2\_PIX\_FMT\_NV12\_8L128 is similar to V4L2\_PIX\_FMT\_NV12M\_8L128 but stores two planes in one memory.

V4L2\_PIX\_FMT\_NV12M\_10BE\_8L128 is similar to V4L2\_PIX\_FMT\_NV12M but stores 10 bits pixels in 2D 8x128 tiles, and stores tiles linearly in memory. the data is arranged in big endian order. The image height must be aligned to a multiple of 128. The layouts of the luma and chroma planes are identical. Note the tile size is 8bytes multiplied by 128 bytes, it means that the low bits and high bits of one pixel may be in different tiles. The 10 bit pixels are packed, so 5 bytes contain 4 10-bit pixels layout like this (for luma): byte 0: Y0(bits 9-2) byte 1: Y0(bits 1-0) Y1(bits 9-4) byte 2: Y1(bits 3-0) Y2(bits 9-6) byte 3: Y2(bits 5-0) Y3(bits 9-8) byte 4: Y3(bits 7-0)

V4L2\_PIX\_FMT\_NV12\_10BE\_8L128 is similar to V4L2\_PIX\_FMT\_NV12M\_10BE\_8L128 but stores two planes in one memory.

V4L2\_PIX\_FMT\_MM21 store luma pixel in 16x32 tiles, and chroma pixels in 16x16 tiles. The line stride must be aligned to a multiple of 16 and the image height must be aligned to a multiple of 32. The number of luma and chroma tiles are identical, even though the tile size differ. The image is formed of two non-contiguous planes.

Fig. 4: V4L2\_PIX\_FMT\_NV12MT macroblock Z shape memory layout

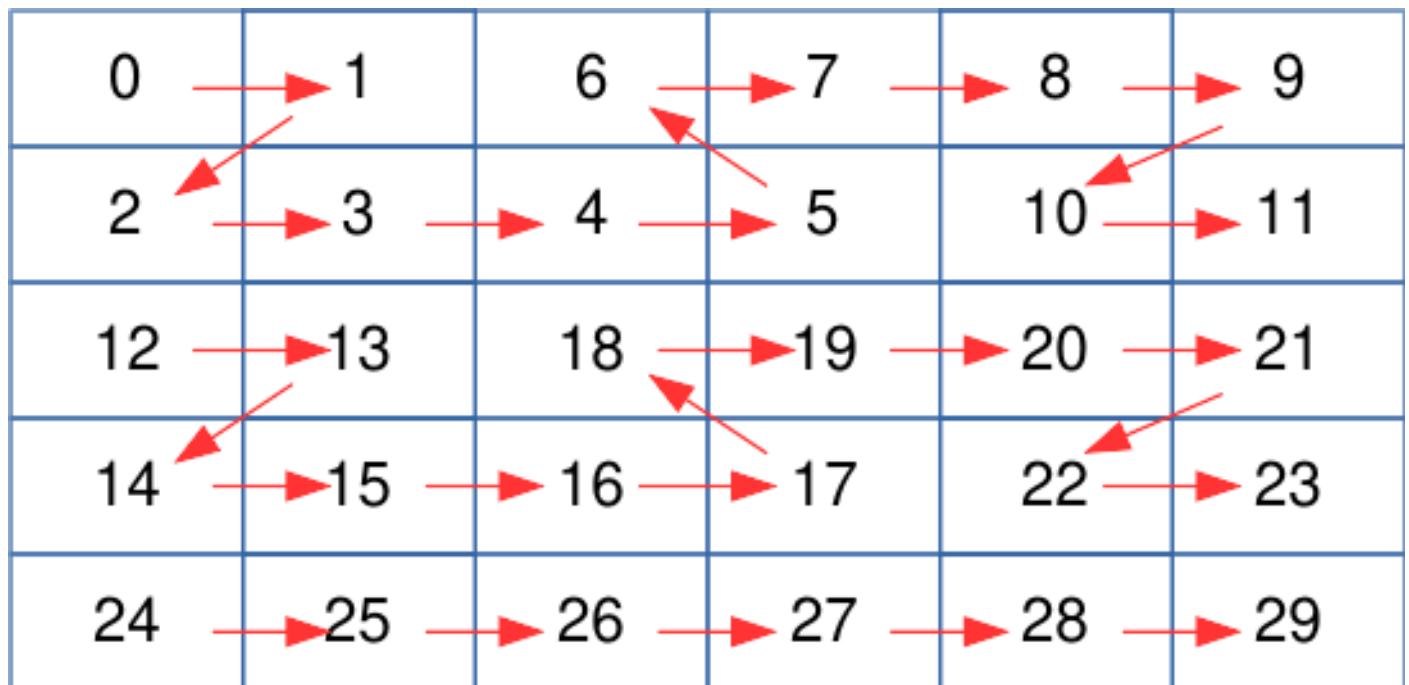


Fig. 5: Example V4L2\_PIX\_FMT\_NV12MT memory layout of tiles

## Tiled NV15

Semi-planar 10-bit YUV 4:2:0 formats, using 4x4 tiling. All components are packed without any padding between each other. As a side-effect, each group of 4 components are stored over 5 bytes (YYYY or UVUV =  $4 * 10$  bits = 40 bits = 5 bytes).

## NV16, NV61, NV16M and NV61M

Semi-planar YUV 4:2:2 formats. The chroma plane is subsampled by 2 in the horizontal direction. Chroma lines contain half the number of pixels and the same number of bytes as luma lines, and the chroma plane contains the same number of lines as the luma plane.

Table 88: Sample 4x4 NV16 Image

start + 0:	$Y'_{00}$	$Y'_{01}$	$Y'_{02}$	$Y'_{03}$
start + 4:	$Y'_{10}$	$Y'_{11}$	$Y'_{12}$	$Y'_{13}$
start + 8:	$Y'_{20}$	$Y'_{21}$	$Y'_{22}$	$Y'_{23}$
start + 12:	$Y'_{30}$	$Y'_{31}$	$Y'_{32}$	$Y'_{33}$
start + 16:	$Cb_{00}$	$Cr_{00}$	$Cb_{01}$	$Cr_{01}$
start + 20:	$Cb_{10}$	$Cr_{10}$	$Cb_{11}$	$Cr_{11}$
start + 24:	$Cb_{20}$	$Cr_{20}$	$Cb_{21}$	$Cr_{21}$
start + 28:	$Cb_{30}$	$Cr_{30}$	$Cb_{31}$	$Cr_{31}$

Table 89: Sample 4x4 NV16M Image

start0 + 0:	$Y'_{00}$	$Y'_{01}$	$Y'_{02}$	$Y'_{03}$
start0 + 4:	$Y'_{10}$	$Y'_{11}$	$Y'_{12}$	$Y'_{13}$
start0 + 8:	$Y'_{20}$	$Y'_{21}$	$Y'_{22}$	$Y'_{23}$
start0 + 12:	$Y'_{30}$	$Y'_{31}$	$Y'_{32}$	$Y'_{33}$
start1 + 0:	$Cb_{00}$	$Cr_{00}$	$Cb_{02}$	$Cr_{02}$
start1 + 4:	$Cb_{10}$	$Cr_{10}$	$Cb_{12}$	$Cr_{12}$
start1 + 8:	$Cb_{20}$	$Cr_{20}$	$Cb_{22}$	$Cr_{22}$
start1 + 12:	$Cb_{30}$	$Cr_{30}$	$Cb_{32}$	$Cr_{32}$

## NV24 and NV42

Semi-planar YUV 4:4:4 formats. The chroma plane is not subsampled. Chroma lines contain the same number of pixels and twice the number of bytes as luma lines, and the chroma plane contains the same number of lines as the luma plane.

Table 90: Sample 4x4 NV24 Image

start + 0:	Y'00	Y'01	Y'02	Y'03				
start + 4:	Y'10	Y'11	Y'12	Y'13				
start + 8:	Y'20	Y'21	Y'22	Y'23				
start + 12:	Y'30	Y'31	Y'32	Y'33				
start + 16:	Cb00	Cr00	Cb01	Cr01	Cb02	Cr02	Cb03	Cr03
start + 24:	Cb10	Cr10	Cb11	Cr11	Cb12	Cr12	Cb13	Cr13
start + 32:	Cb20	Cr20	Cb21	Cr21	Cb22	Cr22	Cb23	Cr23
start + 40:	Cb30	Cr30	Cb31	Cr31	Cb32	Cr32	Cb33	Cr33

## P010 and tiled P010

P010 is like NV12 with 10 bits per component, expanded to 16 bits. Data in the 10 high bits, zeros in the 6 low bits, arranged in little endian order.

Table 91: Sample 4x4 P010 Image

start + 0:	Y'00	Y'01	Y'02	Y'03				
start + 8:	Y'10	Y'11	Y'12	Y'13				
start + 16:	Y'20	Y'21	Y'22	Y'23				
start + 24:	Y'30	Y'31	Y'32	Y'33				
start + 32:	Cb00	Cr00	Cb01	Cr01				
start + 40:	Cb10	Cr10	Cb11	Cr11				

## P012 and P012M

P012 is like NV12 with 12 bits per component, expanded to 16 bits. Data in the 12 high bits, zeros in the 4 low bits, arranged in little endian order.

Table 92: Sample 4x4 P012 Image

start + 0:	Y'00	Y'01	Y'02	Y'03				
start + 8:	Y'10	Y'11	Y'12	Y'13				
start + 16:	Y'20	Y'21	Y'22	Y'23				
start + 24:	Y'30	Y'31	Y'32	Y'33				
start + 32:	Cb00	Cr00	Cb01	Cr01				
start + 40:	Cb10	Cr10	Cb11	Cr11				

Table 93: Sample 4x4 P012M Image

start0 + 0:	Y'00	Y'01	Y'02	Y'03
start0 + 8:	Y'10	Y'11	Y'12	Y'13
start0 + 16:	Y'20	Y'21	Y'22	Y'23
start0 + 24:	Y'30	Y'31	Y'32	Y'33
<hr/>				
start1 + 0:	Cb00	Cr00	Cb01	Cr01
start1 + 8:	Cb10	Cr10	Cb11	Cr11

## Fully Planar YUV Formats

These formats store the Y, Cb and Cr components in three separate planes. The luma plane comes first, and the order of the two chroma planes varies between formats. The two chroma planes always use the same subsampling.

For memory contiguous formats, the number of padding pixels at the end of the chroma lines is identical to the padding of the luma lines. The chroma line stride (in bytes) is thus equal to the luma line stride divided by the horizontal subsampling factor. Vertical subsampling doesn't affect the line stride.

For non-contiguous formats, no constraints are enforced by the format on the relationship between the luma and chroma line padding and stride.

All components are stored with the same number of bits per component.

V4L2\_PIX\_FMT\_P010\_4L4 stores pixels in 4x4 tiles, and stores tiles linearly in memory. The line stride must be aligned to multiple of 8 and image height to a multiple of 4. The layouts of the luma and chroma planes are identical.

Table 94: Overview of Fully Planar YUV Formats

Identifier	Code	Bits per component	Subsampling	Planes or- der <small>Page 278, 4</small>	Contiguous <sup>5</sup>
V4L2_PIX_FMT_YUV410	'YUV9'	8	4:1:0	Y, Cb, Cr	Yes
V4L2_PIX_FMT_YVU410	'YVU9'	8	4:1:0	Y, Cr, Cb	Yes
V4L2_PIX_FMT_YUV411P	'411P'	8	4:1:1	Y, Cb, Cr	Yes
V4L2_PIX_FMT_YUV420M	'YM12'	8	4:2:0	Y, Cb, Cr	No
V4L2_PIX_FMT_YVU420M	'YM21'	8	4:2:0	Y, Cr, Cb	No
V4L2_PIX_FMT_YUV420	'YU12'	8	4:2:0	Y, Cb, Cr	Yes
V4L2_PIX_FMT_YVU420	'YV12'	8	4:2:0	Y, Cr, Cb	Yes
V4L2_PIX_FMT_YUV422P	'422P'	8	4:2:2	Y, Cb, Cr	Yes
V4L2_PIX_FMT_YUV422M	'YM16'	8	4:2:2	Y, Cb, Cr	No
V4L2_PIX_FMT_YVU422M	'YM61'	8	4:2:2	Y, Cr, Cb	No
V4L2_PIX_FMT_YUV444M	'YM24'	8	4:4:4	Y, Cb, Cr	No
V4L2_PIX_FMT_YVU444M	'YM42'	8	4:4:4	Y, Cr, Cb	No

**Color Sample Location:** Chroma samples are *interstitially sited* horizontally.

## YUV410 and YVU410

Planar YUV 4:1:0 formats. The chroma planes are subsampled by 4 in each direction. Chroma lines contain a quarter of the number of pixels and bytes of the luma lines, and the chroma planes contain a quarter of the number of lines of the luma plane.

Table 95: Sample 4x4 YUV410 Image

start + 0:	Y'00	Y'01	Y'02	Y'03
start + 4:	Y'10	Y'11	Y'12	Y'13
start + 8:	Y'20	Y'21	Y'22	Y'23
start + 12:	Y'30	Y'31	Y'32	Y'33
start + 16:	Cr00			
start + 17:	Cb00			

<sup>4</sup> Order of luma and chroma planes

<sup>5</sup> Indicates if planes have to be contiguous in memory or can be disjoint

**YUV411P**

Planar YUV 4:1:1 formats. The chroma planes are subsampled by 4 in the horizontal direction. Chroma lines contain a quarter of the number of pixels and bytes of the luma lines, and the chroma planes contain the same number of lines as the luma plane.

Table 96: Sample 4x4 YUV411P Image

start + 0:	Y'00	Y'01	Y'02	Y'03
start + 4:	Y'10	Y'11	Y'12	Y'13
start + 8:	Y'20	Y'21	Y'22	Y'23
start + 12:	Y'30	Y'31	Y'32	Y'33
start + 16:	Cb00			
start + 17:	Cb10			
start + 18:	Cb20			
start + 19:	Cb30			
start + 20:	Cr00			
start + 21:	Cr10			
start + 22:	Cr20			
start + 23:	Cr30			

**YUV420, YVU420, YUV420M and YVU420M**

Planar YUV 4:2:0 formats. The chroma planes are subsampled by 2 in each direction. Chroma lines contain half of the number of pixels and bytes of the luma lines, and the chroma planes contain half of the number of lines of the luma plane.

Table 97: Sample 4x4 YUV420 Image

start + 0:	Y'00	Y'01	Y'02	Y'03
start + 4:	Y'10	Y'11	Y'12	Y'13
start + 8:	Y'20	Y'21	Y'22	Y'23
start + 12:	Y'30	Y'31	Y'32	Y'33
start + 16:	Cr00	Cr01		
start + 18:	Cr10	Cr11		
start + 20:	Cb00	Cb01		
start + 22:	Cb10	Cb11		

Table 98: Sample 4x4 YUV420M Image

start0 + 0:	Y'00	Y'01	Y'02	Y'03
start0 + 4:	Y'10	Y'11	Y'12	Y'13
start0 + 8:	Y'20	Y'21	Y'22	Y'23
start0 + 12:	Y'30	Y'31	Y'32	Y'33
start1 + 0:	Cb00	Cb01		
start1 + 2:	Cb10	Cb11		
start2 + 0:	Cr00	Cr01		
start2 + 2:	Cr10	Cr11		

**YUV422P, YUV422M and YVU422M**

Planar YUV 4:2:2 formats. The chroma planes are subsampled by 2 in the horizontal direction. Chroma lines contain half of the number of pixels and bytes of the luma lines, and the chroma planes contain the same number of lines as the luma plane.

Table 99: Sample 4x4 YUV422P Image

start + 0:	Y'00	Y'01	Y'02	Y'03
start + 4:	Y'10	Y'11	Y'12	Y'13
start + 8:	Y'20	Y'21	Y'22	Y'23
start + 12:	Y'30	Y'31	Y'32	Y'33
start + 16:	Cb00	Cb01		
start + 18:	Cb10	Cb11		
start + 20:	Cb20	Cb21		
start + 22:	Cb30	Cb31		
start + 24:	Cr00	Cr01		
start + 26:	Cr10	Cr11		
start + 28:	Cr20	Cr21		
start + 30:	Cr30	Cr31		

Table 100: Sample 4x4 YUV422M Image

start0 + 0:	Y'00	Y'01	Y'02	Y'03
start0 + 4:	Y'10	Y'11	Y'12	Y'13
start0 + 8:	Y'20	Y'21	Y'22	Y'23
start0 + 12:	Y'30	Y'31	Y'32	Y'33
start1 + 0:	Cb00	Cb01		
start1 + 2:	Cb10	Cb11		
start1 + 4:	Cb20	Cb21		
start1 + 6:	Cb30	Cb31		
start2 + 0:	Cr00	Cr01		
start2 + 2:	Cr10	Cr11		
start2 + 4:	Cr20	Cr21		
start2 + 6:	Cr30	Cr31		

## YUV444M and YVU444M

Planar YUV 4:4:4 formats. The chroma planes are no subsampled. Chroma lines contain the same number of pixels and bytes of the luma lines, and the chroma planes contain the same number of lines as the luma plane.

Table 101: Sample 4x4 YUV444M Image

start0 + 0:	$Y'_{00}$	$Y'_{01}$	$Y'_{02}$	$Y'_{03}$
start0 + 4:	$Y'_{10}$	$Y'_{11}$	$Y'_{12}$	$Y'_{13}$
start0 + 8:	$Y'_{20}$	$Y'_{21}$	$Y'_{22}$	$Y'_{23}$
start0 + 12:	$Y'_{30}$	$Y'_{31}$	$Y'_{32}$	$Y'_{33}$
<hr/>				
start1 + 0:	$Cb_{00}$	$Cb_{01}$	$Cb_{02}$	$Cb_{03}$
start1 + 4:	$Cb_{10}$	$Cb_{11}$	$Cb_{12}$	$Cb_{13}$
start1 + 8:	$Cb_{20}$	$Cb_{21}$	$Cb_{22}$	$Cb_{23}$
start1 + 12:	$Cb_{30}$	$Cb_{31}$	$Cb_{32}$	$Cb_{33}$
<hr/>				
start2 + 0:	$Cr_{00}$	$Cr_{01}$	$Cr_{02}$	$Cr_{03}$
start2 + 4:	$Cr_{10}$	$Cr_{11}$	$Cr_{12}$	$Cr_{13}$
start2 + 8:	$Cr_{20}$	$Cr_{21}$	$Cr_{22}$	$Cr_{23}$
start2 + 12:	$Cr_{30}$	$Cr_{31}$	$Cr_{32}$	$Cr_{33}$

## Luma-Only Formats

This family of formats only store the luma component of a Y'CbCr image. They are often referred to as greyscale formats.

---

### Note:

- In all the tables that follow, bit 7 is the most significant bit in a byte.
  - Formats are described with the minimum number of pixels needed to create a byte-aligned repeating pattern. ... indicates repetition of the pattern.
  - $Y'_x[9:2]$  denotes bits 9 to 2 of the  $Y'$  value for pixel at column  $x$ .
  - 0 denotes padding bits set to 0.
-

Table 102: Luma-Only Image Formats

Identifier	Code	Byte 0	Byte 1	Byte 2	Byte 3	Byte 4
V4L2_PIX_FMT_GREY	'GREY'	Y'0[7:0]	...	...	...	...
V4L2_PIX_FMT_IPU3_Y10	'ip3y'	Y'0[7:0]	Y'1[5:0] Y'0[9:8]	Y'2[3:0] Y'1[9:6]	Y'3[1:0] Y'2[9:4]	Y'3[9:2]
V4L2_PIX_FMT_Y10	'Y10 '	Y'0[7:0]	000000 Y'0[9:8]	...	...	...
V4L2_PIX_FMT_Y10BPACK	'Y10B'	Y'0[9:2]	Y'0[1:0] Y'1[9:4]	Y'1[3:0] Y'2[9:6]	Y'2[5:0] Y'3[9:8]	Y'3[7:0]
V4L2_PIX_FMT_Y10P	'Y10P'	Y'0[9:2]	Y'1[9:2]	Y'2[9:2]	Y'3[9:2]	Y'3[1:0] Y'2[1:0] Y'1[1:0] Y'0[1:0]
V4L2_PIX_FMT_Y12	'Y12 '	Y'0[7:0]	0000 Y'0[11:8]	...	...	...
V4L2_PIX_FMT_Y012	'Y012'	Y'0[3:0] 0000	Y'0[11:4]	...	...	...
V4L2_PIX_FMT_Y14	'Y14 '	Y'0[7:0]	00 Y'0[13:8]	...	...	...
V4L2_PIX_FMT_Y16	'Y16 '	Y'0[7:0]	Y'0[15:8]	...	...	...
V4L2_PIX_FMT_Y16_BE	'Y16 ' (1U << 31)	Y'0[15:8]	Y'0[7:0]	...	...	...

**Note:** For the Y16 and Y16\_BE formats, the actual sampling precision may be lower than 16 bits. For example, 10 bits per pixel uses values in the range 0 to 1023. For the IPU3\_Y10 format 25 pixels are packed into 32 bytes, which leaves the 6 most significant bits of the last byte padded with 0.

For Y012 and Y12 formats, Y012 places its data in the 12 high bits, with padding zeros in the 4 low bits, in contrast to the Y12 format, which has its padding located in the most significant bits of the 16 bit word.

---

## V4L2\_PIX\_FMT\_Y8I ('Y8I ')

Interleaved grey-scale image, e.g. from a stereo-pair

### Description

This is a grey-scale image with a depth of 8 bits per pixel, but with pixels from 2 sources interleaved. Each pixel is stored in a 16-bit word. E.g. the R200 RealSense camera stores pixel from the left sensor in lower and from the right sensor in the higher 8 bits.

**Byte Order.** Each cell is one byte.

start + 0:	Y'00left	Y'00right	Y'01left	Y'01right	Y'02left	Y'02right	Y'03left	Y'03right
start + 8:	Y'10left	Y'10right	Y'11left	Y'11right	Y'12left	Y'12right	Y'13left	Y'13right
start + 16:	Y'20left	Y'20right	Y'21left	Y'21right	Y'22left	Y'22right	Y'23left	Y'23right
start + 24:	Y'30left	Y'30right	Y'31left	Y'31right	Y'32left	Y'32right	Y'33left	Y'33right

## V4L2\_PIX\_FMT\_Y12I ('Y12I')

Interleaved grey-scale image, e.g. from a stereo-pair

### Description

This is a grey-scale image with a depth of 12 bits per pixel, but with pixels from 2 sources interleaved and bit-packed. Each pixel is stored in a 24-bit word in the little-endian order. On a little-endian machine these pixels can be deinterlaced using

```
__u8 *buf;
left0 = 0xffff & *(__u16 *)buf;
right0 = *(__u16 *)(buf + 1) >> 4;
```

**Bit-packed representation.** pixels cross the byte boundary and have a ratio of 3 bytes for each interleaved pixel.

Y <sub>0</sub> left[7:0]	Y <sub>0</sub> right[3:0]	Y <sub>0</sub> left[11:8]	Y <sub>0</sub> right[11:4]
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## V4L2\_PIX\_FMT\_UV8 ('UV8')

UV plane interleaved

### Description

In this format there is no Y plane, Only CbCr plane. ie (UV interleaved)

**Byte Order.** Each cell is one byte.

start + 0:	Cb <sub>00</sub>	Cr <sub>00</sub>	Cb <sub>01</sub>	Cr <sub>01</sub>
start + 4:	Cb <sub>10</sub>	Cr <sub>10</sub>	Cb <sub>11</sub>	Cr <sub>11</sub>
start + 8:	Cb <sub>20</sub>	Cr <sub>20</sub>	Cb <sub>21</sub>	Cr <sub>21</sub>
start + 12:	Cb <sub>30</sub>	Cr <sub>30</sub>	Cb <sub>31</sub>	Cr <sub>31</sub>

## V4L2\_PIX\_FMT\_M420 ('M420')

Format with  $\frac{1}{2}$  horizontal and vertical chroma resolution, also known as YUV 4:2:0. Hybrid plane line-interleaved layout.

## Description

M420 is a YUV format with  $\frac{1}{2}$  horizontal and vertical chroma subsampling (YUV 4:2:0). Pixels are organized as interleaved luma and chroma planes. Two lines of luma data are followed by one line of chroma data.

The luma plane has one byte per pixel. The chroma plane contains interleaved CbCr pixels subsampled by  $\frac{1}{2}$  in the horizontal and vertical directions. Each CbCr pair belongs to four pixels. For example,  $Cb_0/Cr_0$  belongs to  $Y'_{00}, Y'_{01}, Y'_{10}, Y'_{11}$ .

All line lengths are identical: if the Y lines include pad bytes so do the CbCr lines.

**Byte Order.** Each cell is one byte.

start + 0:	$Y'_{00}$	$Y'_{01}$	$Y'_{02}$	$Y'_{03}$
start + 4:	$Y'_{10}$	$Y'_{11}$	$Y'_{12}$	$Y'_{13}$
start + 8:	$Cb_{00}$	$Cr_{00}$	$Cb_{01}$	$Cr_{01}$
start + 16:	$Y'_{20}$	$Y'_{21}$	$Y'_{22}$	$Y'_{23}$
start + 20:	$Y'_{30}$	$Y'_{31}$	$Y'_{32}$	$Y'_{33}$
start + 24:	$Cb_{10}$	$Cr_{10}$	$Cb_{11}$	$Cr_{11}$

**Color Sample Location:** Chroma samples are *interstitially sited* horizontally and vertically.

## HSV Formats

These formats store the color information of the image in a geometrical representation. The colors are mapped into a cylinder, where the angle is the HUE, the height is the VALUE and the distance to the center is the SATURATION. This is a very useful format for image segmentation algorithms.

### Packed HSV formats

#### Description

The *hue* (h) is measured in degrees, the equivalence between degrees and LSBs depends on the hsv-encoding used, see [Colorsaces](#). The *saturation* (s) and the *value* (v) are measured in percentage of the cylinder: 0 being the smallest value and 255 the maximum.

The values are packed in 24 or 32 bit formats.

Table 103: Packed HSV Image Formats

Identifier	Code	Byte 0 in memory								Byte 1								Byte 2								Byte 3							
		Bit 7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0
V4L2_PIX_FMT_HSV32	'HSV4'									$h_7$	$h_6$	$h_5$	$h_4$	$h_3$	$h_2$	$h_1$	$h_0$	$s_7$	$s_6$	$s_5$	$s_4$	$s_3$	$s_2$	$s_1$	$s_0$	$v_7$	$v_6$	$v_5$	$v_4$	$v_3$	$v_2$	$v_1$	$v_0$
V4L2_PIX_FMT_HSV24	'HSV3'	$h_7$	$h_6$	$h_5$	$h_4$	$h_3$	$h_2$	$h_1$	$h_0$	$s_7$	$s_6$	$s_5$	$s_4$	$s_3$	$s_2$	$s_1$	$s_0$	$v_7$	$v_6$	$v_5$	$v_4$	$v_3$	$v_2$	$v_1$	$v_0$								

Bit 7 is the most significant bit.

## Depth Formats

Depth data provides distance to points, mapped onto the image plane

### **V4L2\_PIX\_FMT\_INZI ('INZI')**

Infrared 10-bit linked with Depth 16-bit images

#### Description

Proprietary multi-planar format used by Intel SR300 Depth cameras, comprise of Infrared image followed by Depth data. The pixel definition is 32-bpp, with the Depth and Infrared Data split into separate continuous planes of identical dimensions.

The first plane - Infrared data - is stored according to [V4L2\\_PIX\\_FMT\\_Y10](#) greyscale format. Each pixel is 16-bit cell, with actual data stored in the 10 LSBs with values in range 0 to 1023. The six remaining MSBs are padded with zeros.

The second plane provides 16-bit per-pixel Depth data arranged in [V4L2\\_PIX\\_FMT\\_Z16](#) format.

**Frame Structure.** Each cell is a 16-bit word with more significant data stored at higher memory address (byte order is little-endian).

Ir <sub>0,0</sub>	Ir <sub>0,1</sub>	Ir <sub>0,2</sub>	...	...	...
...					
Infrared Data					
...					
...	...	...	Ir <sub>n-1,n-3</sub>	Ir <sub>n-1,n-2</sub>	Ir <sub>n-1,n-1</sub>
Depth <sub>0,0</sub>	Depth <sub>0,1</sub>	Depth <sub>0,2</sub>	...	...	...
...					
Depth Data					
...					
...	...	...	Depth <sub>n-1,n-3</sub>	Depth <sub>n-1,n-2</sub>	Depth <sub>n-1,n-1</sub>

### **V4L2\_PIX\_FMT\_Z16 ('Z16')**

16-bit depth data with distance values at each pixel

#### Description

This is a 16-bit format, representing depth data. Each pixel is a distance to the respective point in the image coordinates. Distance unit can vary and has to be negotiated with the device separately. Each pixel is stored in a 16-bit word in the little endian byte order.

**Byte Order.** Each cell is one byte.

start + 0:	Z <sub>00low</sub>	Z <sub>00high</sub>	Z <sub>01low</sub>	Z <sub>01high</sub>	Z <sub>02low</sub>	Z <sub>02high</sub>	Z <sub>03low</sub>	Z <sub>03high</sub>
start + 8:	Z <sub>10low</sub>	Z <sub>10high</sub>	Z <sub>11low</sub>	Z <sub>11high</sub>	Z <sub>12low</sub>	Z <sub>12high</sub>	Z <sub>13low</sub>	Z <sub>13high</sub>
start + 16:	Z <sub>20low</sub>	Z <sub>20high</sub>	Z <sub>21low</sub>	Z <sub>21high</sub>	Z <sub>22low</sub>	Z <sub>22high</sub>	Z <sub>23low</sub>	Z <sub>23high</sub>
start + 24:	Z <sub>30low</sub>	Z <sub>30high</sub>	Z <sub>31low</sub>	Z <sub>31high</sub>	Z <sub>32low</sub>	Z <sub>32high</sub>	Z <sub>33low</sub>	Z <sub>33high</sub>

**V4L2\_PIX\_FMT\_CNF4 ('CNF4')**

Depth sensor confidence information as a 4 bits per pixel packed array

**Description**

Proprietary format used by Intel RealSense Depth cameras containing depth confidence information in range 0-15 with 0 indicating that the sensor was unable to resolve any signal and 15 indicating maximum level of confidence for the specific sensor (actual error margins might change from sensor to sensor).

Every two consecutive pixels are packed into a single byte. Bits 0-3 of byte n refer to confidence value of depth pixel  $2*n$ , bits 4-7 to confidence value of depth pixel  $2*n+1$ .

**Bit-packed representation.**

$Y'_{01[3:0]}$ (bits 7--4)	$Y'_{00[3:0]}$ (bits 3--0)	$Y'_{03[3:0]}$ (bits 7--4)	$Y'_{02[3:0]}$ (bits 3--0)
----------------------------	----------------------------	----------------------------	----------------------------

**Compressed Formats**

Table 104: Compressed Image Formats

Identifier	Code	Details
V4L2_PIX_FMT_JPEG	'JPEG'	TBD. See also <a href="#">VIDIOC_G_JPEGCOMP</a> , <a href="#">VIDIOC_S_JPEGCOMP</a> .
V4L2_PIX_FMT_MPEG	'MPEG'	MPEG multiplexed stream. The actual format is determined by extended control <a href="#">V4L2_CID_MPEG_STREAM_TYPE</a> , see <a href="#">Codec Control IDs</a> .
V4L2_PIX_FMT_H264	'H264'	H264 Access Unit. The decoder expects one Access Unit per buffer. The encoder generates one Access Unit per buffer. If <a href="#">ioctl VIDIOC_ENUM_FMT</a> reports <a href="#">V4L2_FLAG_CONTINUOUS_BYTESTREAM</a> then the decoder has no requirements since it can parse all the information from the raw bytestream.
V4L2_PIX_FMT_H264_NO_SC	'AVC1'	H264 video elementary stream without start codes.
V4L2_PIX_FMT_H264_MVC	'M264'	H264 MVC video elementary stream.

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Table 104 – continued from previous page

Identifier	Code	Details
V4L2_PIX_FMT_H264_SLICE	'S264'	H264 parsed slice data, including slice headers, either with or without the start code, as extracted from the H264 bitstream. This format is adapted for stateless video decoders that implement an H264 pipeline with the <i>Memory-to-memory Stateless Video Decoder Interface</i> . This pixelformat has two modifiers that must be set at least once through the V4L2_CID_STATELESS_H264_DECODE_MODE and V4L2_CID_STATELESS_H264_START_CODE controls. In addition, metadata associated with the frame to decode are required to be passed through the V4L2_CID_STATELESS_H264_SPS, V4L2_CID_STATELESS_H264_PPS, V4L2_CID_STATELESS_H264_SCALING_MATRIX, V4L2_CID_STATELESS_H264_SLICE_PARAMS and V4L2_CID_STATELESS_H264_DECODE_PARAMS controls. See the <i>associated Codec Control IDs</i> . Exactly one output and one capture buffer must be provided for use with this pixel format. The output buffer must contain the appropriate number of macroblocks to decode a full corresponding frame to the matching capture buffer. The syntax for this format is documented in <i>ITU-T Rec. H.264 Specification (04/2017 Edition)</i> , section 7.3.2.8 "Slice layer without partitioning RBSP syntax" and the following sections.
V4L2_PIX_FMT_H263	'H263'	H263 video elementary stream.
V4L2_PIX_FMT_SPK	'SPKO'	Sorenson Spark is an implementation of H.263 for use in Flash Video and Adobe Flash files
V4L2_PIX_FMT_MPEG1	'MPG1'	MPEG1 Picture. Each buffer starts with a Picture header, followed by other headers as needed and ending with the Picture data. If <i>ioctl VIDIOC_ENUM_FMT</i> reports V4L2_FLAG_CONTINUOUS_BYTESTREAM then the decoder has no requirements since it can parse all the information from the raw bytestream.
V4L2_PIX_FMT_MPEG2	'MPG2'	MPEG2 Picture. Each buffer starts with a Picture header, followed by other headers as needed and ending with the Picture data. If <i>ioctl VIDIOC_ENUM_FMT</i> reports V4L2_FLAG_CONTINUOUS_BYTESTREAM then the decoder has no requirements since it can parse all the information from the raw bytestream.
V4L2_PIX_FMT_MPEG2_SLICE	'MG2S'	MPEG-2 parsed slice data, as extracted from the MPEG-2 bitstream. This format is adapted for stateless video decoders that implement a MPEG-2 pipeline with the <i>Memory-to-memory Stateless Video Decoder Interface</i> . Metadata associated with the frame to decode is required to be passed through the V4L2_CID_STATELESS_MPEG2_SEQUENCE and V4L2_CID_STATELESS_MPEG2_PICTURE controls. Quantisation matrices can optionally be specified through the V4L2_CID_STATELESS_MPEG2_QUANTISATION control. See the <i>associated Codec Control IDs</i> . Exactly one output and one capture buffer must be provided for use with this pixel format. The output buffer must contain the appropriate number of macroblocks to decode a full corresponding frame to the matching capture buffer.

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Table 104 – continued from previous page

Identifier	Code	Details
V4L2_PIX_FMT_MPEG4	'MPG4'	MPEG4 video elementary stream.
V4L2_PIX_FMT_XVID	'XVID'	Xvid video elementary stream.
V4L2_PIX_FMT_VC1_ANNEX_G	'VC1G'	VC1, SMPTE 421M Annex G compliant stream.
V4L2_PIX_FMT_VC1_ANNEX_L	'VC1L'	VC1, SMPTE 421M Annex L compliant stream.
V4L2_PIX_FMT_VP8	'VP80'	VP8 compressed video frame. The encoder generates one compressed frame per buffer, and the decoder requires one compressed frame per buffer.
V4L2_PIX_FMT_VP8_FRAME	'VP8F'	VP8 parsed frame, including the frame header, as extracted from the container. This format is adapted for stateless video decoders that implement an VP8 pipeline with the <i>Memory-to-memory Stateless Video Decoder Interface</i> . Metadata associated with the frame to decode is required to be passed through the V4L2_CID_STATELESS_VP8_FRAME control. See the <i>associated Codec Control IDs</i> . Exactly one output and one capture buffer must be provided for use with this pixel format. The output buffer must contain the appropriate number of macroblocks to decode a full corresponding frame to the matching capture buffer.
V4L2_PIX_FMT_VP9	'VP90'	VP9 compressed video frame. The encoder generates one compressed frame per buffer, and the decoder requires one compressed frame per buffer.
V4L2_PIX_FMT_VP9_FRAME	'VP9F'	VP9 parsed frame, including the frame header, as extracted from the container. This format is adapted for stateless video decoders that implement a VP9 pipeline with the <i>Memory-to-memory Stateless Video Decoder Interface</i> . Metadata associated with the frame to decode is required to be passed through the V4L2_CID_STATELESS_VP9_FRAME and the V4L2_CID_STATELESS_VP9_COMPRESSED_HDR controls. See the <i>associated Codec Control IDs</i> . Exactly one output and one capture buffer must be provided for use with this pixel format. The output buffer must contain the appropriate number of macroblocks to decode a full corresponding frame to the matching capture buffer.
V4L2_PIX_FMT_HEVC	'HEVC'	HEVC/H.265 Access Unit. The decoder expects one Access Unit per buffer. The encoder generates one Access Unit per buffer. If <i>ioctl VIDIOC_ENUM_FMT</i> reports V4L2_FLAG_CONTINUOUS_BYTESTREAM then the decoder has no requirements since it can parse all the information from the raw bytestream.

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Table 104 – continued from previous page

Identifier	Code	Details
V4L2_PIX_FMT_HEVC_SLICE	'S265'	HEVC parsed slice data, as extracted from the HEVC bitstream. This format is adapted for stateless video decoders that implement a HEVC pipeline (using the <a href="#">Video Memory-To-Memory Interface</a> and <a href="#">Request API</a> ). This pixelformat has two modifiers that must be set at least once through the V4L2_CID_MPEG_VIDEO_HEVC_DECODE_MODE and V4L2_CID_MPEG_VIDEO_HEVC_START_CODE controls. Metadata associated with the frame to decode is required to be passed through the following controls: V4L2_CID_MPEG_VIDEO_HEVC_SPS, V4L2_CID_MPEG_VIDEO_HEVC_PPS, and V4L2_CID_MPEG_VIDEO_HEVC_SLICE_PARAMS. See the <a href="#">associated Codec Control IDs</a> . Buffers associated with this pixel format must contain the appropriate number of macroblocks to decode a full corresponding frame.
V4L2_PIX_FMT_FWHT	'FWHT'	Video elementary stream using a codec based on the Fast Walsh Hadamard Transform. This codec is implemented by the vicodec ('Virtual Codec') driver. See the codec-fwht.h header for more details. <code>ioctl VIDIOC_ENUM_FMT</code> reports V4L2_FLAG_CONTINUOUS_BYTESTREAM since the decoder can parse all the information from the raw bytestream.
V4L2_PIX_FMT_FWHT_STATELESS	'SFWH'	Same format as V4L2_PIX_FMT_FWHT but requires stateless codec implementation. Metadata associated with the frame to decode is required to be passed through the V4L2_CID_STATELESS_FWHT_PARAMS control. See the <a href="#">associated Codec Control ID</a> .
V4L2_PIX_FMT_RV30	'RV30'	RealVideo, or also spelled as Real Video, is a suite of proprietary video compression formats developed by RealNetworks - the specific format changes with the version. RealVideo codecs are identified by four-character codes. RV30 corresponds to RealVideo 8, suspected to be based largely on an early draft of H.264
V4L2_PIX_FMT_RV40	'RV40'	RV40 represents RealVideo 9 and RealVideo 10. RealVideo 9, suspected to be based on H.264. RealVideo 10, aka RV9 EHQ, This refers to an improved encoder for the RV9 format that is fully backwards compatible with RV9 players - the format and decoder did not change, only the encoder did. As a result, it uses the same FourCC.
V4L2_PIX_FMT_AV1_FRAME	'AV1F'	AV1 parsed frame, including the frame header, as extracted from the container. This format is adapted for stateless video decoders that implement a AV1 pipeline with the <a href="#">Memory-to-memory Stateless Video Decoder Interface</a> . Metadata associated with the frame to decode is required to be passed through the V4L2_CID_STATELESS_AV1_SEQUENCE, V4L2_CID_STATELESS_AV1_FRAME, and V4L2_CID_STATELESS_AV1_TILE_GROUP_ENTRY controls. See the <a href="#">associated Codec Control IDs</a> . Exactly one output and one capture buffer must be provided for use with this pixel format. The output buffer must contain the appropriate number of macroblocks to decode a full corresponding frame to the matching capture buffer.

### SDR Formats

These formats are used for *SDR* interface only.

#### V4L2\_SDR\_FMT\_CU8 ('CU08')

Complex unsigned 8-bit IQ sample

##### Description

This format contains sequence of complex number samples. Each complex number consist two parts, called In-phase and Quadrature (IQ). Both I and Q are represented as a 8 bit unsigned number. I value comes first and Q value after that.

**Byte Order.** Each cell is one byte.

start + 0:	I'_0
start + 1:	Q'_0

#### V4L2\_SDR\_FMT\_CU16LE ('CU16')

Complex unsigned 16-bit little endian IQ sample

##### Description

This format contains sequence of complex number samples. Each complex number consist two parts, called In-phase and Quadrature (IQ). Both I and Q are represented as a 16 bit unsigned little endian number. I value comes first and Q value after that.

**Byte Order.** Each cell is one byte.

start + 0:	I'_0[7:0]	I'_0[15:8]
start + 2:	Q'_0[7:0]	Q'_0[15:8]

#### V4L2\_SDR\_FMT\_CS8 ('CS08')

Complex signed 8-bit IQ sample

## Description

This format contains sequence of complex number samples. Each complex number consist two parts, called In-phase and Quadrature (IQ). Both I and Q are represented as a 8 bit signed number. I value comes first and Q value after that.

**Byte Order.** Each cell is one byte.

start + 0:	I'_0
start + 1:	Q'_0

## V4L2\_SDR\_FMT\_CS14LE ('CS14')

Complex signed 14-bit little endian IQ sample

## Description

This format contains sequence of complex number samples. Each complex number consist two parts, called In-phase and Quadrature (IQ). Both I and Q are represented as a 14 bit signed little endian number. I value comes first and Q value after that. 14 bit value is stored in 16 bit space with unused high bits padded with 0.

**Byte Order.** Each cell is one byte.

start + 0:	I'_0[7:0]	I'_0[13:8]
start + 2:	Q'_0[7:0]	Q'_0[13:8]

## V4L2\_SDR\_FMT\_RU12LE ('RU12')

Real unsigned 12-bit little endian sample

## Description

This format contains sequence of real number samples. Each sample is represented as a 12 bit unsigned little endian number. Sample is stored in 16 bit space with unused high bits padded with 0.

**Byte Order.** Each cell is one byte.

start + 0:	I'_0[7:0]	I'_0[11:8]
------------	-----------	------------

## **V4L2\_SDR\_FMT\_PCU16BE ('PC16')**

Planar complex unsigned 16-bit big endian IQ sample

### Description

This format contains a sequence of complex number samples. Each complex number consist of two parts called In-phase and Quadrature (IQ). Both I and Q are represented as a 16 bit unsigned big endian number stored in 32 bit space. The remaining unused bits within the 32 bit space will be padded with 0. I value starts first and Q value starts at an offset equalling half of the buffer size (i.e.) offset = buffersize/2. Out of the 16 bits, bit 15:2 (14 bit) is data and bit 1:0 (2 bit) can be any value.

**Byte Order.** Each cell is one byte.

Offset:	Byte B0	Byte B1	Byte B2	Byte B3
start + 0:	I'0[13:6]	I'0[5:0]; B1[1:0]=pad	pad	pad
start + 4:	I'1[13:6]	I'1[5:0]; B1[1:0]=pad	pad	pad
...				
start + offset:	Q'0[13:6]	Q'0[5:0]; B1[1:0]=pad	pad	pad
start + offset + 4:	Q'1[13:6]	Q'1[5:0]; B1[1:0]=pad	pad	pad

## **V4L2\_SDR\_FMT\_PCU18BE ('PC18')**

Planar complex unsigned 18-bit big endian IQ sample

### Description

This format contains a sequence of complex number samples. Each complex number consist of two parts called In-phase and Quadrature (IQ). Both I and Q are represented as a 18 bit unsigned big endian number stored in 32 bit space. The remaining unused bits within the 32 bit space will be padded with 0. I value starts first and Q value starts at an offset equalling half of the buffer size (i.e.) offset = buffersize/2. Out of the 18 bits, bit 17:2 (16 bit) is data and bit 1:0 (2 bit) can be any value.

**Byte Order.** Each cell is one byte.

Offset:	Byte B0	Byte B1	Byte B2	Byte B3
start + 0:	I'0[17:10]	I'0[9:2]	I'0[1:0]; B2[5:0]=pad	pad
start + 4:	I'1[17:10]	I'1[9:2]	I'1[1:0]; B2[5:0]=pad	pad
...				
start + offset:	Q'0[17:10]	Q'0[9:2]	Q'0[1:0]; B2[5:0]=pad	pad
start + offset + 4:	Q'1[17:10]	Q'1[9:2]	Q'1[1:0]; B2[5:0]=pad	pad

## V4L2\_SDR\_FMT\_PCU20BE ('PC20')

Planar complex unsigned 20-bit big endian IQ sample

### Description

This format contains a sequence of complex number samples. Each complex number consist of two parts called In-phase and Quadrature (IQ). Both I and Q are represented as a 20 bit unsigned big endian number stored in 32 bit space. The remaining unused bits within the 32 bit space will be padded with 0. I value starts first and Q value starts at an offset equalling half of the buffer size (i.e.) offset = buffersize/2. Out of the 20 bits, bit 19:2 (18 bit) is data and bit 1:0 (2 bit) can be any value.

**Byte Order.** Each cell is one byte.

Offset:	Byte B0	Byte B1	Byte B2	Byte B3
start + 0:	I'0[19:12]	I'0[11:4]	I'0[3:0]; B2[3:0]=pad	pad
start + 4:	I'1[19:12]	I'1[11:4]	I'1[3:0]; B2[3:0]=pad	pad
...				
start + offset:	Q'0[19:12]	Q'0[11:4]	Q'0[3:0]; B2[3:0]=pad	pad
start + offset + 4:	Q'1[19:12]	Q'1[11:4]	Q'1[3:0]; B2[3:0]=pad	pad

### Touch Formats

These formats are used for *Touch Devices* interface only.

## V4L2\_TCH\_FMT\_DELTA\_TD16 ('TD16')

*man V4L2\_TCH\_FMT\_DELTA\_TD16(2)*

16-bit signed little endian Touch Delta

### Description

This format represents delta data from a touch controller.

Delta values may range from -32768 to 32767. Typically the values will vary through a small range depending on whether the sensor is touched or not. The full value may be seen if one of the touchscreen nodes has a fault or the line is not connected.

**Byte Order.** Each cell is one byte.

start + 0:	D'00low	D'00high	D'01low	D'01high	D'02low	D'02high	D'03low	D'03high
start + 8:	D'10low	D'10high	D'11low	D'11high	D'12low	D'12high	D'13low	D'13high
start + 16:	D'20low	D'20high	D'21low	D'21high	D'22low	D'22high	D'23low	D'23high
start + 24:	D'30low	D'30high	D'31low	D'31high	D'32low	D'32high	D'33low	D'33high

## V4L2\_TCH\_FMT\_DELTA\_TD08 ('TD08')

*man V4L2\_TCH\_FMT\_DELTA\_TD08(2)*

8-bit signed Touch Delta

### Description

This format represents delta data from a touch controller.

Delta values may range from -128 to 127. Typically the values will vary through a small range depending on whether the sensor is touched or not. The full value may be seen if one of the touchscreen nodes has a fault or the line is not connected.

**Byte Order.** Each cell is one byte.

start + 0:	D'00	D'01	D'02	D'03
start + 4:	D'10	D'11	D'12	D'13
start + 8:	D'20	D'21	D'22	D'23
start + 12:	D'30	D'31	D'32	D'33

## V4L2\_TCH\_FMT\_TU16 ('TU16')

*man V4L2\_TCH\_FMT\_TU16(2)*

16-bit unsigned little endian raw touch data

### Description

This format represents unsigned 16-bit data from a touch controller.

This may be used for output for raw and reference data. Values may range from 0 to 65535.

**Byte Order.** Each cell is one byte.

start + 0:	R'00low	R'00high	R'01low	R'01high	R'02low	R'02high	R'03low	R'03high
start + 8:	R'10low	R'10high	R'11low	R'11high	R'12low	R'12high	R'13low	R'13high
start + 16:	R'20low	R'20high	R'21low	R'21high	R'22low	R'22high	R'23low	R'23high
start + 24:	R'30low	R'30high	R'31low	R'31high	R'32low	R'32high	R'33low	R'33high

## V4L2\_TCH\_FMT\_TU08 ('TU08')

*man V4L2\_TCH\_FMT\_TU08(2)*

8-bit unsigned raw touch data

## Description

This format represents unsigned 8-bit data from a touch controller.

This may be used for output for raw and reference data. Values may range from 0 to 255.

**Byte Order.** Each cell is one byte.

start + 0:	R'00	R'01	R'02	R'03
start + 4:	R'10	R'11	R'12	R'13
start + 8:	R'20	R'21	R'22	R'23
start + 12:	R'30	R'31	R'32	R'33

## Metadata Formats

These formats are used for the *Metadata Interface* interface only.

### V4L2\_META\_FMT\_D4XX ('D4XX')

Intel D4xx UVC Cameras Metadata

## Description

Intel D4xx (D435, D455 and others) cameras include per-frame metadata in their UVC payload headers, following the Microsoft(R) UVC extension proposal [1]. That means, that the private D4XX metadata, following the standard UVC header, is organised in blocks. D4XX cameras implement several standard block types, proposed by Microsoft, and several proprietary ones. Supported standard metadata types are `MetadataId_CaptureStats` (ID 3), `MetadataId_CameraExtrinsics` (ID 4), and `MetadataId_CameraIntrinsics` (ID 5). For their description see [1]. This document describes proprietary metadata types, used by D4xx cameras.

`V4L2_META_FMT_D4XX` buffers follow the metadata buffer layout of `V4L2_META_FMT_UVC` with the only difference, that it also includes proprietary payload header data. D4xx cameras use bulk transfers and only send one payload per frame, therefore their headers cannot be larger than 255 bytes.

This document implements Intel Configuration version 3 [9].

Below are proprietary Microsoft style metadata types, used by D4xx cameras, where all fields are in little endian order:

Table 105: D4xx metadata

Field	Description
<i>Depth Control</i>	
<code>_u32 ID</code>	0x80000000
<code>_u32 Size</code>	Size in bytes, include ID (all protocol versions: 60)
<code>_u32 Version</code>	Version of this structure. The documentation herein covers versions 1, 2 and 3. The version number will be incremented when new fields are added.

continues on next page

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<b>Field</b>	<b>Description</b>
<code>_u32 Flags</code>	A bitmask of flags: see [2] below
<code>_u32 Gain</code>	Gain value in internal units, same as the V4L2_CID_GAIN control, used to capture the frame
<code>_u32 Exposure</code>	Exposure time (in microseconds) used to capture the frame
<code>_u32 Laser power</code>	Power of the laser LED 0-360, used for depth measurement
<code>_u32 AE mode</code>	0: manual; 1: automatic exposure
<code>_u32 Exposure priority</code>	Exposure priority value: 0 - constant frame rate
<code>_u32 AE ROI left</code>	Left border of the AE Region of Interest (all ROI values are in pixels and lie between 0 and maximum width or height respectively)
<code>_u32 AE ROI right</code>	Right border of the AE Region of Interest
<code>_u32 AE ROI top</code>	Top border of the AE Region of Interest
<code>_u32 AE ROI bottom</code>	Bottom border of the AE Region of Interest
<code>_u32 Preset</code>	Preset selector value, default: 0, unless changed by the user
<code>_u8 Emitter mode (v3 only) (_u32 Laser mode for v1) [8]</code>	0: off, 1: on, same as <code>_u32 Laser mode</code> for v1
<code>_u8 RFU byte (v3 only)</code>	Spare byte for future use
<code>_u16 LED Power (v3 only)</code>	Led power value 0-360 (F416 SKU)
<i>Capture Timing</i>	
<code>_u32 ID</code>	0x80000001
<code>_u32 Size</code>	Size in bytes, include ID (all protocol versions: 40)
<code>_u32 Version</code>	Version of this structure. The documentation herein corresponds to version xxx. The version number will be incremented when new fields are added.
<code>_u32 Flags</code>	A bitmask of flags: see [3] below
<code>_u32 Frame counter</code>	Monotonically increasing counter
<code>_u32 Optical time</code>	Time in microseconds from the beginning of a frame till its middle
<code>_u32 Readout time</code>	Time, used to read out a frame in microseconds
<code>_u32 Exposure time</code>	Frame exposure time in microseconds
<code>_u32 Frame interval</code>	In microseconds = 1000000 / framerate
<code>_u32 Pipe latency</code>	Time in microseconds from start of frame to data in USB buffer
<i>Configuration</i>	
<code>_u32 ID</code>	0x80000002
<code>_u32 Size</code>	Size in bytes, include ID (v1:36, v3:40)
<code>_u32 Version</code>	Version of this structure. The documentation herein corresponds to version xxx. The version number will be incremented when new fields are added.
<code>_u32 Flags</code>	A bitmask of flags: see [4] below
<code>_u8 Hardware type</code>	Camera hardware version [5]
<code>_u8 SKU ID</code>	Camera hardware configuration [6]
<code>_u32 Cookie</code>	Internal synchronisation
<code>_u16 Format</code>	Image format code [7]
<code>_u16 Width</code>	Width in pixels
<code>_u16 Height</code>	Height in pixels

continues on next page

Table 105 – continued from previous page

Field	Description
_u16 Framerate	Requested frame rate per second
_u16 Trigger	Byte 0: bit 0: depth and RGB are synchronised, bit 1: external trigger
_u16 Calibration count (v3 only)	Calibration counter, see [4] below
_u8 GPIO input data (v3 only)	GPIO readout, see [4] below (Supported from FW 5.12.7.0)
_u32 Sub-preset info (v3 only)	Sub-preset choice information, see [4] below
_u8 reserved (v3 only)	RFU byte.

[1] <https://docs.microsoft.com/en-us/windows-hardware/drivers/stream/uvc-extensions-1-5>

[2] Depth Control flags specify which fields are valid:

```
0x00000001 Gain
0x00000002 Exposure
0x00000004 Laser power
0x00000008 AE mode
0x00000010 Exposure priority
0x00000020 AE ROI
0x00000040 Preset
0x00000080 Emitter mode
0x00000100 LED Power
```

[3] Capture Timing flags specify which fields are valid:

```
0x00000001 Frame counter
0x00000002 Optical time
0x00000004 Readout time
0x00000008 Exposure time
0x00000010 Frame interval
0x00000020 Pipe latency
```

[4] Configuration flags specify which fields are valid:

```
0x00000001 Hardware type
0x00000002 SKU ID
0x00000004 Cookie
0x00000008 Format
0x00000010 Width
0x00000020 Height
0x00000040 Framerate
0x00000080 Trigger
0x00000100 Cal count
0x00000200 GPIO Input Data
0x00000400 Sub-preset Info
```

[5] Camera model:

```
0 DS5  
1 IVCAM2
```

[6] 8-bit camera hardware configuration bitfield:

```
[1:0] depthCamera  
 00: no depth  
 01: standard depth  
 10: wide depth  
 11: reserved  
[2] depthIsActive - has a laser projector  
[3] RGB presence  
[4] Inertial Measurement Unit (IMU) presence  
[5] projectorType  
 0: HPTG  
 1: Princeton  
[6] 0: a projector, 1: an LED  
[7] reserved
```

[7] Image format codes per video streaming interface:

Depth:

```
1 Z16  
2 Z
```

Left sensor:

```
1 Y8  
2 UYVY  
3 R8L8  
4 Calibration  
5 W10
```

Fish Eye sensor:

```
1 RAW8
```

[8] The "Laser mode" has been replaced in version 3 by three different fields. "Laser" has been renamed to "Emitter" as there are multiple technologies for camera projectors. As we have another field for "Laser Power" we introduced "LED Power" for extra emitter.

**The "Laser mode" `_u32` fields has been split into: ::**

1 `_u8` Emitter mode 2 `_u8` RFU byte 3 `_u16` LED Power

This is a change between versions 1 and 3. All versions 1, 2 and 3 are backward compatible with the same data format and they are supported. See [2] for which attributes are valid.

[9] LibRealSense SDK metadata source: <https://github.com/IntelRealSense/librealsense/blob/master/src/metadata.h>

**V4L2\_META\_FMT\_IPU3\_PARAMS ('ip3p'), V4L2\_META\_FMT\_IPU3\_3A ('ip3s')****3A statistics**

The IPU3 ImgU 3A statistics accelerators collect different statistics over an input Bayer frame. Those statistics are obtained from the "ipu3-imgu [01] 3a stat" metadata capture video nodes, using the `v4l2_meta_format` interface. They are formatted as described by the `ipu3_uapi_stats_3a` structure.

The statistics collected are AWB (Auto-white balance) RGBS (Red, Green, Blue and Saturation measure) cells, AWB filter response, AF (Auto-focus) filter response, and AE (Auto-exposure) histogram.

The struct `ipu3_uapi_4a_config` saves all configurable parameters.

```
struct ipu3_uapi_stats_3a {
    struct ipu3_uapi_awb_raw_buffer awb_raw_buffer;
    struct ipu3_uapi_ae_raw_buffer_aligned ae_raw_buffer[IPU3_UAPI_MAX_
→STRIPES];
    struct ipu3_uapi_af_raw_buffer af_raw_buffer;
    struct ipu3_uapi_awb_fr_raw_buffer awb_fr_raw_buffer;
    struct ipu3_uapi_4a_config stats_4a_config;
    __u32 ae_join_buffers;
    __u8 padding[28];
    struct ipu3_uapi_stats_3a_bubble_info_per_stripe stats_3a_bubble_per_
→stripe;
    struct ipu3_uapi_ff_status stats_3a_status;
};
```

**Pipeline parameters**

The pipeline parameters are passed to the "ipu3-imgu [01] parameters" metadata output video nodes, using the `v4l2_meta_format` interface. They are formatted as described by the `ipu3_uapi_params` structure.

Both 3A statistics and pipeline parameters described here are closely tied to the underlying camera sub-system (CSS) APIs. They are usually consumed and produced by dedicated user space libraries that comprise the important tuning tools, thus freeing the developers from being bothered with the low level hardware and algorithm details.

```
struct ipu3_uapi_params {
    /* Flags which of the settings below are to be applied */
    struct ipu3_uapi_flags use;

    /* Accelerator cluster parameters */
    struct ipu3_uapi_acc_param acc_param;

    /* ISP vector address space parameters */
    struct ipu3_uapi_isp_lin_vmem_params lin_vmem_params;
    struct ipu3_uapi_isp_tnr3_vmem_params tnr3_vmem_params;
    struct ipu3_uapi_isp_xnr3_vmem_params xnr3_vmem_params;
```

```

/* ISP data memory (DMEM) parameters */
struct ipu3_uapi_isp_tnr3_params tnr3_dmem_params;
struct ipu3_uapi_isp_xnr3_params xnr3_dmem_params;

/* Optical black level compensation */
struct ipu3_uapi_obgrid_param obgrid_param;
};

```

## Intel IPU3 ImgU uAPI data types

### **struct ipu3\_uapi\_grid\_config**

Grid plane config

#### **Definition:**

```

struct ipu3_uapi_grid_config {
    __u8 width;
    __u8 height;
    __u16 block_width_log2:3;
    __u16 block_height_log2:3;
    __u16 height_per_slice:8;
    __u16 x_start;
    __u16 y_start;
    __u16 x_end;
    __u16 y_end;
};

```

#### **Members**

##### **width**

Grid horizontal dimensions, in number of grid blocks(cells). For AWB, the range is (16, 80). For AF/AE, the range is (16, 32).

##### **height**

Grid vertical dimensions, in number of grid cells. For AWB, the range is (16, 60). For AF/AE, the range is (16, 24).

##### **block\_width\_log2**

Log2 of the width of each cell in pixels. For AWB, the range is [3, 6]. For AF/AE, the range is [3, 7].

##### **block\_height\_log2**

Log2 of the height of each cell in pixels. For AWB, the range is [3, 6]. For AF/AE, the range is [3, 7].

##### **height\_per\_slice**

The number of blocks in vertical axis per slice. Default 2.

##### **x\_start**

X value of top left corner of Region of Interest(ROI).

**y\_start**

Y value of top left corner of ROI

**x\_end**

X value of bottom right corner of ROI

**y\_end**

Y value of bottom right corner of ROI

**Description**

Due to the size of total amount of collected data, most statistics create a grid-based output, and the data is then divided into "slices".

**struct ipu3\_uapi\_awb\_set\_item**

Memory layout for each cell in AWB

**Definition:**

```
struct ipu3_uapi_awb_set_item {
    __u8 Gr_avg;
    __u8 R_avg;
    __u8 B_avg;
    __u8 Gb_avg;
    __u8 sat_ratio;
    __u8 padding0;
    __u8 padding1;
    __u8 padding2;
};
```

**Members****Gr\_avg**

Green average for red lines in the cell.

**R\_avg**

Red average in the cell.

**B\_avg**

Blue average in the cell.

**Gb\_avg**

Green average for blue lines in the cell.

**sat\_ratio**

Percentage of pixels over the thresholds specified in ipu3\_uapi\_awb\_config\_s, coded from 0 to 255.

**padding0**

Unused byte for padding.

**padding1**

Unused byte for padding.

**padding2**

Unused byte for padding.

**struct ipu3\_uapi\_awb\_raw\_buffer**

AWB raw buffer

### Definition:

```
struct ipu3_uapi_awb_raw_buffer {
    struct ipu3_uapi_awb_set_item meta_data[IPU3_UAPI_AWB_MAX_BUFFER_SIZE] ;
};
```

### Members

#### meta\_data

buffer to hold auto white balance meta data which is the average values for each color channel.

#### struct ipu3\_uapi\_awb\_config\_s

AWB config

### Definition:

```
struct ipu3_uapi_awb_config_s {
    __u16 rgbs_thr_gr;
    __u16 rgbs_thr_r;
    __u16 rgbs_thr_gb;
    __u16 rgbs_thr_b;
    struct ipu3_uapi_grid_config grid;
};
```

### Members

#### rgbs\_thr\_gr

gr threshold value.

#### rgbs\_thr\_r

Red threshold value.

#### rgbs\_thr\_gb

gb threshold value.

#### rgbs\_thr\_b

Blue threshold value.

#### grid

*ipu3\_uapi\_grid\_config*, the default grid resolution is 16x16 cells.

### Description

The threshold is a saturation measure range [0, 8191], 8191 is default. Values over threshold may be optionally rejected for averaging.

#### struct ipu3\_uapi\_awb\_config

AWB config wrapper

### Definition:

```
struct ipu3_uapi_awb_config {
    struct ipu3_uapi_awb_config_s config ;
};
```

### Members

**config**

config for auto white balance as defined by *ipu3\_uapi\_awb\_config\_s*

**struct ipu3\_uapi\_ae\_raw\_buffer**

AE global weighted histogram

**Definition:**

```
struct ipu3_uapi_ae_raw_buffer {
    __u32 vals[IPU3_UAPI_AE_BINS * IPU3_UAPI_AE_COLORS];
};
```

**Members****vals**

Sum of IPU3\_UAPI\_AE\_COLORS in cell

**Description**

Each histogram contains IPU3\_UAPI\_AE\_BINS bins. Each bin has 24 bit unsigned for counting the number of the pixel.

**struct ipu3\_uapi\_ae\_raw\_buffer\_aligned**

AE raw buffer

**Definition:**

```
struct ipu3_uapi_ae_raw_buffer_aligned {
    struct ipu3_uapi_ae_raw_buffer buff ;
};
```

**Members****buff**

*ipu3\_uapi\_ae\_raw\_buffer* to hold full frame meta data.

**struct ipu3\_uapi\_ae\_grid\_config**

AE weight grid

**Definition:**

```
struct ipu3_uapi_ae_grid_config {
    __u8 width;
    __u8 height;
    __u8 block_width_log2:4;
    __u8 block_height_log2:4;
    __u8 reserved0:5;
    __u8 ae_en:1;
    __u8 rst_hist_array:1;
    __u8 done_rst_hist_array:1;
    __u16 x_start;
    __u16 y_start;
    __u16 x_end;
    __u16 y_end;
};
```

**Members****width**

Grid horizontal dimensions. Value: [16, 32], default 16.

**height**

Grid vertical dimensions. Value: [16, 24], default 16.

**block\_width\_log2**

Log2 of the width of the grid cell, value: [3, 7].

**block\_height\_log2**

Log2 of the height of the grid cell, value: [3, 7]. default is 3 (cell size 8x8), 4 cell per grid.

**reserved0**

reserved

**ae\_en**

0: does not write to *ipu3\_uapi\_ae\_raw\_buffer\_aligned* array, 1: write normally.

**rst\_hist\_array**

write 1 to trigger histogram array reset.

**done\_rst\_hist\_array**

flag for histogram array reset done.

**x\_start**

X value of top left corner of ROI, default 0.

**y\_start**

Y value of top left corner of ROI, default 0.

**x\_end**

X value of bottom right corner of ROI

**y\_end**

Y value of bottom right corner of ROI

**Description**

The AE block accumulates 4 global weighted histograms(R, G, B, Y) over a defined ROI within the frame. The contribution of each pixel into the histogram, defined by *ipu3\_uapi\_ae\_weight\_elem* LUT, is indexed by a grid.

**struct ipu3\_uapi\_ae\_weight\_elem**

AE weights LUT

**Definition:**

```
struct ipu3_uapi_ae_weight_elem {
    __u32 cell0:4;
    __u32 cell1:4;
    __u32 cell2:4;
    __u32 cell3:4;
    __u32 cell4:4;
    __u32 cell5:4;
    __u32 cell6:4;
    __u32 cell7:4;
};
```

## Members

**cell0**

weighted histogram grid value.

**cell1**

weighted histogram grid value.

**cell2**

weighted histogram grid value.

**cell3**

weighted histogram grid value.

**cell4**

weighted histogram grid value.

**cell5**

weighted histogram grid value.

**cell6**

weighted histogram grid value.

**cell7**

weighted histogram grid value.

## Description

Use weighted grid value to give a different contribution factor to each cell. Precision u4, range [0, 15].

**struct ipu3\_uapi\_ae\_ccm**

AE coefficients for WB and CCM

**Definition:**

```
struct ipu3_uapi_ae_ccm {
    __u16 gain_gr;
    __u16 gain_r;
    __u16 gain_b;
    __u16 gain_gb;
    __s16 mat[16];
};
```

## Members

**gain\_gr**

WB gain factor for the gr channels. Default 256.

**gain\_r**

WB gain factor for the r channel. Default 256.

**gain\_b**

WB gain factor for the b channel. Default 256.

**gain\_gb**

WB gain factor for the gb channels. Default 256.

**mat**

4x4 matrix that transforms Bayer quad output from WB to RGB+Y.

## Description

### Default:

```
128, 0, 0, 0, 0, 128, 0, 0, 0, 0, 128, 0, 0, 0, 0, 128,
```

As part of the raw frame pre-process stage, the WB and color conversion need to be applied to expose the impact of these gain operations.

### struct ipu3\_uapi\_ae\_config

AE config

### Definition:

```
struct ipu3_uapi_ae_config {
    struct ipu3_uapi_ae_grid_config grid_cfg ;
    struct ipu3_uapi_ae_weight_elem weights[IPU3_UAPI_AE_WEIGHTS] ;
    struct ipu3_uapi_ae_ccm ae_ccm ;
};
```

## Members

### grid\_cfg

config for auto exposure statistics grid. See struct [ipu3\\_uapi\\_ae\\_grid\\_config](#), as Imgu did not support output auto exposure statistics, so user can ignore this configuration and use the RGB table in auto-whitebalance statistics instead.

### weights

IPU3\_UAPI\_AE\_WEIGHTS is based on 32x24 blocks in the grid. Each grid cell has a corresponding value in weights LUT called grid value, global histogram is updated based on grid value and pixel value.

### ae\_ccm

Color convert matrix pre-processing block.

## Description

Calculate AE grid from image resolution, resample ae weights.

### struct ipu3\_uapi\_af\_filter\_config

AF 2D filter for contrast measurements

### Definition:

```
struct ipu3_uapi_af_filter_config {
    struct {
        __u8 a1;
        __u8 a2;
        __u8 a3;
        __u8 a4;
    } y1_coeff_0;
    struct {
        __u8 a5;
        __u8 a6;
        __u8 a7;
        __u8 a8;
    } y1_coeff_1;
    struct {
```

```

    __u8 a9;
    __u8 a10;
    __u8 a11;
    __u8 a12;
} y1_coeff_2;
__u32 y1_sign_vec;
struct {
    __u8 a1;
    __u8 a2;
    __u8 a3;
    __u8 a4;
} y2_coeff_0;
struct {
    __u8 a5;
    __u8 a6;
    __u8 a7;
    __u8 a8;
} y2_coeff_1;
struct {
    __u8 a9;
    __u8 a10;
    __u8 a11;
    __u8 a12;
} y2_coeff_2;
__u32 y2_sign_vec;
struct {
    __u8 y_gen_rate_gr;
    __u8 y_gen_rate_r;
    __u8 y_gen_rate_b;
    __u8 y_gen_rate_gb;
} y_calc;
struct {
    __u32 reserved0:8;
    __u32 y1_nf:4;
    __u32 reserved1:4;
    __u32 y2_nf:4;
    __u32 reserved2:12;
} nf;
};


```

## Members

### **y1\_coeff\_0**

filter Y1, structure: 3x11, support both symmetry and anti-symmetry type. A12 is center, A1-A11 are neighbours. for analyzing low frequency content, used to calculate sum of gradients in x direction.

### **y1\_coeff\_0.a1**

filter1 coefficients A1, u8, default 0.

### **y1\_coeff\_0.a2**

filter1 coefficients A2, u8, default 0.

**y1\_coeff\_0.a3**

filter1 coefficients A3, u8, default 0.

**y1\_coeff\_0.a4**

filter1 coefficients A4, u8, default 0.

**y1\_coeff\_1**

Struct

**y1\_coeff\_1.a5**

filter1 coefficients A5, u8, default 0.

**y1\_coeff\_1.a6**

filter1 coefficients A6, u8, default 0.

**y1\_coeff\_1.a7**

filter1 coefficients A7, u8, default 0.

**y1\_coeff\_1.a8**

filter1 coefficients A8, u8, default 0.

**y1\_coeff\_2**

Struct

**y1\_coeff\_2.a9**

filter1 coefficients A9, u8, default 0.

**y1\_coeff\_2.a10**

filter1 coefficients A10, u8, default 0.

**y1\_coeff\_2.a11**

filter1 coefficients A11, u8, default 0.

**y1\_coeff\_2.a12**

filter1 coefficients A12, u8, default 128.

**y1\_sign\_vec**

Each bit corresponds to one coefficient sign bit, 0: positive, 1: negative, default 0.

**y2\_coeff\_0**

Y2, same structure as Y1. For analyzing high frequency content.

**y2\_coeff\_0.a1**

filter2 coefficients A1, u8, default 0.

**y2\_coeff\_0.a2**

filter2 coefficients A2, u8, default 0.

**y2\_coeff\_0.a3**

filter2 coefficients A3, u8, default 0.

**y2\_coeff\_0.a4**

filter2 coefficients A4, u8, default 0.

**y2\_coeff\_1**

Struct

**y2\_coeff\_1.a5**

filter2 coefficients A5, u8, default 0.

**y2\_coeff\_1.a6**  
filter2 coefficients A6, u8, default 0.

**y2\_coeff\_1.a7**  
filter2 coefficients A7, u8, default 0.

**y2\_coeff\_1.a8**  
filter2 coefficients A8, u8, default 0.

**y2\_coeff\_2**  
Struct

**y2\_coeff\_2.a9**  
filter1 coefficients A9, u8, default 0.

**y2\_coeff\_2.a10**  
filter1 coefficients A10, u8, default 0.

**y2\_coeff\_2.a11**  
filter1 coefficients A11, u8, default 0.

**y2\_coeff\_2.a12**  
filter1 coefficients A12, u8, default 128.

**y\_sign\_vec**  
Each bit corresponds to one coefficient sign bit, 0: positive, 1: negative, default 0.

**y\_calc**  
Pre-processing that converts Bayer quad to RGB+Y values to be used for building histogram. Range [0, 32], default 8. Rule:  $y\_gen\_rate\_gr + y\_gen\_rate\_r + y\_gen\_rate\_b + y\_gen\_rate\_gb = 32$  A single Y is calculated based on sum of Gr/R/B/Gb based on their contribution ratio.

**y\_calc.y\_gen\_rate\_gr**  
Contribution ratio Gr for Y

**y\_calc.y\_gen\_rate\_r**  
Contribution ratio R for Y

**y\_calc.y\_gen\_rate\_b**  
Contribution ratio B for Y

**y\_calc.y\_gen\_rate\_gb**  
Contribution ratio Gb for Y

**nf**  
The shift right value that should be applied during the Y1/Y2 filter to make sure the total memory needed is 2 bytes per grid cell.

**nf.reserved0**  
reserved

**nf.y1\_nf**  
Normalization factor for the convolution coeffs of y1, should be log2 of the sum of the abs values of the filter coeffs, default 7 ( $2^7 = 128$ ).

**nf.reserved1**  
reserved

### **nf.y2\_nf**

Normalization factor for y2, should be log2 of the sum of the abs values of the filter coeffs.

### **nf.reserved2**

reserved

### **struct ipu3\_uapi\_af\_raw\_buffer**

AF meta data

#### **Definition:**

```
struct ipu3_uapi_af_raw_buffer {  
    __u8 y_table[IPU3_UAPI_AF_Y_TABLE_MAX_SIZE] ;  
};
```

### **Members**

#### **y\_table**

Each color component will be convolved separately with filter1 and filter2 and the result will be summed out and averaged for each cell.

### **struct ipu3\_uapi\_af\_config\_s**

AF config

#### **Definition:**

```
struct ipu3_uapi_af_config_s {  
    struct ipu3_uapi_af_filter_config filter_config ;  
    __u8 padding[4];  
    struct ipu3_uapi_grid_config grid_cfg ;  
};
```

### **Members**

#### **filter\_config**

AF uses Y1 and Y2 filters as configured in *ipu3\_uapi\_af\_filter\_config*

#### **padding**

paddings

#### **grid\_cfg**

See *ipu3\_uapi\_grid\_config*, default resolution 16x16. Use large grid size for large image and vice versa.

### **struct ipu3\_uapi\_awb\_fr\_raw\_buffer**

AWB filter response meta data

#### **Definition:**

```
struct ipu3_uapi_awb_fr_raw_buffer {  
    __u8 meta_data[IPU3_UAPI_AWB_FR_BAYER_TABLE_MAX_SIZE] ;  
};
```

### **Members**

#### **meta\_data**

Statistics output on the grid after convolving with 1D filter.

**struct ipu3\_uapi\_awb\_fr\_config\_s**

AWB filter response config

**Definition:**

```
struct ipu3_uapi_awb_fr_config_s {
    struct ipu3_uapi_grid_config grid_cfg;
    __u8 bayer_coeff[6];
    __u16 reserved1;
    __u32 bayer_sign;
    __u8 bayer_nf;
    __u8 reserved2[7];
};
```

**Members**

**grid\_cfg**

grid config, default 16x16.

**bayer\_coeff**

1D Filter 1x11 center symmetry/anti-symmetry. coefficients defaults { 0, 0, 0, 0, 0, 128 }. Applied on whole image for each Bayer channel separately by a weighted sum of its 11x1 neighbors.

**reserved1**

reserved

**bayer\_sign**

sign of filter coefficients, default 0.

**bayer\_nf**

normalization factor for the convolution coeffs, to make sure total memory needed is within pre-determined range. NF should be the log2 of the sum of the abs values of the filter coeffs, range [7, 14], default 7.

**reserved2**

reserved

**struct ipu3\_uapi\_4a\_config**

4A config

**Definition:**

```
struct ipu3_uapi_4a_config {
    struct ipu3_uapi_awb_config_s awb_config ;
    struct ipu3_uapi_ae_grid_config ae_grd_config;
    __u8 padding[20];
    struct ipu3_uapi_af_config_s af_config;
    struct ipu3_uapi_awb_fr_config_s awb_fr_config ;
};
```

**Members**

**awb\_config**

*ipu3\_uapi\_awb\_config\_s*, default resolution 16x16

**ae\_grd\_config**  
auto exposure statistics *ipu3\_uapi\_ae\_grid\_config*

**padding**  
paddings

**af\_config**  
auto focus config *ipu3\_uapi\_af\_config\_s*

**awb\_fr\_config**  
*ipu3\_uapi\_awb\_fr\_config\_s*, default resolution 16x16

struct **ipu3\_uapi\_bubble\_info**  
Bubble info for host side debugging

### Definition:

```
struct ipu3_uapi_bubble_info {  
    __u32 num_of_stripes ;  
    __u8 padding[28];  
    __u32 num_sets;  
    __u8 padding1[28];  
    __u32 size_of_set;  
    __u8 padding2[28];  
    __u32 bubble_size;  
    __u8 padding3[28];  
};
```

### Members

#### **num\_of\_stripes**

A single frame is divided into several parts called stripes due to limitation on line buffer memory. The separation between the stripes is vertical. Each such stripe is processed as a single frame by the ISP pipe.

#### **padding**

padding bytes.

#### **num\_sets**

number of sets.

#### **padding1**

padding bytes.

#### **size\_of\_set**

set size.

#### **padding2**

padding bytes.

#### **bubble\_size**

is the amount of padding in the bubble expressed in "sets".

#### **padding3**

padding bytes.

#### struct **ipu3\_uapi\_ff\_status**

Enable bits for each 3A fixed function

**Definition:**

```
struct ipu3_uapi_ff_status {
    __u32 awb_en ;
    __u8 padding[28];
    __u32 ae_en;
    __u8 padding1[28];
    __u32 af_en;
    __u8 padding2[28];
    __u32 awb_fr_en;
    __u8 padding3[28];
};
```

**Members****awb\_en**

auto white balance enable

**padding**

padding config

**ae\_en**

auto exposure enable

**padding1**

padding config

**af\_en**

auto focus enable

**padding2**

padding config

**awb\_fr\_en**

awb filter response enable bit

**padding3**

padding config

**struct ipu3\_uapi\_stats\_3a**

3A statistics

**Definition:**

```
struct ipu3_uapi_stats_3a {
    struct ipu3_uapi_awb_raw_buffer awb_raw_buffer;
    struct ipu3_uapi_ae_raw_buffer_aligned ae_raw_buffer[IPU3_UAPI_MAX_
→STRIPES];
    struct ipu3_uapi_af_raw_buffer af_raw_buffer;
    struct ipu3_uapi_awb_fr_raw_buffer awb_fr_raw_buffer;
    struct ipu3_uapi_4a_config stats_4a_config;
    __u32 ae_join_buffers;
    __u8 padding[28];
    struct ipu3_uapi_stats_3a_bubble_info_per_stripe stats_3a_bubble_per_
→stripe;
    struct ipu3_uapi_ff_status stats_3a_status;
```

```
};
```

## Members

### **awb\_raw\_buffer**

auto white balance meta data [\*ipu3\\_uapi\\_awb\\_raw\\_buffer\*](#)

### **ae\_raw\_buffer**

auto exposure raw data [\*ipu3\\_uapi\\_ae\\_raw\\_buffer\\_aligned\*](#) current Imgu does not output the auto exposure statistics to ae\_raw\_buffer, the user such as 3A algorithm can use the RGB table in [\*ipu3\\_uapi\\_awb\\_raw\\_buffer\*](#) to do auto-exposure.

### **af\_raw\_buffer**

[\*ipu3\\_uapi\\_af\\_raw\\_buffer\*](#) for auto focus meta data

### **awb\_fr\_raw\_buffer**

value as specified by [\*ipu3\\_uapi\\_awb\\_fr\\_raw\\_buffer\*](#)

### **stats\_4a\_config**

4a statistics config as defined by [\*ipu3\\_uapi\\_4a\\_config\*](#).

### **ae\_join\_buffers**

1 to use ae\_raw\_buffer.

### **padding**

padding config

### **stats\_3a\_bubble\_per\_stripe**

a [\*ipu3\\_uapi\\_stats\\_3a\\_bubble\\_info\\_per\\_stripe\*](#)

### **stats\_3a\_status**

3a statistics status set in [\*ipu3\\_uapi\\_ff\\_status\*](#)

### **struct ipu3\_uapi\_bnr\_static\_config\_wb\_gains\_config**

White balance gains

## Definition:

```
struct ipu3_uapi_bnr_static_config_wb_gains_config {
    __u16 gr;
    __u16 r;
    __u16 b;
    __u16 gb;
};
```

## Members

### **gr**

white balance gain for Gr channel.

### **r**

white balance gain for R channel.

### **b**

white balance gain for B channel.

### **gb**

white balance gain for Gb channel.

## Description

For BNR parameters WB gain factor for the three channels [Ggr, Ggb, Gb, Gr]. Their precision is U3.13 and the range is (0, 8) and the actual gain is  $Gx + 1$ , it is typically  $Gx = 1$ .

$P_{out} = \{Pin * (1 + Gx)\}$ .

**struct ipu3\_uapi\_bnr\_static\_config\_wb\_gains\_thr\_config**  
Threshold config

### Definition:

```
struct ipu3_uapi_bnr_static_config_wb_gains_thr_config {
    __u8 gr;
    __u8 r;
    __u8 b;
    __u8 gb;
};
```

## Members

**gr**  
white balance threshold gain for Gr channel.

**r**  
white balance threshold gain for R channel.

**b**  
white balance threshold gain for B channel.

**gb**  
white balance threshold gain for Gb channel.

## Description

Defines the threshold that specifies how different a defect pixel can be from its neighbors.(used by dynamic defect pixel correction sub block) Precision u4.4 range [0, 8].

**struct ipu3\_uapi\_bnr\_static\_config\_thr\_coeffs\_config**

Noise model coefficients that controls noise threshold

### Definition:

```
struct ipu3_uapi_bnr_static_config_thr_coeffs_config {
    __u32 cf:13;
    __u32 reserved0:3;
    __u32 cg:5;
    __u32 ci:5;
    __u32 reserved1:1;
    __u32 r_nf:5;
};
```

## Members

**cf**  
Free coefficient for threshold calculation, range [0, 8191], default 0.

**reserved0**

reserved

**cg**

Gain coefficient for threshold calculation, [0, 31], default 8.

**ci**

Intensity coefficient for threshold calculation. range [0, 0x1f] default 6. format: u3.2 (3 most significant bits represent whole number, 2 least significant bits represent the fractional part with each count representing 0.25) e.g. 6 in binary format is 00110, that translates to 1.5

**reserved1**

reserved

**r\_nf**

Normalization shift value for  $r^2$  calculation, range [12, 20] where r is a radius of pixel [row, col] from center of sensor. default 14.

**Description**

Threshold used to distinguish between noise and details.

**struct ipu3\_uapi\_bnr\_static\_config\_thr\_ctrl\_shd\_config**

Shading config

**Definition:**

```
struct ipu3_uapi_bnr_static_config_thr_ctrl_shd_config {  
    __u8 gr;  
    __u8 r;  
    __u8 b;  
    __u8 gb;  
};
```

**Members****gr**

Coefficient defines lens shading gain approximation for gr channel

**r**

Coefficient defines lens shading gain approximation for r channel

**b**

Coefficient defines lens shading gain approximation for b channel

**gb**

Coefficient defines lens shading gain approximation for gb channel

**Description**

Parameters for noise model (NM) adaptation of BNR due to shading correction. All above have precision of u3.3, default to 0.

**struct ipu3\_uapi\_bnr\_static\_config\_opt\_center\_config**

Optical center config

**Definition:**

```
struct ipu3_uapi_bnr_static_config_opt_center_config {
    __s32 x_reset:13;
    __u32 reserved0:3;
    __s32 y_reset:13;
    __u32 reserved2:3;
};
```

**Members****x\_reset**

Reset value of X (col start - X center). Precision s12.0.

**reserved0**

reserved

**y\_reset**

Reset value of Y (row start - Y center). Precision s12.0.

**reserved2**

reserved

**Description**

Distance from corner to optical center for NM adaptation due to shading correction (should be calculated based on shading tables)

**struct ipu3\_uapi\_bnr\_static\_config\_lut\_config**

BNR square root lookup table

**Definition:**

```
struct ipu3_uapi_bnr_static_config_lut_config {
    __u8 values[IPU3_UAPI_BNR_LUT_SIZE];
};
```

**Members****values**

pre-calculated values of square root function.

**Description**

LUT implementation of square root operation.

**struct ipu3\_uapi\_bnr\_static\_config\_bp\_ctrl\_config**

Detect bad pixels (bp)

**Definition:**

```
struct ipu3_uapi_bnr_static_config_bp_ctrl_config {
    __u32 bp_thr_gain:5;
    __u32 reserved0:2;
    __u32 defect_mode:1;
    __u32 bp_gain:6;
    __u32 reserved1:18;
    __u32 w0_coeff:4;
    __u32 reserved2:4;
```

```

    __u32 w1_coeff:4;
    __u32 reserved3:20;
};

```

**Members****bp\_thr\_gain**

Defines the threshold that specifies how different a defect pixel can be from its neighbors. Threshold is dependent on de-noise threshold calculated by algorithm. Range [4, 31], default 4.

**reserved0**

reserved

**defect\_mode**

Mode of addressed defect pixels, 0 - single defect pixel is expected, 1 - 2 adjacent defect pixels are expected, default 1.

**bp\_gain**

Defines how 2nd derivation that passes through a defect pixel is different from 2nd derivations that pass through neighbor pixels. u4.2, range [0, 256], default 8.

**reserved1**

reserved

**w0\_coeff**

Blending coefficient of defect pixel correction. Precision u4, range [0, 8], default 8.

**reserved2**

reserved

**w1\_coeff**

Enable influence of incorrect defect pixel correction to be avoided. Precision u4, range [1, 8], default 8.

**reserved3**

reserved

**struct ipu3\_uapi\_bnr\_static\_config\_dn\_detect\_ctrl\_config**

Denoising config

**Definition:**

```

struct ipu3_uapi_bnr_static_config_dn_detect_ctrl_config {
    __u32 alpha:4;
    __u32 beta:4;
    __u32 gamma:4;
    __u32 reserved0:4;
    __u32 max_inf:4;
    __u32 reserved1:7;
    __u32 gd_enable:1;
    __u32 bpc_enable:1;
    __u32 bnr_enable:1;
    __u32 ff_enable:1;
    __u32 reserved2:1;
};

```

**Members****alpha**

Weight of central element of smoothing filter.

**beta**

Weight of peripheral elements of smoothing filter, default 4.

**gamma**

Weight of diagonal elements of smoothing filter, default 4.

**reserved0**

reserved

**max\_inf**

Maximum increase of peripheral or diagonal element influence relative to the pre-defined value range: [0x5, 0xa]

**reserved1**

reserved

**gd\_enable**

Green disparity enable control, 0 - disable, 1 - enable.

**bpc\_enable**

Bad pixel correction enable control, 0 - disable, 1 - enable.

**bnr\_enable**

Bayer noise removal enable control, 0 - disable, 1 - enable.

**ff\_enable**

Fixed function enable, 0 - disable, 1 - enable.

**reserved2**

reserved

**Description****beta and gamma parameter define the strength of the noise removal filter.**

All above has precision u0.4, range [0, 0xf] format: u0.4 (no / zero bits represent whole number, 4 bits represent the fractional part with each count representing 0.0625) e.g. 0xf translates to  $0.0625 \times 15 = 0.9375$

**struct ipu3\_uapi\_bnr\_static\_config\_opt\_center\_sqr\_config**

BNR optical square

**Definition:**

```
struct ipu3_uapi_bnr_static_config_opt_center_sqr_config {
    __u32 x_sqr_reset;
    __u32 y_sqr_reset;
};
```

**Members****x\_sqr\_reset**

Reset value of  $X^2$ .

**y\_sqr\_reset**

Reset value of  $Y^2$ .

## Description

Please note:

1. X and Y ref to `ipu3_uapi_bnr_static_config_opt_center_config`
2. Both structs are used in threshold formula to calculate  $r^2$ , where r is a radius of pixel [row, col] from center of sensor.

```
struct ipu3_uapi_bnr_static_config
    BNR static config
```

## Definition:

```
struct ipu3_uapi_bnr_static_config {
    struct ipu3_uapi_bnr_static_config_wb_gains_config wb_gains;
    struct ipu3_uapi_bnr_static_config_wb_gains_thr_config wb_gains_thr;
    struct ipu3_uapi_bnr_static_config_thr_coeffs_config thr_coeffs;
    struct ipu3_uapi_bnr_static_config_thr_ctrl_shd_config thr_ctrl_shd;
    struct ipu3_uapi_bnr_static_config_opt_center_config opt_center;
    struct ipu3_uapi_bnr_static_config_lut_config lut;
    struct ipu3_uapi_bnr_static_config_bp_ctrl_config bp_ctrl;
    struct ipu3_uapi_bnr_static_config_dn_detect_ctrl_config dn_detect_ctrl;
    __u32 column_size;
    struct ipu3_uapi_bnr_static_config_opt_center_sqr_config opt_center_sqr;
};
```

## Members

### **wb\_gains**

white balance gains `ipu3_uapi_bnr_static_config_wb_gains_config`

### **wb\_gains\_thr**

white balance gains threshold as defined by `ipu3_uapi_bnr_static_config_wb_gains_thr_config`

### **thr\_coeffs**

coefficients of threshold `ipu3_uapi_bnr_static_config_thr_coeffs_config`

### **thr\_ctrl\_shd**

control of shading threshold `ipu3_uapi_bnr_static_config_thr_ctrl_shd_config`

### **opt\_center**

optical center `ipu3_uapi_bnr_static_config_opt_center_config`

### **lut**

lookup table `ipu3_uapi_bnr_static_config_lut_config`

### **bp\_ctrl**

detect and remove bad pixels as defined in struct `ipu3_uapi_bnr_static_config_bp_ctrl_config`

### **dn\_detect\_ctrl**

detect and remove noise. `ipu3_uapi_bnr_static_config_dn_detect_ctrl_config`

### **column\_size**

The number of pixels in column.

### **opt\_center\_sqr**

Reset value of  $r^2$  to optical center, see `ipu3_uapi_bnr_static_config_opt_center_sqr_config`

## Description

Above parameters and opt\_center\_sqr are used for white balance and shading.

### struct ipu3\_uapi\_bnr\_static\_config\_green\_disparity

Correct green disparity

#### Definition:

```
struct ipu3_uapi_bnr_static_config_green_disparity {
    __u32 gd_red:6;
    __u32 reserved0:2;
    __u32 gd_green:6;
    __u32 reserved1:2;
    __u32 gd_blue:6;
    __u32 reserved2:10;
    __u32 gd_black:14;
    __u32 reserved3:2;
    __u32 gd_shading:7;
    __u32 reserved4:1;
    __u32 gd_support:2;
    __u32 reserved5:1;
    __u32 gd_clip:1;
    __u32 gd_central_weight:4;
};
```

## Members

### gd\_red

Shading gain coeff for gr disparity level in bright red region. Precision u0.6, default 4(0.0625).

### reserved0

reserved

### gd\_green

Shading gain coeff for gr disparity level in bright green region. Precision u0.6, default 4(0.0625).

### reserved1

reserved

### gd\_blue

Shading gain coeff for gr disparity level in bright blue region. Precision u0.6, default 4(0.0625).

### reserved2

reserved

### gd\_black

Maximal green disparity level in dark region (stronger disparity assumed to be image detail). Precision u14, default 80.

### reserved3

reserved

### **gd\_shading**

Change maximal green disparity level according to square distance from image center.

### **reserved4**

reserved

### **gd\_support**

Lower bound for the number of second green color pixels in current pixel neighborhood with less than threshold difference from it.

### **reserved5**

reserved

### **gd\_clip**

Turn green disparity clip on/off, [0, 1], default 1.

### **gd\_central\_weight**

Central pixel weight in 9 pixels weighted sum.

## **Description**

The shading gain coeff of red, green, blue and black are used to calculate threshold given a pixel's color value and its coordinates in the image.

### **struct ipu3\_uapi\_dm\_config**

De-mosaic parameters

#### **Definition:**

```
struct ipu3_uapi_dm_config {  
    __u32 dm_en:1;  
    __u32 ch_ar_en:1;  
    __u32 fcc_en:1;  
    __u32 reserved0:13;  
    __u32 frame_width:16;  
    __u32 gamma_sc:5;  
    __u32 reserved1:3;  
    __u32 lc_ctrl:5;  
    __u32 reserved2:3;  
    __u32 cr_param1:5;  
    __u32 reserved3:3;  
    __u32 cr_param2:5;  
    __u32 reserved4:3;  
    __u32 coring_param:5;  
    __u32 reserved5:27;  
};
```

## **Members**

### **dm\_en**

de-mosaic enable.

### **ch\_ar\_en**

Checker artifacts removal enable flag. Default 0.

### **fcc\_en**

False color correction (FCC) enable flag. Default 0.

**reserved0**  
reserved

**frame\_width**  
do not care

**gamma\_sc**  
Sharpening coefficient (coefficient of 2-d derivation of complementary color in Hamilton-Adams interpolation). u5, range [0, 31], default 8.

**reserved1**  
reserved

**lc\_ctrl**  
Parameter that controls weights of Chroma Homogeneity metric in calculation of final homogeneity metric. u5, range [0, 31], default 7.

**reserved2**  
reserved

**cr\_param1**  
First parameter that defines Checker artifact removal feature gain. Precision u5, range [0, 31], default 8.

**reserved3**  
reserved

**cr\_param2**  
Second parameter that defines Checker artifact removal feature gain. Precision u5, range [0, 31], default 8.

**reserved4**  
reserved

**coring\_param**  
Defines power of false color correction operation. low for preserving edge colors, high for preserving gray edge artifacts. Precision u1.4, range [0, 1.9375], default 4 (0.25).

**reserved5**  
reserved

## Description

The demosaic fixed function block is responsible to covert Bayer(mosaiced) images into color images based on demosaicing algorithm.

### struct ipu3\_uapi\_ccm\_mat\_config

Color correction matrix

#### Definition:

```
struct ipu3_uapi_ccm_mat_config {
    __s16 coeff_m11;
    __s16 coeff_m12;
    __s16 coeff_m13;
    __s16 coeff_o_r;
    __s16 coeff_m21;
    __s16 coeff_m22;
    __s16 coeff_m23;
```

```

__s16 coeff_o_g;
__s16 coeff_m31;
__s16 coeff_m32;
__s16 coeff_m33;
__s16 coeff_o_b;
};

```

## Members

### **coeff\_m11**

CCM 3x3 coefficient, range [-65536, 65535]

### **coeff\_m12**

CCM 3x3 coefficient, range [-8192, 8191]

### **coeff\_m13**

CCM 3x3 coefficient, range [-32768, 32767]

### **coeff\_o\_r**

Bias 3x1 coefficient, range [-8191, 8181]

### **coeff\_m21**

CCM 3x3 coefficient, range [-32767, 32767]

### **coeff\_m22**

CCM 3x3 coefficient, range [-8192, 8191]

### **coeff\_m23**

CCM 3x3 coefficient, range [-32768, 32767]

### **coeff\_o\_g**

Bias 3x1 coefficient, range [-8191, 8181]

### **coeff\_m31**

CCM 3x3 coefficient, range [-32768, 32767]

### **coeff\_m32**

CCM 3x3 coefficient, range [-8192, 8191]

### **coeff\_m33**

CCM 3x3 coefficient, range [-32768, 32767]

### **coeff\_o\_b**

Bias 3x1 coefficient, range [-8191, 8181]

## Description

Transform sensor specific color space to standard sRGB by applying 3x3 matrix and adding a bias vector O. The transformation is basically a rotation and translation in the 3-dimensional color spaces. Here are the defaults:

9775, -2671, 1087, 0 -1071, 8303, 815, 0 -23, -7887, 16103, 0

### **struct ipu3\_uapi\_gamma\_corr\_ctrl**

Gamma correction

## Definition:

```
struct ipu3_uapi_gamma_corr_ctrl {
    __u32 enable:1;
    __u32 reserved:31;
};
```

**Members****enable**

gamma correction enable.

**reserved**

reserved

**struct ipu3\_uapi\_gamma\_corr\_lut**

Per-pixel tone mapping implemented as LUT.

**Definition:**

```
struct ipu3_uapi_gamma_corr_lut {
    __u16 lut[IPU3_UAPI_GAMMA_CORR_LUT_ENTRIES];
};
```

**Members****lut**

256 tabulated values of the gamma function. LUT[1].. LUT[256] format u13.0, range [0, 8191].

**Description**

The tone mapping operation is done by a Piece wise linear graph that is implemented as a lookup table(LUT). The pixel component input intensity is the X-axis of the graph which is the table entry.

**struct ipu3\_uapi\_gamma\_config**

Gamma config

**Definition:**

```
struct ipu3_uapi_gamma_config {
    struct ipu3_uapi_gamma_corr_ctrl gc_ctrl ;
    struct ipu3_uapi_gamma_corr_lut gc_lut ;
};
```

**Members****gc\_ctrl**

control of gamma correction *ipu3\_uapi\_gamma\_corr\_ctrl*

**gc\_lut**

lookup table of gamma correction *ipu3\_uapi\_gamma\_corr\_lut*

**struct ipu3\_uapi\_csc\_mat\_config**

Color space conversion matrix config

**Definition:**

```
struct ipu3_uapi_csc_mat_config {
    __s16 coeff_c11;
    __s16 coeff_c12;
    __s16 coeff_c13;
    __s16 coeff_b1;
    __s16 coeff_c21;
    __s16 coeff_c22;
    __s16 coeff_c23;
    __s16 coeff_b2;
    __s16 coeff_c31;
    __s16 coeff_c32;
    __s16 coeff_c33;
    __s16 coeff_b3;
};
```

## Members

### **coeff\_c11**

Conversion matrix value, format s0.14, range [-16384, 16383].

### **coeff\_c12**

Conversion matrix value, format s0.14, range [-8192, 8191].

### **coeff\_c13**

Conversion matrix value, format s0.14, range [-16384, 16383].

### **coeff\_b1**

Bias 3x1 coefficient, s13.0 range [-8192, 8191].

### **coeff\_c21**

Conversion matrix value, format s0.14, range [-16384, 16383].

### **coeff\_c22**

Conversion matrix value, format s0.14, range [-8192, 8191].

### **coeff\_c23**

Conversion matrix value, format s0.14, range [-16384, 16383].

### **coeff\_b2**

Bias 3x1 coefficient, s13.0 range [-8192, 8191].

### **coeff\_c31**

Conversion matrix value, format s0.14, range [-16384, 16383].

### **coeff\_c32**

Conversion matrix value, format s0.14, range [-8192, 8191].

### **coeff\_c33**

Conversion matrix value, format s0.14, range [-16384, 16383].

### **coeff\_b3**

Bias 3x1 coefficient, s13.0 range [-8192, 8191].

## Description

To transform each pixel from RGB to YUV (Y - brightness/luminance, UV -chroma) by applying the pixel's values by a 3x3 matrix and adding an optional bias 3x1 vector. Here are the default values for the matrix:

4898, 9617, 1867, 0, -2410, -4732, 7143, 0, 10076, -8437, -1638, 0,  
 (i.e. for real number 0.299,  $0.299 * 2^{14}$  becomes 4898.)

**struct ipu3\_uapi\_cds\_params**  
 Chroma down-scaling

**Definition:**

```
struct ipu3_uapi_cds_params {
    __u32 ds_c00:2;
    __u32 ds_c01:2;
    __u32 ds_c02:2;
    __u32 ds_c03:2;
    __u32 ds_c10:2;
    __u32 ds_c11:2;
    __u32 ds_c12:2;
    __u32 ds_c13:2;
    __u32 ds_nf:5;
    __u32 reserved0:3;
    __u32 csc_en:1;
    __u32 uv_bin_output:1;
    __u32 reserved1:6;
};
```

**Members**

**ds\_c00**  
 range [0, 3]

**ds\_c01**  
 range [0, 3]

**ds\_c02**  
 range [0, 3]

**ds\_c03**  
 range [0, 3]

**ds\_c10**  
 range [0, 3]

**ds\_c11**  
 range [0, 3]

**ds\_c12**  
 range [0, 3]

**ds\_c13**  
 range [0, 3]

**ds\_nf**  
 Normalization factor for Chroma output downscaling filter, range 0..4, default 2.

**reserved0**  
 reserved

**csc\_en**

Color space conversion enable

**uv\_bin\_output**

0: output YUV 4.2.0, 1: output YUV 4.2.2(default).

**reserved1**

reserved

**Description**

**In case user does not provide, above 4x2 filter will use following defaults:**

1, 3, 3, 1, 1, 3, 3, 1,

**struct ipu3\_uapi\_shd\_grid\_config**

Bayer shading(darkening) correction

**Definition:**

```
struct ipu3_uapi_shd_grid_config {  
    __u8 width;  
    __u8 height;  
    __u8 block_width_log2:3;  
    __u8 reserved0:1;  
    __u8 block_height_log2:3;  
    __u8 reserved1:1;  
    __u8 grid_height_per_slice;  
    __s16 x_start;  
    __s16 y_start;  
};
```

**Members**

**width**

Grid horizontal dimensions, u8, [8, 128], default 73

**height**

Grid vertical dimensions, u8, [8, 128], default 56

**block\_width\_log2**

Log2 of the width of the grid cell in pixel count u4, [0, 15], default value 5.

**reserved0**

reserved

**block\_height\_log2**

Log2 of the height of the grid cell in pixel count u4, [0, 15], default value 6.

**reserved1**

reserved

**grid\_height\_per\_slice**

SHD\_MAX\_CELLS\_PER\_SET/width. (with SHD\_MAX\_CELLS\_PER\_SET = 146).

**x\_start**

X value of top left corner of sensor relative to ROI s13, [-4096, 0], default 0, only negative values.

**y\_start**

Y value of top left corner of sensor relative to ROI s13, [-4096, 0], default 0, only negative values.

**struct ipu3\_uapi\_shd\_general\_config**

Shading general config

**Definition:**

```
struct ipu3_uapi_shd_general_config {
    __u32 init_set_vrt_offset_ul:8;
    __u32 shd_enable:1;
    __u32 gain_factor:2;
    __u32 reserved:21;
};
```

**Members****init\_set\_vrt\_offset\_ul**

set vertical offset, y\_start >> block\_height\_log2 % grid\_height\_per\_slice.

**shd\_enable**

shading enable.

**gain\_factor**

Gain factor. Shift calculated anti shading value. Precision u2. 0x0 - gain factor [1, 5], means no shift interpolated value. 0x1 - gain factor [1, 9], means shift interpolated by 1. 0x2 - gain factor [1, 17], means shift interpolated by 2.

**reserved**

reserved

**Description**

Correction is performed by multiplying a gain factor for each of the 4 Bayer channels as a function of the pixel location in the sensor.

**struct ipu3\_uapi\_shd\_black\_level\_config**

Black level correction

**Definition:**

```
struct ipu3_uapi_shd_black_level_config {
    __s16 bl_r;
    __s16 bl_gr;
    __s16 bl_gb;
    __s16 bl_b;
};
```

**Members****bl\_r**

Bios values for green red. s11 range [-2048, 2047].

**bl\_gr**

Bios values for green blue. s11 range [-2048, 2047].

### bl\_gb

Bios values for red. s11 range [-2048, 2047].

### bl\_b

Bios values for blue. s11 range [-2048, 2047].

### struct ipu3\_uapi\_shd\_config\_static

Shading config static

#### Definition:

```
struct ipu3_uapi_shd_config_static {  
    struct ipu3_uapi_shd_grid_config grid;  
    struct ipu3_uapi_shd_general_config general;  
    struct ipu3_uapi_shd_black_level_config black_level;  
};
```

### Members

#### grid

shading grid config *ipu3\_uapi\_shd\_grid\_config*

#### general

shading general config *ipu3\_uapi\_shd\_general\_config*

#### black\_level

black level config for shading correction as defined by  
*ipu3\_uapi\_shd\_black\_level\_config*

### struct ipu3\_uapi\_shd\_lut

Shading gain factor lookup table.

#### Definition:

```
struct ipu3_uapi_shd_lut {  
    struct {  
        struct {  
            __u16 r;  
            __u16 gr;  
        } r_and_gr[IPU3_UAPI_SHD_MAX_CELLS_PER_SET];  
        __u8 reserved1[24];  
        struct {  
            __u16 gb;  
            __u16 b;  
        } gb_and_b[IPU3_UAPI_SHD_MAX_CELLS_PER_SET];  
        __u8 reserved2[24];  
    } sets[IPU3_UAPI_SHD_MAX_CFG_SETS];  
};
```

### Members

#### sets

array

#### sets.r\_and\_gr

Red and GreenR Lookup table.

**sets.r\_and\_gr.r**

Red shading factor.

**sets.r\_and\_gr.gr**

GreenR shading factor.

**sets.reserved1**

reserved

**sets.gb\_and\_b**

GreenB and Blue Lookup table.

**sets.gb\_and\_b.gb**

GreenB shading factor.

**sets.gb\_and\_b.b**

Blue shading factor.

**sets.reserved2**

reserved

**Description**

Map to shading correction LUT register set.

**struct ipu3\_uapi\_shd\_config**

Shading config

**Definition:**

```
struct ipu3_uapi_shd_config {
    struct ipu3_uapi_shd_config_static shd ;
    struct ipu3_uapi_shd_lut shd_lut ;
};
```

**Members****shd**

shading static config, see *ipu3\_uapi\_shd\_config\_static*

**shd\_lut**

shading lookup table *ipu3\_uapi\_shd\_lut*

**struct ipu3\_uapi\_iefd\_cux2**

IEFd Config Unit 2 parameters

**Definition:**

```
struct ipu3_uapi_iefd_cux2 {
    __u32 x0:9;
    __u32 x1:9;
    __u32 a01:9;
    __u32 b01:5;
};
```

**Members****x0**

X0 point of Config Unit, u9.0, default 0.

**x1**

X1 point of Config Unit, u9.0, default 0.

**a01**

Slope A of Config Unit, s4.4, default 0.

**b01**

Slope B, always 0.

## Description

Calculate weight for blending directed and non-directed denoise elements

All CU inputs are unsigned, they will be converted to signed when written to register, i.e. a01 will be written to 9 bit register in s4.4 format. The data precision s4.4 means 4 bits for integer parts and 4 bits for the fractional part, the first bit indicates positive or negative value. For userspace software (commonly the imaging library), the computation for the CU slope values should be based on the slope resolution 1/16 (binary 0.0001 - the minimal interval value), the slope value range is [-256, +255]. This applies to [ipu3\\_uapi\\_iefd\\_cux6\\_ed](#), [ipu3\\_uapi\\_iefd\\_cux2\\_1](#), [ipu3\\_uapi\\_iefd\\_cux2\\_1](#), [ipu3\\_uapi\\_iefd\\_cux4](#) and [ipu3\\_uapi\\_iefd\\_cux6\\_rad](#).

## Note

Each instance of Config Unit needs X coordinate of n points and slope A factor between points calculated by driver based on calibration parameters.

**struct ipu3\_uapi\_iefd\_cux6\_ed**

Calculate power of non-directed sharpening element, Config Unit 6 for edge detail (ED).

## Definition:

```
struct ipu3_uapi_iefd_cux6_ed {
    __u32 x0:9;
    __u32 x1:9;
    __u32 x2:9;
    __u32 reserved0:5;
    __u32 x3:9;
    __u32 x4:9;
    __u32 x5:9;
    __u32 reserved1:5;
    __u32 a01:9;
    __u32 a12:9;
    __u32 a23:9;
    __u32 reserved2:5;
    __u32 a34:9;
    __u32 a45:9;
    __u32 reserved3:14;
    __u32 b01:9;
    __u32 b12:9;
    __u32 b23:9;
    __u32 reserved4:5;
    __u32 b34:9;
    __u32 b45:9;
    __u32 reserved5:14;
};
```

## Members

**x0**

X coordinate of point 0, u9.0, default 0.

**x1**

X coordinate of point 1, u9.0, default 0.

**x2**

X coordinate of point 2, u9.0, default 0.

**reserved0**

reserved

**x3**

X coordinate of point 3, u9.0, default 0.

**x4**

X coordinate of point 4, u9.0, default 0.

**x5**

X coordinate of point 5, u9.0, default 0.

**reserved1**

reserved

**a01**

slope A points 01, s4.4, default 0.

**a12**

slope A points 12, s4.4, default 0.

**a23**

slope A points 23, s4.4, default 0.

**reserved2**

reserved

**a34**

slope A points 34, s4.4, default 0.

**a45**

slope A points 45, s4.4, default 0.

**reserved3**

reserved

**b01**

slope B points 01, s4.4, default 0.

**b12**

slope B points 12, s4.4, default 0.

**b23**

slope B points 23, s4.4, default 0.

**reserved4**

reserved

**b34**

slope B points 34, s4.4, default 0.

**b45**

slope B points 45, s4.4, default 0.

**reserved5**

reserved.

**struct ipu3\_uapi\_iefd\_cux2\_1**

Calculate power of non-directed denoise element apply.

**Definition:**

```
struct ipu3_uapi_iefd_cux2_1 {  
    __u32 x0:9;  
    __u32 x1:9;  
    __u32 a01:9;  
    __u32 reserved1:5;  
    __u32 b01:8;  
    __u32 reserved2:24;  
};
```

**Members****x0**

X0 point of Config Unit, u9.0, default 0.

**x1**

X1 point of Config Unit, u9.0, default 0.

**a01**

Slope A of Config Unit, s4.4, default 0.

**reserved1**

reserved

**b01**

offset B0 of Config Unit, u7.0, default 0.

**reserved2**

reserved

**struct ipu3\_uapi\_iefd\_cux4**

Calculate power of non-directed sharpening element.

**Definition:**

```
struct ipu3_uapi_iefd_cux4 {  
    __u32 x0:9;  
    __u32 x1:9;  
    __u32 x2:9;  
    __u32 reserved0:5;  
    __u32 x3:9;  
    __u32 a01:9;  
    __u32 a12:9;  
    __u32 reserved1:5;
```

```

__u32 a23:9;
__u32 b01:8;
__u32 b12:8;
__u32 reserved2:7;
__u32 b23:8;
__u32 reserved3:24;
};

```

**Members**

**x0** X0 point of Config Unit, u9.0, default 0.

**x1** X1 point of Config Unit, u9.0, default 0.

**x2** X2 point of Config Unit, u9.0, default 0.

**reserved0**  
reserved

**x3** X3 point of Config Unit, u9.0, default 0.

**a01** Slope A0 of Config Unit, s4.4, default 0.

**a12** Slope A1 of Config Unit, s4.4, default 0.

**reserved1**  
reserved

**a23** Slope A2 of Config Unit, s4.4, default 0.

**b01** Offset B0 of Config Unit, s7.0, default 0.

**b12** Offset B1 of Config Unit, s7.0, default 0.

**reserved2**  
reserved

**b23** Offset B2 of Config Unit, s7.0, default 0.

**reserved3**  
reserved

struct **ipu3\_uapi\_iefd\_cux6\_rad**  
Radial Config Unit (CU)

**Definition:**

```
struct ipu3_uapi_iefd_cux6_rad {
    __u32 x0:8;
    __u32 x1:8;
    __u32 x2:8;
    __u32 x3:8;
    __u32 x4:8;
    __u32 x5:8;
    __u32 reserved1:16;
    __u32 a01:16;
    __u32 a12:16;
    __u32 a23:16;
    __u32 a34:16;
    __u32 a45:16;
    __u32 reserved2:16;
    __u32 b01:10;
    __u32 b12:10;
    __u32 b23:10;
    __u32 reserved4:2;
    __u32 b34:10;
    __u32 b45:10;
    __u32 reserved5:12;
};
```

## Members

### x0

x0 points of Config Unit radial, u8.0

### x1

x1 points of Config Unit radial, u8.0

### x2

x2 points of Config Unit radial, u8.0

### x3

x3 points of Config Unit radial, u8.0

### x4

x4 points of Config Unit radial, u8.0

### x5

x5 points of Config Unit radial, u8.0

### reserved1

reserved

### a01

Slope A of Config Unit radial, s7.8

### a12

Slope A of Config Unit radial, s7.8

### a23

Slope A of Config Unit radial, s7.8

**a34**  
Slope A of Config Unit radial, s7.8

**a45**  
Slope A of Config Unit radial, s7.8

**reserved2**  
reserved

**b01**  
Slope B of Config Unit radial, s9.0

**b12**  
Slope B of Config Unit radial, s9.0

**b23**  
Slope B of Config Unit radial, s9.0

**reserved4**  
reserved

**b34**  
Slope B of Config Unit radial, s9.0

**b45**  
Slope B of Config Unit radial, s9.0

**reserved5**  
reserved

**struct ipu3\_uapi\_yuvpl\_iefd\_cfg\_units**  
IEFd Config Units parameters

#### Definition:

```
struct ipu3_uapi_yuvpl_iefd_cfg_units {
    struct ipu3_uapi_iefd_cux2 cu_1;
    struct ipu3_uapi_iefd_cux6_ed cu_ed;
    struct ipu3_uapi_iefd_cux2 cu_3;
    struct ipu3_uapi_iefd_cux2_1 cu_5;
    struct ipu3_uapi_iefd_cux4 cu_6;
    struct ipu3_uapi_iefd_cux2 cu_7;
    struct ipu3_uapi_iefd_cux4 cu_unsharp;
    struct ipu3_uapi_iefd_cux6_rad cu_radial;
    struct ipu3_uapi_iefd_cux2 cu_vssnlm;
};
```

#### Members

**cu\_1**  
calculate weight for blending directed and non-directed denoise elements. See [ipu3\\_uapi\\_iefd\\_cux2](#)

**cu\_ed**  
calculate power of non-directed sharpening element, see [ipu3\\_uapi\\_iefd\\_cux6\\_ed](#)

**cu\_3**  
calculate weight for blending directed and non-directed denoise elements. A

*ipu3\_uapi\_iefd\_cux2*

**cu\_5**  
calculate power of non-directed denoise element apply, use *ipu3\_uapi\_iefd\_cux2\_1*

**cu\_6**  
calculate power of non-directed sharpening element. See *ipu3\_uapi\_iefd\_cux4*

**cu\_7**  
calculate weight for blending directed and non-directed denoise elements. Use *ipu3\_uapi\_iefd\_cux2*

**cu\_unsharp**  
Config Unit of unsharp *ipu3\_uapi\_iefd\_cux4*

**cu\_radial**  
Config Unit of radial *ipu3\_uapi\_iefd\_cux6\_rad*

**cu\_vssnlm**  
Config Unit of vssnlm *ipu3\_uapi\_iefd\_cux2*

**struct ipu3\_uapi\_yuvpl\_iefd\_config\_s**  
IEFD config

**Definition:**

```
struct ipu3_uapi_yuvpl_iefd_config_s {
    __u32 horver_diag_coeff:7;
    __u32 reserved0:1;
    __u32 clamp_stitch:6;
    __u32 reserved1:2;
    __u32 direct_metric_update:5;
    __u32 reserved2:3;
    __u32 ed_horver_diag_coeff:7;
    __u32 reserved3:1;
};
```

**Members****horver\_diag\_coeff**

Gradient compensation. Compared with vertical / horizontal (0 / 90 degree), coefficient of diagonal (45 / 135 degree) direction should be corrected by approx.  $1/\sqrt{2}$ .

**reserved0**

reserved

**clamp\_stitch**

Slope to stitch between clamped and unclamped edge values

**reserved1**

reserved

**direct\_metric\_update**

Update coeff for direction metric

**reserved2**

reserved

**ed\_horver\_diag\_coeff**

Radial Coefficient that compensates for different distance for vertical/horizontal and diagonal gradient calculation (approx. 1/sqrt(2))

**reserved3**

reserved

**struct ipu3\_uapi\_yuvpl\_iefd\_control**

IEFd control

**Definition:**

```
struct ipu3_uapi_yuvpl_iefd_control {
    __u32 iefd_en:1;
    __u32 denoise_en:1;
    __u32 direct_smooth_en:1;
    __u32 rad_en:1;
    __u32 vssnlm_en:1;
    __u32 reserved:27;
};
```

**Members****iefd\_en**

Enable IEFd

**denoise\_en**

Enable denoise

**direct\_smooth\_en**

Enable directional smooth

**rad\_en**

Enable radial update

**vssnlm\_en**

Enable VSSNLM output filter

**reserved**

reserved

**struct ipu3\_uapi\_sharp\_cfg**

Sharpening config

**Definition:**

```
struct ipu3_uapi_sharp_cfg {
    __u32 nega_lmt_txt:13;
    __u32 reserved0:19;
    __u32 posi_lmt_txt:13;
    __u32 reserved1:19;
    __u32 nega_lmt_dir:13;
    __u32 reserved2:19;
    __u32 posi_lmt_dir:13;
    __u32 reserved3:19;
};
```

**Members****nega\_lmt\_txt**

Sharpening limit for negative overshoots for texture.

**reserved0**

reserved

**posi\_lmt\_txt**

Sharpening limit for positive overshoots for texture.

**reserved1**

reserved

**nega\_lmt\_dir**

Sharpening limit for negative overshoots for direction (edge).

**reserved2**

reserved

**posi\_lmt\_dir**

Sharpening limit for positive overshoots for direction (edge).

**reserved3**

reserved

**Description**

Fixed point type u13.0, range [0, 8191].

**struct ipu3\_uapi\_far\_w**

Sharpening config for far sub-group

**Definition:**

```
struct ipu3_uapi_far_w {
    __u32 dir_shrp:7;
    __u32 reserved0:1;
    __u32 dir_dns:7;
    __u32 reserved1:1;
    __u32 ndir_dns_powr:7;
    __u32 reserved2:9;
};
```

**Members****dir\_shrp**

Weight of wide direct sharpening, u1.6, range [0, 64], default 64.

**reserved0**

reserved

**dir\_dns**

Weight of wide direct denoising, u1.6, range [0, 64], default 0.

**reserved1**

reserved

**ndir\_dns\_powr**

Power of non-direct denoising, Precision u1.6, range [0, 64], default 64.

**reserved2**

reserved

**struct ipu3\_uapi\_unsharp\_cfg**

Unsharp config

**Definition:**

```
struct ipu3_uapi_unsharp_cfg {
    __u32 unsharp_weight:7;
    __u32 reserved0:1;
    __u32 unsharp_amount:9;
    __u32 reserved1:15;
};
```

**Members****unsharp\_weight**

Unsharp mask blending weight. u1.6, range [0, 64], default 16. 0 - disabled, 64 - use only unsharp.

**reserved0**

reserved

**unsharp\_amount**

Unsharp mask amount, u4.5, range [0, 511], default 0.

**reserved1**

reserved

**struct ipu3\_uapi\_yuvpl\_iefd\_shrp\_cfg**

IEFd sharpness config

**Definition:**

```
struct ipu3_uapi_yuvpl_iefd_shrp_cfg {
    struct ipu3_uapi_sharp_cfg cfg;
    struct ipu3_uapi_far_w far_w;
    struct ipu3_uapi_unsharp_cfg unshrp_cfg;
};
```

**Members****cfg**

sharpness config [ipu3\\_uapi\\_sharp\\_cfg](#)

**far\_w**

wide range config, value as specified by [ipu3\\_uapi\\_far\\_w](#): The 5x5 environment is separated into 2 sub-groups, the 3x3 nearest neighbors (8 pixels called Near), and the second order neighborhood around them (16 pixels called Far).

**unshrp\_cfg**

unsharpness config. [ipu3\\_uapi\\_unsharp\\_cfg](#)

**struct ipu3\_uapi\_unsharp\_coef0**

Unsharp mask coefficients

**Definition:**

```
struct ipu3_uapi_unsharp_coef0 {  
    __u32 c00:9;  
    __u32 c01:9;  
    __u32 c02:9;  
    __u32 reserved:5;  
};
```

### Members

#### c00

Coeff11, s0.8, range [-255, 255], default 1.

#### c01

Coeff12, s0.8, range [-255, 255], default 5.

#### c02

Coeff13, s0.8, range [-255, 255], default 9.

#### reserved

reserved

### Description

Configurable registers for common sharpening support.

```
struct ipu3_uapi_unsharp_coef1
```

Unsharp mask coefficients

### Definition:

```
struct ipu3_uapi_unsharp_coef1 {  
    __u32 c11:9;  
    __u32 c12:9;  
    __u32 c22:9;  
    __u32 reserved:5;  
};
```

### Members

#### c11

Coeff22, s0.8, range [-255, 255], default 29.

#### c12

Coeff23, s0.8, range [-255, 255], default 55.

#### c22

Coeff33, s0.8, range [-255, 255], default 96.

#### reserved

reserved

```
struct ipu3_uapi_yuvpl_iefd_unshrp_cfg
```

Unsharp mask config

### Definition:

```
struct ipu3_uapi_yuvpl_iefd_unshrp_cfg {
    struct ipu3_uapi_unsharp_coef0 unsharp_coef0;
    struct ipu3_uapi_unsharp_coef1 unsharp_coef1;
};
```

**Members****unsharp\_coef0**

unsharp coefficient 0 config. See *ipu3\_uapi\_unsharp\_coef0*

**unsharp\_coef1**

unsharp coefficient 1 config. See *ipu3\_uapi\_unsharp\_coef1*

**struct ipu3\_uapi\_radial\_reset\_xy**

Radial coordinate reset

**Definition:**

```
struct ipu3_uapi_radial_reset_xy {
    __s32 x:13;
    __u32 reserved0:3;
    __s32 y:13;
    __u32 reserved1:3;
};
```

**Members****x**

Radial reset of x coordinate. Precision s12, [-4095, 4095], default 0.

**reserved0**

reserved

**y**

Radial center y coordinate. Precision s12, [-4095, 4095], default 0.

**reserved1**

reserved

**struct ipu3\_uapi\_radial\_reset\_x2**

Radial X^2 reset

**Definition:**

```
struct ipu3_uapi_radial_reset_x2 {
    __u32 x2:24;
    __u32 reserved:8;
};
```

**Members****x2**

Radial reset of x^2 coordinate. Precision u24, default 0.

**reserved**

reserved

struct **ipu3\_uapi\_radial\_reset\_y2**

Radial Y^2 reset

### Definition:

```
struct ipu3_uapi_radial_reset_y2 {  
    __u32 y2:24;  
    __u32 reserved:8;  
};
```

### Members

**y2**

Radial reset of y^2 coordinate. Precision u24, default 0.

**reserved**

reserved

struct **ipu3\_uapi\_radial\_cfg**

Radial config

### Definition:

```
struct ipu3_uapi_radial_cfg {  
    __u32 rad_nf:4;  
    __u32 reserved0:4;  
    __u32 rad_inv_r2:7;  
    __u32 reserved1:17;  
};
```

### Members

**rad\_nf**

Radial. R^2 normalization factor is scale down by 2^ - (15 + scale)

**reserved0**

reserved

**rad\_inv\_r2**

Radial R^-2 normelized to (0.5..1). Precision u7, range [0, 127].

**reserved1**

reserved

struct **ipu3\_uapi\_rad\_far\_w**

Radial FAR sub-group

### Definition:

```
struct ipu3_uapi_rad_far_w {  
    __u32 rad_dir_far_sharp_w:8;  
    __u32 rad_dir_far_dns_w:8;  
    __u32 rad_ndir_far_dns_power:8;  
    __u32 reserved:8;  
};
```

### Members

**rad\_dir\_far\_sharp\_w**

Weight of wide direct sharpening, u1.6, range [0, 64], default 64.

**rad\_dir\_far\_dns\_w**

Weight of wide direct denoising, u1.6, range [0, 64], default 0.

**rad\_ndir\_far\_dns\_power**

power of non-direct sharpening, u1.6, range [0, 64], default 0.

**reserved**

reserved

**struct ipu3\_uapi\_cu\_cfg0**

Radius Config Unit cfg0 register

**Definition:**

```
struct ipu3_uapi_cu_cfg0 {
    __u32 cu6_pow:7;
    __u32 reserved0:1;
    __u32 cu_unsharp_pow:7;
    __u32 reserved1:1;
    __u32 rad_cu6_pow:7;
    __u32 reserved2:1;
    __u32 rad_cu_unsharp_pow:6;
    __u32 reserved3:2;
};
```

**Members****cu6\_pow**

Power of CU6. Power of non-direct sharpening, u3.4.

**reserved0**

reserved

**cu\_unsharp\_pow**

Power of unsharp mask, u2.4.

**reserved1**

reserved

**rad\_cu6\_pow**

Radial/corner CU6. Directed sharpening power, u3.4.

**reserved2**

reserved

**rad\_cu\_unsharp\_pow**

Radial power of unsharp mask, u2.4.

**reserved3**

reserved

**struct ipu3\_uapi\_cu\_cfg1**

Radius Config Unit cfg1 register

**Definition:**

```
struct ipu3_uapi_cu_cfg1 {
    __u32 rad_cu6_x1:9;
    __u32 reserved0:1;
    __u32 rad_cu_unsharp_x1:9;
    __u32 reserved1:13;
};
```

**Members****rad\_cu6\_x1**

X1 point of Config Unit 6, precision u9.0.

**reserved0**

reserved

**rad\_cu\_unsharp\_x1**

X1 point for Config Unit unsharp for radial/corner point precision u9.0.

**reserved1**

reserved

**struct ipu3\_uapi\_yuvpl\_iefd\_rad\_cfg**

IEFd parameters changed radially over the picture plane.

**Definition:**

```
struct ipu3_uapi_yuvpl_iefd_rad_cfg {
    struct ipu3_uapi_radial_reset_xy reset_xy;
    struct ipu3_uapi_radial_reset_x2 reset_x2;
    struct ipu3_uapi_radial_reset_y2 reset_y2;
    struct ipu3_uapi_radial_cfg cfg;
    struct ipu3_uapi_rad_far_w rad_far_w;
    struct ipu3_uapi_cu_cfg0 cu_cfg0;
    struct ipu3_uapi_cu_cfg1 cu_cfg1;
};
```

**Members****reset\_xy**

reset xy value in radial calculation. [ipu3\\_uapi\\_radial\\_reset\\_xy](#)

**reset\_x2**

reset x square value in radial calculation. See struct [ipu3\\_uapi\\_radial\\_reset\\_x2](#)

**reset\_y2**

reset y square value in radial calculation. See struct [ipu3\\_uapi\\_radial\\_reset\\_y2](#)

**cfg**

radial config defined in [ipu3\\_uapi\\_radial\\_cfg](#)

**rad\_far\_w**

weight for wide range radial. [ipu3\\_uapi\\_rad\\_far\\_w](#)

**cu\_cfg0**

configuration unit 0. See [ipu3\\_uapi\\_cu\\_cfg0](#)

**cu\_cfg1**

configuration unit 1. See [ipu3\\_uapi\\_cu\\_cfg1](#)

**struct ipu3\_uapi\_vss\_lut\_x**

Vssnlm LUT x0/x1/x2

**Definition:**

```
struct ipu3_uapi_vss_lut_x {
    __u32 vs_x0:8;
    __u32 vs_x1:8;
    __u32 vs_x2:8;
    __u32 reserved2:8;
};
```

**Members****vs\_x0**

Vssnlm LUT x0, precision u8, range [0, 255], default 16.

**vs\_x1**

Vssnlm LUT x1, precision u8, range [0, 255], default 32.

**vs\_x2**

Vssnlm LUT x2, precision u8, range [0, 255], default 64.

**reserved2**

reserved

**struct ipu3\_uapi\_vss\_lut\_y**

Vssnlm LUT y0/y1/y2

**Definition:**

```
struct ipu3_uapi_vss_lut_y {
    __u32 vs_y1:4;
    __u32 reserved0:4;
    __u32 vs_y2:4;
    __u32 reserved1:4;
    __u32 vs_y3:4;
    __u32 reserved2:12;
};
```

**Members****vs\_y1**

Vssnlm LUT y1, precision u4, range [0, 8], default 1.

**reserved0**

reserved

**vs\_y2**

Vssnlm LUT y2, precision u4, range [0, 8], default 3.

**reserved1**

reserved

**vs\_y3**

Vssnlm LUT y3, precision u4, range [0, 8], default 8.

**reserved2**

reserved

**struct ipu3\_uapi\_yuvpl\_iefd\_vssnlm\_cfg**

IEFd Vssnlm Lookup table

**Definition:**

```
struct ipu3_uapi_yuvpl_iefd_vssnlm_cfg {
    struct ipu3_uapi_vss_lut_x vss_lut_x;
    struct ipu3_uapi_vss_lut_y vss_lut_y;
};
```

**Members****vss\_lut\_x**

vss lookup table. See [\*ipu3\\_uapi\\_vss\\_lut\\_x\*](#) description

**vss\_lut\_y**

vss lookup table. See [\*ipu3\\_uapi\\_vss\\_lut\\_y\*](#) description

**struct ipu3\_uapi\_yuvpl\_iefd\_config**

IEFd config

**Definition:**

```
struct ipu3_uapi_yuvpl_iefd_config {
    struct ipu3_uapi_yuvpl_iefd_cfg_units units;
    struct ipu3_uapi_yuvpl_iefd_config_s config;
    struct ipu3_uapi_yuvpl_iefd_control control;
    struct ipu3_uapi_yuvpl_iefd_shrp_cfg sharp;
    struct ipu3_uapi_yuvpl_iefd_unshrp_cfg unsharp;
    struct ipu3_uapi_yuvpl_iefd_rad_cfg rad;
    struct ipu3_uapi_yuvpl_iefd_vssnlm_cfg vsslrm;
};
```

**Members****units**

configuration unit setting, [\*ipu3\\_uapi\\_yuvpl\\_iefd\\_cfg\\_units\*](#)

**config**

configuration, as defined by [\*ipu3\\_uapi\\_yuvpl\\_iefd\\_config\\_s\*](#)

**control**

control setting, as defined by [\*ipu3\\_uapi\\_yuvpl\\_iefd\\_control\*](#)

**sharp**

sharpness setting, as defined by [\*ipu3\\_uapi\\_yuvpl\\_iefd\\_shrp\\_cfg\*](#)

**unsharp**

unsharpness setting, as defined by [\*ipu3\\_uapi\\_yuvpl\\_iefd\\_unshrp\\_cfg\*](#)

**rad**

radial setting, as defined by [\*ipu3\\_uapi\\_yuvpl\\_iefd\\_rad\\_cfg\*](#)

**vsslnm**

vsslnm setting, as defined by *ipu3\_uapi\_yuvpl\_iefd\_vssnlm\_cfg*

**struct ipu3\_uapi\_yuvpl\_yds\_config**

Y Down-Sampling config

**Definition:**

```
struct ipu3_uapi_yuvpl_yds_config {
    __u32 c00:2;
    __u32 c01:2;
    __u32 c02:2;
    __u32 c03:2;
    __u32 c10:2;
    __u32 c11:2;
    __u32 c12:2;
    __u32 c13:2;
    __u32 norm_factor:5;
    __u32 reserved0:4;
    __u32 bin_output:1;
    __u32 reserved1:6;
};
```

**Members**

**c00**  
range [0, 3], default 0x0

**c01**  
range [0, 3], default 0x1

**c02**  
range [0, 3], default 0x1

**c03**  
range [0, 3], default 0x0

**c10**  
range [0, 3], default 0x0

**c11**  
range [0, 3], default 0x1

**c12**  
range [0, 3], default 0x1

**c13**  
range [0, 3], default 0x0

**norm\_factor**  
Normalization factor, range [0, 4], default 2 0 - divide by 1 1 - divide by 2 2 - divide by 4 3 - divide by 8 4 - divide by 16

**reserved0**  
reserved

**bin\_output**  
Down sampling on Luma channel in two optional modes 0 - Bin output 4.2.0 (default), 1

output 4.2.2.

**reserved1**  
reserved

### Description

Above are 4x2 filter coefficients for chroma output downscaling.

**struct ipu3\_uapi\_yuvpl\_chnr\_enable\_config**

Chroma noise reduction enable

### Definition:

```
struct ipu3_uapi_yuvpl_chnr_enable_config {  
    __u32 enable:1;  
    __u32 yuv_mode:1;  
    __u32 reserved0:14;  
    __u32 col_size:12;  
    __u32 reserved1:4;  
};
```

### Members

**enable**

enable/disable chroma noise reduction

**yuv\_mode**

0 - YUV420, 1 - YUV422

**reserved0**

reserved

**col\_size**

number of columns in the frame, max width is 2560

**reserved1**

reserved

**struct ipu3\_uapi\_yuvpl\_chnr\_coring\_config**

Coring thresholds for UV

### Definition:

```
struct ipu3_uapi_yuvpl_chnr_coring_config {  
    __u32 u:13;  
    __u32 reserved0:3;  
    __u32 v:13;  
    __u32 reserved1:3;  
};
```

### Members

**u**

U coring level, u0.13, range [0.0, 1.0], default 0.0

**reserved0**

reserved

**v**

V coring level, u0.13, range [0.0, 1.0], default 0.0

**reserved1**

reserved

**struct ipu3\_uapi\_yuvpl\_chnr\_sense\_gain\_config**

Chroma noise reduction gains

**Definition:**

```
struct ipu3_uapi_yuvpl_chnr_sense_gain_config {
    __u32 vy:8;
    __u32 vu:8;
    __u32 vv:8;
    __u32 reserved0:8;
    __u32 hy:8;
    __u32 hu:8;
    __u32 hv:8;
    __u32 reserved1:8;
};
```

**Members****vy**

Sensitivity of horizontal edge of Y, default 100

**vu**

Sensitivity of horizontal edge of U, default 100

**vv**

Sensitivity of horizontal edge of V, default 100

**reserved0**

reserved

**hy**

Sensitivity of vertical edge of Y, default 50

**hu**

Sensitivity of vertical edge of U, default 50

**hv**

Sensitivity of vertical edge of V, default 50

**reserved1**

reserved

**Description**

All sensitivity gain parameters have precision u13.0, range [0, 8191].

**struct ipu3\_uapi\_yuvpl\_chnr\_iir\_fir\_config**

Chroma IIR/FIR filter config

**Definition:**

```
struct ipu3_uapi_yuvpl_chnr_iir_fir_config {
    __u32 fir_0h:6;
    __u32 reserved0:2;
    __u32 fir_1h:6;
    __u32 reserved1:2;
    __u32 fir_2h:6;
    __u32 dalpha_clip_val:9;
    __u32 reserved2:1;
};
```

**Members****fir\_0h**

Value of center tap in horizontal FIR, range [0, 32], default 8.

**reserved0**

reserved

**fir\_1h**

Value of distance 1 in horizontal FIR, range [0, 32], default 12.

**reserved1**

reserved

**fir\_2h**

Value of distance 2 tap in horizontal FIR, range [0, 32], default 0.

**dalpha\_clip\_val**

weight for previous row in IIR, range [1, 256], default 0.

**reserved2**

reserved

**struct ipu3\_uapi\_yuvpl\_chnr\_config**

Chroma noise reduction config

**Definition:**

```
struct ipu3_uapi_yuvpl_chnr_config {
    struct ipu3_uapi_yuvpl_chnr_enable_config enable;
    struct ipu3_uapi_yuvpl_chnr_coring_config coring;
    struct ipu3_uapi_yuvpl_chnr_sense_gain_config sense_gain;
    struct ipu3_uapi_yuvpl_chnr_iir_fir_config iir_fir;
};
```

**Members****enable**

chroma noise reduction enable, see *ipu3\_uapi\_yuvpl\_chnr\_enable\_config*

**coring**

coring config for chroma noise reduction, see *ipu3\_uapi\_yuvpl\_chnr\_coring\_config*

**sense\_gain**

sensitivity config for chroma noise reduction, see *ipu3\_uapi\_yuvpl\_chnr\_sense\_gain\_config*

**iir\_fir**

iir and fir config for chroma noise reduction, see ipu3\_uapi\_yuvp1\_chnr\_iir\_fir\_config

**struct ipu3\_uapi\_yuvp1\_y\_ee\_nr\_lpf\_config**

Luma(Y) edge enhancement low-pass filter coefficients

**Definition:**

```
struct ipu3_uapi_yuvp1_y_ee_nr_lpf_config {
    __u32 a_diag:5;
    __u32 reserved0:3;
    __u32 a_periph:5;
    __u32 reserved1:3;
    __u32 a_cent:5;
    __u32 reserved2:9;
    __u32 enable:1;
};
```

**Members****a\_diag**

Smoothing diagonal coefficient, u5.0.

**reserved0**

reserved

**a\_periph**

Image smoothing perpherial, u5.0.

**reserved1**

reserved

**a\_cent**

Image Smoothing center coefficient, u5.0.

**reserved2**

reserved

**enable**

0: Y\_EE\_NR disabled, output = input; 1: Y\_EE\_NR enabled.

**struct ipu3\_uapi\_yuvp1\_y\_ee\_nr\_sense\_config**

Luma(Y) edge enhancement noise reduction sensitivity gains

**Definition:**

```
struct ipu3_uapi_yuvp1_y_ee_nr_sense_config {
    __u32 edge_sense_0:13;
    __u32 reserved0:3;
    __u32 delta_edge_sense:13;
    __u32 reserved1:3;
    __u32 corner_sense_0:13;
    __u32 reserved2:3;
    __u32 delta_corner_sense:13;
    __u32 reserved3:3;
};
```

**Members****edge\_sense\_0**

Sensitivity of edge in dark area. u13.0, default 8191.

**reserved0**

reserved

**delta\_edge\_sense**

Difference in the sensitivity of edges between the bright and dark areas. u13.0, default 0.

**reserved1**

reserved

**corner\_sense\_0**

Sensitivity of corner in dark area. u13.0, default 0.

**reserved2**

reserved

**delta\_corner\_sense**

Difference in the sensitivity of corners between the bright and dark areas. u13.0, default 8191.

**reserved3**

reserved

**struct ipu3\_uapi\_yuvpl\_y\_ee\_nr\_gain\_config**

Luma(Y) edge enhancement noise reduction gain config

**Definition:**

```
struct ipu3_uapi_yuvpl_y_ee_nr_gain_config {
    __u32 gain_pos_0:5;
    __u32 reserved0:3;
    __u32 delta_gain_posi:5;
    __u32 reserved1:3;
    __u32 gain_neg_0:5;
    __u32 reserved2:3;
    __u32 delta_gain_neg:5;
    __u32 reserved3:3;
};
```

**Members****gain\_pos\_0**

Gain for positive edge in dark area. u5.0, [0, 16], default 2.

**reserved0**

reserved

**delta\_gain\_posi**

Difference in the gain of edges between the bright and dark areas for positive edges. u5.0, [0, 16], default 0.

**reserved1**

reserved

**gain\_neg\_0**

Gain for negative edge in dark area. u5.0, [0, 16], default 8.

**reserved2**

reserved

**delta\_gain\_neg**

Difference in the gain of edges between the bright and dark areas for negative edges. u5.0, [0, 16], default 0.

**reserved3**

reserved

**struct ipu3\_uapi\_yuvpl\_y\_ee\_nr\_clip\_config**

Luma(Y) edge enhancement noise reduction clipping config

**Definition:**

```
struct ipu3_uapi_yuvpl_y_ee_nr_clip_config {
    __u32 clip_pos_0:5;
    __u32 reserved0:3;
    __u32 delta_clip_posi:5;
    __u32 reserved1:3;
    __u32 clip_neg_0:5;
    __u32 reserved2:3;
    __u32 delta_clip_neg:5;
    __u32 reserved3:3;
};
```

**Members****clip\_pos\_0**

Limit of positive edge in dark area u5, value [0, 16], default 8.

**reserved0**

reserved

**delta\_clip\_posi**

Difference in the limit of edges between the bright and dark areas for positive edges. u5, value [0, 16], default 8.

**reserved1**

reserved

**clip\_neg\_0**

Limit of negative edge in dark area u5, value [0, 16], default 8.

**reserved2**

reserved

**delta\_clip\_neg**

Difference in the limit of edges between the bright and dark areas for negative edges. u5, value [0, 16], default 8.

**reserved3**

reserved

**struct ipu3\_uapi\_yuvpl\_y\_ee\_nr\_frng\_config**

Luma(Y) edge enhancement noise reduction fringe config

**Definition:**

```
struct ipu3_uapi_yuvpl_y_ee_nr_frng_config {  
    __u32 gain_exp:4;  
    __u32 reserved0:28;  
    __u32 min_edge:13;  
    __u32 reserved1:3;  
    __u32 lin_seg_param:4;  
    __u32 reserved2:4;  
    __u32 t1:1;  
    __u32 t2:1;  
    __u32 reserved3:6;  
};
```

**Members**

**gain\_exp**

Common exponent of gains, u4, [0, 8], default 2.

**reserved0**

reserved

**min\_edge**

Threshold for edge and smooth stitching, u13.

**reserved1**

reserved

**lin\_seg\_param**

Power of LinSeg, u4.

**reserved2**

reserved

**t1**

Parameter for enabling/disabling the edge enhancement, u1.0, [0, 1], default 1.

**t2**

Parameter for enabling/disabling the smoothing, u1.0, [0, 1], default 1.

**reserved3**

reserved

**struct ipu3\_uapi\_yuvpl\_y\_ee\_nr\_diag\_config**

Luma(Y) edge enhancement noise reduction diagonal config

**Definition:**

```
struct ipu3_uapi_yuvpl_y_ee_nr_diag_config {  
    __u32 diag_disc_g:4;  
    __u32 reserved0:4;  
    __u32 hvw_hor:4;  
    __u32 dw_hor:4;  
    __u32 hvw_diag:4;
```

```

    __u32 dw_diag:4;
    __u32 reserved1:8;
};

```

**Members****diag\_disc\_g**

Coefficient that prioritize diagonal edge direction on horizontal or vertical for final enhancement. u4.0, [1, 15], default 1.

**reserved0**

reserved

**hvw\_hor**

Weight of horizontal/vertical edge enhancement for hv edge. u2.2, [1, 15], default 4.

**dw\_hor**

Weight of diagonal edge enhancement for hv edge. u2.2, [1, 15], default 1.

**hvw\_diag**

Weight of horizontal/vertical edge enhancement for diagonal edge. u2.2, [1, 15], default 1.

**dw\_diag**

Weight of diagonal edge enhancement for diagonal edge. u2.2, [1, 15], default 4.

**reserved1**

reserved

**struct ipu3\_uapi\_yuvpl\_y\_ee\_nr\_fc\_coring\_config**

Luma(Y) edge enhancement noise reduction false color correction (FCC) coring config

**Definition:**

```

struct ipu3_uapi_yuvpl_y_ee_nr_fc_coring_config {
    __u32 pos_0:13;
    __u32 reserved0:3;
    __u32 pos_delta:13;
    __u32 reserved1:3;
    __u32 neg_0:13;
    __u32 reserved2:3;
    __u32 neg_delta:13;
    __u32 reserved3:3;
};

```

**Members****pos\_0**

Gain for positive edge in dark, u13.0, [0, 16], default 0.

**reserved0**

reserved

**pos\_delta**

Gain for positive edge in bright, value: pos\_0 + pos\_delta <=16 u13.0, default 0.

**reserved1**  
reserved

**neg\_0**  
Gain for negative edge in dark area, u13.0, range [0, 16], default 0.

**reserved2**  
reserved

**neg\_delta**  
Gain for negative edge in bright area. neg\_0 + neg\_delta <=16 u13.0, default 0.

**reserved3**  
reserved

## Description

Coring is a simple soft thresholding technique.

struct **ipu3\_uapi\_yuvpl\_y\_ee\_nr\_config**  
Edge enhancement and noise reduction

## Definition:

```
struct ipu3_uapi_yuvpl_y_ee_nr_config {
    struct ipu3_uapi_yuvpl_y_ee_nr_lpf_config lpf;
    struct ipu3_uapi_yuvpl_y_ee_nr_sense_config sense;
    struct ipu3_uapi_yuvpl_y_ee_nr_gain_config gain;
    struct ipu3_uapi_yuvpl_y_ee_nr_clip_config clip;
    struct ipu3_uapi_yuvpl_y_ee_nr_frng_config frng;
    struct ipu3_uapi_yuvpl_y_ee_nr_diag_config diag;
    struct ipu3_uapi_yuvpl_y_ee_nr_fc_coring_config fc_coring;
};
```

## Members

### lpf

low-pass filter config. See *ipu3\_uapi\_yuvpl\_y\_ee\_nr\_lpf\_config*

### sense

sensitivity config. See *ipu3\_uapi\_yuvpl\_y\_ee\_nr\_sense\_config*

### gain

gain config as defined in *ipu3\_uapi\_yuvpl\_y\_ee\_nr\_gain\_config*

### clip

clip config as defined in *ipu3\_uapi\_yuvpl\_y\_ee\_nr\_clip\_config*

### frng

fringe config as defined in *ipu3\_uapi\_yuvpl\_y\_ee\_nr\_frng\_config*

### diag

diagonal edge config. See *ipu3\_uapi\_yuvpl\_y\_ee\_nr\_diag\_config*

### fc\_coring

coring config for fringe control. See *ipu3\_uapi\_yuvpl\_y\_ee\_nr\_fc\_coring\_config*

### struct ipu3\_uapi\_yuvp2\_tcc\_gen\_control\_static\_config

Total color correction general control config

**Definition:**

```
struct ipu3_uapi_yuvp2_tcc_gen_control_static_config {
    __u32 en:1;
    __u32 blend_shift:3;
    __u32 gain_according_to_y_only:1;
    __u32 reserved0:11;
    __s32 gamma:5;
    __u32 reserved1:3;
    __s32 delta:5;
    __u32 reserved2:3;
};
```

**Members**

**en**  
0 - TCC disabled. Output = input 1 - TCC enabled.

**blend\_shift**  
blend shift, Range[3, 4], default NA.

**gain\_according\_to\_y\_only**  
0: Gain is calculated according to YUV, 1: Gain is calculated according to Y only

**reserved0**  
reserved

**gamma**  
Final blending coefficients. Values[-16, 16], default NA.

**reserved1**  
reserved

**delta**  
Final blending coefficients. Values[-16, 16], default NA.

**reserved2**  
reserved

**struct ipu3\_uapi\_yuvp2\_tcc\_macc\_elem\_static\_config**  
Total color correction multi-axis color control (MACC) config

**Definition:**

```
struct ipu3_uapi_yuvp2_tcc_macc_elem_static_config {
    __s32 a:12;
    __u32 reserved0:4;
    __s32 b:12;
    __u32 reserved1:4;
    __s32 c:12;
    __u32 reserved2:4;
    __s32 d:12;
    __u32 reserved3:4;
};
```

**Members**

**a**  
a coefficient for 2x2 MACC conversion matrix.

**reserved0**  
reserved

**b**  
b coefficient 2x2 MACC conversion matrix.

**reserved1**  
reserved

**c**  
c coefficient for 2x2 MACC conversion matrix.

**reserved2**  
reserved

**d**  
d coefficient for 2x2 MACC conversion matrix.

**reserved3**  
reserved

**struct ipu3\_uapi\_yuvp2\_tcc\_macc\_table\_static\_config**  
Total color correction multi-axis color control (MACC) table array

#### Definition:

```
struct ipu3_uapi_yuvp2_tcc_macc_table_static_config {
    struct ipu3_uapi_yuvp2_tcc_macc_elem_static_config entries[IPU3_UAPI_YUVP2_
    ↴TCC_MACC_TABLE_ELEMENTS];
};
```

#### Members

**entries**  
config for multi axis color correction, as specified by *ipu3\_uapi\_yuvp2\_tcc\_macc\_elem\_static\_config*

**struct ipu3\_uapi\_yuvp2\_tcc\_inv\_y\_lut\_static\_config**  
Total color correction inverse y lookup table

#### Definition:

```
struct ipu3_uapi_yuvp2_tcc_inv_y_lut_static_config {
    __u16 entries[IPU3_UAPI_YUVP2_TCC_INV_Y_LUT_ELEMENTS];
};
```

#### Members

**entries**  
lookup table for inverse y estimation, and use it to estimate the ratio between luma and chroma. Chroma by approximate the absolute value of the radius on the chroma plane ( $R = \sqrt{u^2+v^2}$ ) and luma by approximate by  $1/Y$ .

**struct ipu3\_uapi\_yuvp2\_tcc\_gain\_pcwl\_lut\_static\_config**  
Total color correction lookup table for PCWL

#### Definition:

```
struct ipu3_uapi_yuvp2_tcc_gain_pcwl_lut_static_config {
    __u16 entries[IPU3_UAPI_YUVP2_TCC_GAIN_PCWL_LUT_ELEMENTS];
};
```

**Members****entries**

lookup table for gain piece wise linear transformation (PCWL)

**struct ipu3\_uapi\_yuvp2\_tcc\_r\_sqr\_lut\_static\_config**

Total color correction lookup table for r square root

**Definition:**

```
struct ipu3_uapi_yuvp2_tcc_r_sqr_lut_static_config {
    __s16 entries[IPU3_UAPI_YUVP2_TCC_R_SQR_LUT_ELEMENTS];
};
```

**Members****entries**

lookup table for r square root estimation

**struct ipu3\_uapi\_yuvp2\_tcc\_static\_config**

Total color correction static

**Definition:**

```
struct ipu3_uapi_yuvp2_tcc_static_config {
    struct ipu3_uapi_yuvp2_tcc_gen_control_static_config gen_control;
    struct ipu3_uapi_yuvp2_tcc_macc_table_static_config macc_table;
    struct ipu3_uapi_yuvp2_tcc_inv_y_lut_static_config inv_y_lut;
    struct ipu3_uapi_yuvp2_tcc_gain_pcwl_lut_static_config gain_pcwl;
    struct ipu3_uapi_yuvp2_tcc_r_sqr_lut_static_config r_sqr_lut;
};
```

**Members****gen\_control**

general config for Total Color Correction

**macc\_table**

config for multi axis color correction

**inv\_y\_lut**

lookup table for inverse y estimation

**gain\_pcwl**

lookup table for gain PCWL

**r\_sqr\_lut**

lookup table for r square root estimation.

**struct ipu3\_uapi\_anr\_transform\_config**

Advanced noise reduction transform

**Definition:**

```

struct ipu3_uapi_anr_transform_config {
    __u32 enable:1;
    __u32 adaptive_threshold_en:1;
    __u32 reserved1:30;
    __u8 reserved2[44];
    struct ipu3_uapi_anr_alpha alpha[3];
    struct ipu3_uapi_anr_beta beta[3];
    struct ipu3_uapi_anr_plane_color color[3];
    __u16 sqrt_lut[IPU3_UAPI_ANR_LUT_SIZE];
    __s16 xreset:13;
    __u16 reserved3:3;
    __s16 yreset:13;
    __u16 reserved4:3;
    __u32 x_sqr_reset:24;
    __u32 r_normfactor:5;
    __u32 reserved5:3;
    __u32 y_sqr_reset:24;
    __u32 gain_scale:8;
};

```

## Members

### **enable**

advanced noise reduction enabled.

### **adaptive\_threshold\_en**

On IPU3, adaptive threshold is always enabled.

### **reserved1**

reserved

### **reserved2**

reserved

### **alpha**

using following defaults: 13, 13, 13, 13, 0, 0, 0, 0 11, 11, 11, 11, 0, 0, 0, 0 14, 14, 14, 14, 0, 0, 0, 0

### **beta**

use following defaults: 24, 24, 24, 24 21, 20, 20, 21 25, 25, 25, 25

### **color**

use defaults defined in driver/media/pci/intel/ipu3-tables.c

### **sqrt\_lut**

11 bits per element, values = [724 768 810 849 887 923 958 991 1024 1056 1116 1145 1173 1201 1086 1228 1254 1280 1305 1330 1355 1379 1402 1425 1448]

### **xreset**

Reset value of X for  $r^2$  calculation Value: col\_start-X\_center Constraint: Xreset + FrameWidth=4095 Xreset= -4095, default -1632.

### **reserved3**

reserved

### **yreset**

Reset value of Y for  $r^2$  calculation Value: row\_start-Y\_center Constraint: Yreset + Frame-Height=4095 Yreset= -4095, default -1224.

**reserved4**

reserved

**x\_sqr\_reset**

Reset value of  $X^2$  for  $r^2$  calculation Value =  $(X_{reset})^2$

**r\_normfactor**

Normalization factor for R. Default 14.

**reserved5**

reserved

**y\_sqr\_reset**

Reset value of  $Y^2$  for  $r^2$  calculation Value =  $(Y_{reset})^2$

**gain\_scale**

Parameter describing shading gain as a function of distance from the image center. A single value per frame, loaded by the driver. Default 115.

**struct ipu3\_uapi\_anr\_stitch\_pyramid**

ANR stitch pyramid

**Definition:**

```
struct ipu3_uapi_anr_stitch_pyramid {
    __u32 entry0:6;
    __u32 entry1:6;
    __u32 entry2:6;
    __u32 reserved:14;
};
```

**Members****entry0**

pyramid LUT entry0, range [0x0, 0x3f]

**entry1**

pyramid LUT entry1, range [0x0, 0x3f]

**entry2**

pyramid LUT entry2, range [0x0, 0x3f]

**reserved**

reserved

**struct ipu3\_uapi\_anr\_stitch\_config**

ANR stitch config

**Definition:**

```
struct ipu3_uapi_anr_stitch_config {
    __u32 anr_stitch_en;
    __u8 reserved[44];
    struct ipu3_uapi_anr_stitch_pyramid pyramid[IPU3_UAPI_ANR_PYRAMID_SIZE];
};
```

**Members****anr\_stitch\_en**

enable stitch. Enabled with 1.

**reserved**

reserved

**pyramid**

pyramid table as defined by [\*ipu3\\_uapi\\_anr\\_stitch\\_pyramid\*](#) default values: { 1, 3, 5 }, { 7, 7, 5 }, { 3, 1, 3 }, { 9, 15, 21 }, { 21, 15, 9 }, { 3, 5, 15 }, { 25, 35, 35 }, { 25, 15, 5 }, { 7, 21, 35 }, { 49, 49, 35 }, { 21, 7, 7 }, { 21, 35, 49 }, { 49, 35, 21 }, { 7, 5, 15 }, { 25, 35, 35 }, { 25, 15, 5 }, { 3, 9, 15 }, { 21, 21, 15 }, { 9, 3, 1 }, { 3, 5, 7 }, { 7, 5, 3 }, { 1 }

**struct ipu3\_uapi\_anr\_config**

ANR config

**Definition:**

```
struct ipu3_uapi_anr_config {
    struct ipu3_uapi_anr_transform_config transform ;
    struct ipu3_uapi_anr_stitch_config stitch ;
};
```

**Members****transform**

advanced noise reduction transform config as specified by  
[\*ipu3\\_uapi\\_anr\\_transform\\_config\*](#)

**stitch**

create 4x4 patch from 4 surrounding 8x8 patches.

**struct ipu3\_uapi\_acc\_param**

Accelerator cluster parameters

**Definition:**

```
struct ipu3_uapi_acc_param {
    struct ipu3_uapi_bnr_static_config bnr;
    struct ipu3_uapi_bnr_static_config_green_disparity green_disparity ;
    struct ipu3_uapi_dm_config dm ;
    struct ipu3_uapi_ccm_mat_config ccm ;
    struct ipu3_uapi_gamma_config gamma ;
    struct ipu3_uapi_csc_mat_config csc ;
    struct ipu3_uapi_cds_params cds ;
    struct ipu3_uapi_shd_config shd ;
    struct ipu3_uapi_yuvpl_iefd_config iefd ;
    struct ipu3_uapi_yuvpl_yds_config yds_c0 ;
    struct ipu3_uapi_yuvpl_chnr_config chnr_c0 ;
    struct ipu3_uapi_yuvpl_y_ee_nr_config y_ee_nr ;
    struct ipu3_uapi_yuvpl_yds_config yds ;
    struct ipu3_uapi_yuvpl_chnr_config chnr ;
    struct ipu3_uapi_yuvpl_yds_config yds2 ;
    struct ipu3_uapi_yuvp2_tcc_static_config tcc ;
    struct ipu3_uapi_anr_config anr;
```

```

    struct ipu3_uapi_awb_fr_config_s awb_fr;
    struct ipu3_uapi_ae_config ae;
    struct ipu3_uapi_af_config_s af;
    struct ipu3_uapi_awb_config awb;
};

}

```

## Members

- bnr** parameters for bayer noise reduction static config. See [\*ipu3\\_uapi\\_bnr\\_static\\_config\*](#)
- green\_disparity** disparity static config between gr and gb channel. See [\*ipu3\\_uapi\\_bnr\\_static\\_config\\_green\\_disparity\*](#)
- dm** de-mosaic config. See [\*ipu3\\_uapi\\_dm\\_config\*](#)
- ccm** color correction matrix. See [\*ipu3\\_uapi\\_ccm\\_mat\\_config\*](#)
- gamma** gamma correction config. See [\*ipu3\\_uapi\\_gamma\\_config\*](#)
- csc** color space conversion matrix. See [\*ipu3\\_uapi\\_csc\\_mat\\_config\*](#)
- cds** color down sample config. See [\*ipu3\\_uapi\\_cds\\_params\*](#)
- shd** lens shading correction config. See [\*ipu3\\_uapi\\_shd\\_config\*](#)
- iefd** Image enhancement filter and denoise config. [\*ipu3\\_uapi\\_yuvp1\\_iefd\\_config\*](#)
- yds\_c0** y down scaler config. [\*ipu3\\_uapi\\_yuvp1\\_yds\\_config\*](#)
- chnr\_c0** chroma noise reduction config. [\*ipu3\\_uapi\\_yuvp1\\_chnr\\_config\*](#)
- y\_ee\_nr** y edge enhancement and noise reduction config. [\*ipu3\\_uapi\\_yuvp1\\_y\\_ee\\_nr\\_config\*](#)
- yds** y down scaler config. See [\*ipu3\\_uapi\\_yuvp1\\_yds\\_config\*](#)
- chnr** chroma noise reduction config. See [\*ipu3\\_uapi\\_yuvp1\\_chnr\\_config\*](#)
- yds2** y channel down scaler config. See [\*ipu3\\_uapi\\_yuvp1\\_yds\\_config\*](#)
- tcc** total color correction config as defined in struct [\*ipu3\\_uapi\\_yuvp2\\_tcc\\_static\\_config\*](#)
- anr** advanced noise reduction config. See [\*ipu3\\_uapi\\_anr\\_config\*](#)

### **awb\_fr**

AWB filter response config. See `ipu3_uapi_awb_fr_config`

### **ae**

auto exposure config As specified by `ipu3_uapi_ae_config`

### **af**

auto focus config. As specified by `ipu3_uapi_af_config`

### **awb**

auto white balance config. As specified by `ipu3_uapi_awb_config`

## Description

ACC refers to the HW cluster containing all Fixed Functions (FFs). Each FF implements a specific algorithm.

### struct `ipu3_uapi_isp_lin_vmem_params`

Linearization parameters

### Definition:

```
struct ipu3_uapi_isp_lin_vmem_params {  
    __s16 lin_lutlow_gr[IPU3_UAPI_LIN_LUT_SIZE];  
    __s16 lin_lutlow_r[IPU3_UAPI_LIN_LUT_SIZE];  
    __s16 lin_lutlow_b[IPU3_UAPI_LIN_LUT_SIZE];  
    __s16 lin_lutlow_gb[IPU3_UAPI_LIN_LUT_SIZE];  
    __s16 lin_lutdif_gr[IPU3_UAPI_LIN_LUT_SIZE];  
    __s16 lin_lutdif_r[IPU3_UAPI_LIN_LUT_SIZE];  
    __s16 lin_lutdif_b[IPU3_UAPI_LIN_LUT_SIZE];  
    __s16 lin_lutdif_gb[IPU3_UAPI_LIN_LUT_SIZE];  
};
```

## Members

### **lin\_lutlow\_gr**

linearization look-up table for GR channel interpolation.

### **lin\_lutlow\_r**

linearization look-up table for R channel interpolation.

### **lin\_lutlow\_b**

linearization look-up table for B channel interpolation.

### **lin\_lutlow\_gb**

linearization look-up table for GB channel interpolation. `lin_lutlow_gr / lin_lutlow_r / lin_lutlow_b / lin_lutlow_gb <= LIN_MAX_VALUE - 1.`

### **lin\_lutdif\_gr**

`lin_lutlow_gr[i+1] - lin_lutlow_gr[i].`

### **lin\_lutdif\_r**

`lin_lutlow_r[i+1] - lin_lutlow_r[i].`

### **lin\_lutdif\_b**

`lin_lutlow_b[i+1] - lin_lutlow_b[i].`

### **lin\_lutdif\_gb**

`lin_lutlow_gb[i+1] - lin_lutlow_gb[i].`

**struct ipu3\_uapi\_isp\_tnr3\_vmem\_params**

Temporal noise reduction vector memory parameters

**Definition:**

```
struct ipu3_uapi_isp_tnr3_vmem_params {
    __u16 slope[IPU3_UAPI_ISP_TNR3_VMEM_LEN];
    __u16 reserved1[IPU3_UAPI_ISP_VEC_ELEMS - IPU3_UAPI_ISP_TNR3_VMEM_LEN];
    __u16 sigma[IPU3_UAPI_ISP_TNR3_VMEM_LEN];
    __u16 reserved2[IPU3_UAPI_ISP_VEC_ELEMS - IPU3_UAPI_ISP_TNR3_VMEM_LEN];
};
```

**Members****slope**

slope setting in interpolation curve for temporal noise reduction.

**reserved1**

reserved

**sigma**

knee point setting in interpolation curve for temporal noise reduction.

**reserved2**

reserved

**struct ipu3\_uapi\_isp\_tnr3\_params**

Temporal noise reduction v3 parameters

**Definition:**

```
struct ipu3_uapi_isp_tnr3_params {
    __u32 knee_y1;
    __u32 knee_y2;
    __u32 maxfb_y;
    __u32 maxfb_u;
    __u32 maxfb_v;
    __u32 round_adj_y;
    __u32 round_adj_u;
    __u32 round_adj_v;
    __u32 ref_buf_select;
};
```

**Members****knee\_y1**

Knee point TNR3 assumes standard deviation of Y,U and V at Y1 are TnrY1\_Sigma\_Y, U and V.

**knee\_y2**

Knee point TNR3 assumes standard deviation of Y,U and V at Y2 are TnrY2\_Sigma\_Y, U and V.

**maxfb\_y**

Max feedback gain for Y

**maxfb\_u**  
 Max feedback gain for U

**maxfb\_v**  
 Max feedback gain for V

**round\_adj\_y**  
 rounding Adjust for Y

**round\_adj\_u**  
 rounding Adjust for U

**round\_adj\_v**  
 rounding Adjust for V

**ref\_buf\_select**  
 selection of the reference frame buffer to be used.

**struct ipu3\_uapi\_isp\_xnr3\_vmem\_params**  
 Extreme noise reduction v3 vector memory parameters

#### Definition:

```
struct ipu3_uapi_isp_xnr3_vmem_params {
    __u16 x[IPU3_UAPI_ISP_VEC_ELEMS];
    __u16 a[IPU3_UAPI_ISP_VEC_ELEMS];
    __u16 b[IPU3_UAPI_ISP_VEC_ELEMS];
    __u16 c[IPU3_UAPI_ISP_VEC_ELEMS];
};
```

#### Members

**x**  
 xnr3 parameters.

**a**  
 xnr3 parameters.

**b**  
 xnr3 parameters.

**c**  
 xnr3 parameters.

**struct ipu3\_uapi\_xnr3\_alpha\_params**  
 Extreme noise reduction v3 alpha tuning parameters

#### Definition:

```
struct ipu3_uapi_xnr3_alpha_params {
    __u32 y0;
    __u32 u0;
    __u32 v0;
    __u32 ydiff;
    __u32 udiff;
    __u32 vdiff;
};
```

**Members****y0**

Sigma for Y range similarity in dark area.

**u0**

Sigma for U range similarity in dark area.

**v0**

Sigma for V range similarity in dark area.

**ydiff**

Sigma difference for Y between bright area and dark area.

**udiff**

Sigma difference for U between bright area and dark area.

**vdiff**

Sigma difference for V between bright area and dark area.

**struct ipu3\_uapi\_xnr3\_coring\_params**

Extreme noise reduction v3 coring parameters

**Definition:**

```
struct ipu3_uapi_xnr3_coring_params {
    __u32 u0;
    __u32 v0;
    __u32 udiff;
    __u32 vdiff;
};
```

**Members****u0**

Coring Threshold of U channel in dark area.

**v0**

Coring Threshold of V channel in dark area.

**udiff**

Threshold difference of U channel between bright and dark area.

**vdiff**

Threshold difference of V channel between bright and dark area.

**struct ipu3\_uapi\_xnr3\_blending\_params**

Blending factor

**Definition:**

```
struct ipu3_uapi_xnr3_blending_params {
    __u32 strength;
};
```

**Members**

### **strength**

The factor for blending output with input. This is tuning parameterHigher values lead to more aggressive XNR operation.

**struct ipu3\_uapi\_isp\_xnr3\_params**  
Extreme noise reduction v3 parameters

### **Definition:**

```
struct ipu3_uapi_isp_xnr3_params {  
    struct ipu3_uapi_xnr3_alpha_params alpha;  
    struct ipu3_uapi_xnr3_coring_params coring;  
    struct ipu3_uapi_xnr3_blending_params blending;  
};
```

### **Members**

#### **alpha**

parameters for xnr3 alpha. See [\*ipu3\\_uapi\\_xnr3\\_alpha\\_params\*](#)

#### **coring**

parameters for xnr3 coring. See [\*ipu3\\_uapi\\_xnr3\\_coring\\_params\*](#)

#### **blending**

parameters for xnr3 blending. See [\*ipu3\\_uapi\\_xnr3\\_blending\\_params\*](#)

### **struct ipu3\_uapi\_obgrid\_param**

Optical black level compensation parameters

### **Definition:**

```
struct ipu3_uapi_obgrid_param {  
    __u16 gr;  
    __u16 r;  
    __u16 b;  
    __u16 gb;  
};
```

### **Members**

#### **gr**

Grid table values for color GR

#### **r**

Grid table values for color R

#### **b**

Grid table values for color B

#### **gb**

Grid table values for color GB

### **Description**

Black level is different for red, green, and blue channels. So black level compensation is different per channel.

**struct ipu3\_uapi\_flags**  
 bits to indicate which pipeline needs update

**Definition:**

```
struct ipu3_uapi_flags {
    __u32 gdc:1;
    __u32 obgrid:1;
    __u32 reserved1:30;
    __u32 acc_bnr:1;
    __u32 acc_green_disparity:1;
    __u32 acc_dm:1;
    __u32 acc_ccm:1;
    __u32 acc_gamma:1;
    __u32 acc_csc:1;
    __u32 acc_cds:1;
    __u32 acc_shd:1;
    __u32 reserved2:2;
    __u32 acc_iefd:1;
    __u32 acc_yds_c0:1;
    __u32 acc_chnr_c0:1;
    __u32 acc_y_ee_nr:1;
    __u32 acc_yds:1;
    __u32 acc_chnr:1;
    __u32 acc_ytm:1;
    __u32 acc_yds2:1;
    __u32 acc_tcc:1;
    __u32 acc_dpc:1;
    __u32 acc_bds:1;
    __u32 acc_anr:1;
    __u32 acc_awb_fr:1;
    __u32 acc_ae:1;
    __u32 acc_af:1;
    __u32 acc_awb:1;
    __u32 reserved3:4;
    __u32 lin_vmem_params:1;
    __u32 tnr3_vmem_params:1;
    __u32 xnr3_vmem_params:1;
    __u32 tnr3_dmem_params:1;
    __u32 xnr3_dmem_params:1;
    __u32 reserved4:1;
    __u32 obgrid_param:1;
    __u32 reserved5:25;
};
```

**Members****gdc**

0 = no update, 1 = update.

**obgrid**

0 = no update, 1 = update.

**reserved1**

Not used.

**acc\_bnr**

0 = no update, 1 = update.

**acc\_green\_disparity**

0 = no update, 1 = update.

**acc\_dm**

0 = no update, 1 = update.

**acc\_ccm**

0 = no update, 1 = update.

**acc\_gamma**

0 = no update, 1 = update.

**acc\_csc**

0 = no update, 1 = update.

**acc\_cds**

0 = no update, 1 = update.

**acc\_shd**

0 = no update, 1 = update.

**reserved2**

Not used.

**acc\_iefd**

0 = no update, 1 = update.

**acc\_yds\_c0**

0 = no update, 1 = update.

**acc\_chnr\_c0**

0 = no update, 1 = update.

**acc\_y\_ee\_nr**

0 = no update, 1 = update.

**acc\_yds**

0 = no update, 1 = update.

**acc\_chnr**

0 = no update, 1 = update.

**acc\_ytm**

0 = no update, 1 = update.

**acc\_yds2**

0 = no update, 1 = update.

**acc\_tcc**

0 = no update, 1 = update.

**acc\_dpc**

0 = no update, 1 = update.

**acc\_bds**  
0 = no update, 1 = update.

**acc\_anr**  
0 = no update, 1 = update.

**acc\_awb\_fr**  
0 = no update, 1 = update.

**acc\_ae**  
0 = no update, 1 = update.

**acc\_af**  
0 = no update, 1 = update.

**acc\_awb**  
0 = no update, 1 = update.

**reserved3**  
Not used.

**lin\_vmem\_params**  
0 = no update, 1 = update.

**tnr3\_vmem\_params**  
0 = no update, 1 = update.

**xnr3\_vmem\_params**  
0 = no update, 1 = update.

**tnr3\_dmem\_params**  
0 = no update, 1 = update.

**xnr3\_dmem\_params**  
0 = no update, 1 = update.

**reserved4**  
Not used.

**obgrid\_param**  
0 = no update, 1 = update.

**reserved5**  
Not used.

**struct ipu3\_uapi\_params**  
V4L2\_META\_FMT\_IPU3\_PARAMS

#### Definition:

```
struct ipu3_uapi_params {
    struct ipu3_uapi_flags use ;
    struct ipu3_uapi_acc_param acc_param;
    struct ipu3_uapi_isp_lin_vmem_params lin_vmem_params;
    struct ipu3_uapi_isp_tnr3_vmem_params tnr3_vmem_params;
    struct ipu3_uapi_isp_xnr3_vmem_params xnr3_vmem_params;
    struct ipu3_uapi_isp_tnr3_params tnr3_dmem_params;
    struct ipu3_uapi_isp_xnr3_params xnr3_dmem_params;
```

```
    struct ipu3_uapi_obgrid_param obgrid_param;  
};
```

## Members

### use

select which parameters to apply, see *ipu3\_uapi\_flags*

### acc\_param

ACC parameters, as specified by *ipu3\_uapi\_acc\_param*

### lin\_vmem\_params

linearization VMEM, as specified by *ipu3\_uapi\_isp\_lin\_vmem\_params*

### tnr3\_vmem\_params

tnr3 VMEM as specified by *ipu3\_uapi\_isp\_tnr3\_vmem\_params*

### xnr3\_vmem\_params

xnr3 VMEM as specified by *ipu3\_uapi\_isp\_xnr3\_vmem\_params*

### tnr3\_dmem\_params

tnr3 DMEM as specified by *ipu3\_uapi\_isp\_tnr3\_params*

### xnr3\_dmem\_params

xnr3 DMEM as specified by *ipu3\_uapi\_isp\_xnr3\_params*

### obgrid\_param

obgrid parameters as specified by *ipu3\_uapi\_obgrid\_param*

## Description

The video queue "parameters" is of format V4L2\_META\_FMT\_IPU3\_PARAMS. This is a "single plane" v4l2\_meta\_format using V4L2\_BUF\_TYPE\_META\_OUTPUT.

*struct ipu3\_uapi\_params* as defined below contains a lot of parameters and *ipu3\_uapi\_flags* selects which parameters to apply.

**V4L2\_META\_FMT\_RK\_ISP1\_PARAMS ('rk1p'), V4L2\_META\_FMT\_RK\_ISP1\_STAT\_3A ('rk1s')**

## Configuration parameters

The configuration parameters are passed to the rkisp1\_params metadata output video node, using the *v4l2\_meta\_format* interface. The buffer contains a single instance of the C structure *rkisp1\_params\_cfg* defined in *rkisp1-config.h*. So the structure can be obtained from the buffer by:

```
struct rkisp1_params_cfg *params = (struct rkisp1_params_cfg*) buffer;
```

### 3A and histogram statistics

The ISP1 device collects different statistics over an input Bayer frame. Those statistics are obtained from the rkisp1\_stats metadata capture video node, using the `v4l2_meta_format` interface. The buffer contains a single instance of the C structure `rkisp1_stat_buffer` defined in `rkisp1-config.h`. So the structure can be obtained from the buffer by:

```
struct rkisp1_stat_buffer *stats = (struct rkisp1_stat_buffer*) buffer;
```

The statistics collected are Exposure, AWB (Auto-white balance), Histogram and AF (Auto-focus). See `rkisp1_stat_buffer` for details of the statistics.

The 3A statistics and configuration parameters described here are usually consumed and produced by dedicated user space libraries that comprise the important tuning tools using software control loop.

### rkisp1 uAPI data types

#### enum `rkisp1_cif_isp_version`

ISP variants

#### Constants

##### `RKISP1_V10`

used at least in rk3288 and rk3399

##### `RKISP1_V11`

declared in the original vendor code, but not used

##### `RKISP1_V12`

used at least in rk3326 and px30

##### `RKISP1_V13`

used at least in rk1808

#### enum `rkisp1_cif_isp_exp_ctrl_autostop`

stop modes

#### Constants

##### `RKISP1_CIF_ISP_EXP_CTRL_AUTOSTOP_0`

continuous measurement

##### `RKISP1_CIF_ISP_EXP_CTRL_AUTOSTOP_1`

stop measuring after a complete frame

#### enum `rkisp1_cif_isp_exp_meas_mode`

Exposure measure mode

#### Constants

##### `RKISP1_CIF_ISP_EXP_MEASURING_MODE_0`

$Y = 16 + 0.25R + 0.5G + 0.1094B$

##### `RKISP1_CIF_ISP_EXP_MEASURING_MODE_1`

$Y = (R + G + B) \times (85/256)$

struct **rkisp1\_cif\_isp\_window**

measurement window.

### Definition:

```
struct rkisp1_cif_isp_window {  
    __u16 h_offs;  
    __u16 v_offs;  
    __u16 h_size;  
    __u16 v_size;  
};
```

### Members

#### **h\_offs**

the horizontal offset of the window from the left of the frame in pixels.

#### **v\_offs**

the vertical offset of the window from the top of the frame in pixels.

#### **h\_size**

the horizontal size of the window in pixels

#### **v\_size**

the vertical size of the window in pixels.

### Description

Measurements are calculated per window inside the frame. This struct represents a window for a measurement.

struct **rkisp1\_cif\_isp\_bls\_fixed\_val**

BLS fixed subtraction values

### Definition:

```
struct rkisp1_cif_isp_bls_fixed_val {  
    __s16 r;  
    __s16 gr;  
    __s16 gb;  
    __s16 b;  
};
```

### Members

#### **r**

Fixed (signed!) subtraction value for Bayer pattern R

#### **gr**

Fixed (signed!) subtraction value for Bayer pattern Gr

#### **gb**

Fixed (signed!) subtraction value for Bayer pattern Gb

#### **b**

Fixed (signed!) subtraction value for Bayer pattern B

### Description

The values will be subtracted from the sensor values. Therefore a negative value means addition instead of subtraction!

### **struct rkisp1\_cif\_isp\_bls\_config**

Configuration used by black level subtraction

#### **Definition:**

```
struct rkisp1_cif_isp_bls_config {
    __u8 enable_auto;
    __u8 en_windows;
    struct rkisp1_cif_isp_window bls_window1;
    struct rkisp1_cif_isp_window bls_window2;
    __u8 bls_samples;
    struct rkisp1_cif_isp_bls_fixed_val fixed_val;
};
```

#### **Members**

##### **enable\_auto**

Automatic mode activated means that the measured values are subtracted. Otherwise the fixed subtraction values will be subtracted.

##### **en\_windows**

enabled window

##### **bls\_window1**

Measurement window 1 size

##### **bls\_window2**

Measurement window 2 size

##### **bls\_samples**

Set amount of measured pixels for each Bayer position (A, B,C and D) to  $2^{bls\_samples}$ .

##### **fixed\_val**

Fixed subtraction values

### **struct rkisp1\_cif\_isp\_dpcc\_methods\_config**

DPCC methods set configuration

#### **Definition:**

```
struct rkisp1_cif_isp_dpcc_methods_config {
    __u32 method;
    __u32 line_thresh;
    __u32 line_mad_fac;
    __u32 pg_fac;
    __u32 rnd_thresh;
    __u32 rg_fac;
};
```

#### **Members**

##### **method**

Method enable bits (RKISP1\_CIF\_ISP\_DPCC\_METHODS\_SET\_\*)

**line\_thresh**

Line threshold (RKISP1\_CIF\_ISP\_DPCC\_LINE\_THRESH\_\*)

**line\_mad\_fac**

Line Mean Absolute Difference factor (RKISP1\_CIF\_ISP\_DPCC\_LINE\_MAD\_FAC\_\*)

**pg\_fac**

Peak gradient factor (RKISP1\_CIF\_ISP\_DPCC\_PG\_FAC\_\*)

**rnd\_thresh**

Rank Neighbor Difference threshold (RKISP1\_CIF\_ISP\_DPCC\_RND\_THRESH\_\*)

**rg\_fac**

Rank gradient factor (RKISP1\_CIF\_ISP\_DPCC\_RG\_FAC\_\*)

**Description**

This structure stores the configuration of one set of methods for the DPCC algorithm. Multiple methods can be selected in each set (independently for the Green and Red/Blue components) through the **method** field, the result is the logical AND of all enabled methods. The remaining fields set thresholds and factors for each method.

**struct rkisp1\_cif\_isp\_dpcc\_config**

Configuration used by DPCC

**Definition:**

```
struct rkisp1_cif_isp_dpcc_config {
    __u32 mode;
    __u32 output_mode;
    __u32 set_use;
    struct rkisp1_cif_isp_dpcc_methods_config methods[RKISP1_CIF_ISP_DPCC_
    METHODS_MAX];
    __u32 ro_limits;
    __u32 rnd_offs;
};
```

**Members****mode**

DPCC mode (RKISP1\_CIF\_ISP\_DPCC\_MODE\_\*)

**output\_mode**

Interpolation output mode (RKISP1\_CIF\_ISP\_DPCC\_OUTPUT\_MODE\_\*)

**set\_use**

Methods sets selection (RKISP1\_CIF\_ISP\_DPCC\_SET\_USE\_\*)

**methods**

Methods sets configuration

**ro\_limits**

Rank order limits (RKISP1\_CIF\_ISP\_DPCC\_RO\_LIMITS\_\*)

**rnd\_offs**

Differential rank offsets for rank neighbor difference (RKISP1\_CIF\_ISP\_DPCC\_RND\_OFFSET\_\*)

## Description

Configuration used by Defect Pixel Cluster Correction. Three sets of methods can be configured and selected through the **set\_use** field. The result is the logical OR of all enabled sets.

**struct rkisp1\_cif\_isp\_gamma\_corr\_curve**

gamma curve point definition y-axis (output).

### Definition:

```
struct rkisp1_cif_isp_gamma_corr_curve {
    __u16 gamma_y[RKISP1_CIF_ISP_DEGAMMA_CURVE_SIZE];
};
```

## Members

**gamma\_y**

the values for the y-axis of gamma curve points. Each value is 12 bit.

### Description

The reset values define a linear curve which has the same effect as bypass. Reset values are: gamma\_y[0] = 0x0000, gamma\_y[1] = 0x0100, ... gamma\_y[15] = 0x0f00, gamma\_y[16] = 0xffff

**struct rkisp1\_cif\_isp\_gamma\_curve\_x\_axis\_pnts**

De-Gamma Curve definition x increments (sampling points). gamma\_dx0 is for the lower samples (1-8), gamma\_dx1 is for the higher samples (9-16). The reset values for both fields is 0x44444444. This means that each sample is 4 units away from the previous one on the x-axis.

### Definition:

```
struct rkisp1_cif_isp_gamma_curve_x_axis_pnts {
    __u32 gamma_dx0;
    __u32 gamma_dx1;
};
```

## Members

**gamma\_dx0**

gamma curve sample points definitions. Bits 0:2 for sample 1. Bit 3 unused. Bits 4:6 for sample 2. bit 7 unused ... Bits 28:30 for sample 8. Bit 31 unused

**gamma\_dx1**

gamma curve sample points definitions. Bits 0:2 for sample 9. Bit 3 unused. Bits 4:6 for sample 10. bit 7 unused ... Bits 28:30 for sample 16. Bit 31 unused

**struct rkisp1\_cif\_isp\_sdg\_config**

Configuration used by sensor degamma

### Definition:

```
struct rkisp1_cif_isp_sdg_config {
    struct rkisp1_cif_isp_gamma_corr_curve curve_r;
    struct rkisp1_cif_isp_gamma_corr_curve curve_g;
    struct rkisp1_cif_isp_gamma_corr_curve curve_b;
```

```
    struct rkisp1_cif_isp_gamma_curve_x_axis_pnts xa_pnts;
};
```

**Members****curve\_r**

gamma curve point definition axis for red

**curve\_g**

gamma curve point definition axis for green

**curve\_b**

gamma curve point definition axis for blue

**xa\_pnts**

x axis increments

**struct rkisp1\_cif\_isp\_lsc\_config**

Configuration used by Lens shading correction

**Definition:**

```
struct rkisp1_cif_isp_lsc_config {
    __u16 r_data_tbl[RKISP1_CIF_ISP_LSC_SAMPLES_MAX][RKISP1_CIF_ISP_LSC_
    ↵SAMPLES_MAX];
    __u16 gr_data_tbl[RKISP1_CIF_ISP_LSC_SAMPLES_MAX][RKISP1_CIF_ISP_LSC_
    ↵SAMPLES_MAX];
    __u16 gb_data_tbl[RKISP1_CIF_ISP_LSC_SAMPLES_MAX][RKISP1_CIF_ISP_LSC_
    ↵SAMPLES_MAX];
    __u16 b_data_tbl[RKISP1_CIF_ISP_LSC_SAMPLES_MAX][RKISP1_CIF_ISP_LSC_
    ↵SAMPLES_MAX];
    __u16 x_grad_tbl[RKISP1_CIF_ISP_LSC_SECTORS_TBL_SIZE];
    __u16 y_grad_tbl[RKISP1_CIF_ISP_LSC_SECTORS_TBL_SIZE];
    __u16 x_size_tbl[RKISP1_CIF_ISP_LSC_SECTORS_TBL_SIZE];
    __u16 y_size_tbl[RKISP1_CIF_ISP_LSC_SECTORS_TBL_SIZE];
    __u16 config_width;
    __u16 config_height;
};
```

**Members****r\_data\_tbl**

sample table red

**gr\_data\_tbl**

sample table green (red)

**gb\_data\_tbl**

sample table green (blue)

**b\_data\_tbl**

sample table blue

**x\_grad\_tbl**

gradient table x

**y\_grad\_tbl**  
gradient table y

**x\_size\_tbl**  
size table x

**y\_size\_tbl**  
size table y

**config\_width**  
not used at the moment

**config\_height**  
not used at the moment

**struct rkisp1\_cif\_isp\_ie\_config**  
Configuration used by image effects

#### Definition:

```
struct rkisp1_cif_isp_ie_config {
    __u16 effect;
    __u16 color_sel;
    __u16 eff_mat_1;
    __u16 eff_mat_2;
    __u16 eff_mat_3;
    __u16 eff_mat_4;
    __u16 eff_mat_5;
    __u16 eff_tint;
};
```

#### Members

##### **effect**

values from 'enum v4l2\_colorfx'. Possible values are: V4L2\_COLORFX\_SEPIA, V4L2\_COLORFX\_SET\_CBCR, V4L2\_COLORFX\_AQUA, V4L2\_COLORFX\_EMBOSS, V4L2\_COLORFX\_SKETCH, V4L2\_COLORFX\_BW, V4L2\_COLORFX\_NEGATIVE

##### **color\_sel**

bits 0:2 - colors bitmask (001 - blue, 010 - green, 100 - red). bits 8:15 - Threshold value of the RGB colors for the color selection effect.

##### **eff\_mat\_1**

3x3 Matrix Coefficients for Emboss Effect 1

##### **eff\_mat\_2**

3x3 Matrix Coefficients for Emboss Effect 2

##### **eff\_mat\_3**

3x3 Matrix Coefficients for Emboss 3/Sketch 1

##### **eff\_mat\_4**

3x3 Matrix Coefficients for Sketch Effect 2

##### **eff\_mat\_5**

3x3 Matrix Coefficients for Sketch Effect 3

**eff\_tint**

Chrominance increment values of tint (used for sepia effect)

**struct rkisp1\_cif\_isp\_cproc\_config**

Configuration used by Color Processing

**Definition:**

```
struct rkisp1_cif_isp_cproc_config {
    __u8 c_out_range;
    __u8 y_in_range;
    __u8 y_out_range;
    __u8 contrast;
    __u8 brightness;
    __u8 sat;
    __u8 hue;
};
```

**Members****c\_out\_range**

Chrominance pixel clipping range at output. (0 for limit, 1 for full)

**y\_in\_range**

Luminance pixel clipping range at output.

**y\_out\_range**

Luminance pixel clipping range at output.

**contrast**

00~ff, 0.0~1.992

**brightness**

80~7F, -128~+127

**sat**

saturation, 00~FF, 0.0~1.992

**hue**

80~7F, -90~+87.188

**struct rkisp1\_cif\_isp\_awb\_meas\_config**

Configuration for the AWB statistics

**Definition:**

```
struct rkisp1_cif_isp_awb_meas_config {
    struct rkisp1_cif_isp_window awb_wnd;
    __u32 awb_mode;
    __u8 max_y;
    __u8 min_y;
    __u8 max_csum;
    __u8 min_c;
    __u8 frames;
    __u8 awb_ref_cr;
    __u8 awb_ref_cb;
```

```
    __u8 enable_ymax_cmp;
};
```

**Members****awb\_wnd**

white balance measurement window (in pixels)

**awb\_mode**

the awb meas mode. From enum rkisp1\_cif\_isp\_awb\_mode\_type.

**max\_y**

only pixels values < max\_y contribute to awb measurement, set to 0 to disable this feature

**min\_y**

only pixels values > min\_y contribute to awb measurement

**max\_csum**

Chrominance sum maximum value, only consider pixels with Cb+Cr, smaller than threshold for awb measurements

**min\_c**

Chrominance minimum value, only consider pixels with Cb/Cr each greater than threshold value for awb measurements

**frames**

number of frames - 1 used for mean value calculation (ucFrames=0 means 1 Frame)

**awb\_ref\_cr**

reference Cr value for AWB regulation, target for AWB

**awb\_ref\_cb**

reference Cb value for AWB regulation, target for AWB

**enable\_ymax\_cmp**

enable Y\_MAX compare (Not valid in RGB measurement mode.)

**struct rkisp1\_cif\_isp\_awb\_gain\_config**

Configuration used by auto white balance gain

**Definition:**

```
struct rkisp1_cif_isp_awb_gain_config {
    __u16 gain_red;
    __u16 gain_green_r;
    __u16 gain_blue;
    __u16 gain_green_b;
};
```

**Members****gain\_red**

gain value for red component.

**gain\_green\_r**

gain value for green component in red line.

**gain\_blue**

gain value for blue component.

**gain\_green\_b**

gain value for green component in blue line.

**Description**

All fields in this struct are 10 bit, where: 0x100h = 1, unsigned integer value, range 0 to 4 with 8 bit fractional part.

```
out_data_x = ( AWB_GAIN_X * in_data + 128) >> 8
```

**struct rkisp1\_cif\_isp\_flt\_config**

Configuration used by ISP filtering

**Definition:**

```
struct rkisp1_cif_isp_flt_config {
    __u32 mode;
    __u8 grn_stage1;
    __u8 chr_h_mode;
    __u8 chr_v_mode;
    __u32 thresh_b10;
    __u32 thresh_b11;
    __u32 thresh_sh0;
    __u32 thresh_sh1;
    __u32 lum_weight;
    __u32 fac_sh1;
    __u32 fac_sh0;
    __u32 fac_mid;
    __u32 fac_b10;
    __u32 fac_b11;
};
```

**Members****mode**

ISP\_FILT\_MODE register fields (from enum rkisp1\_cif\_isp\_flt\_mode)

**grn\_stage1**

Green filter stage 1 select (range 0x0...0x8)

**chr\_h\_mode**

Chroma filter horizontal mode

**chr\_v\_mode**

Chroma filter vertical mode

**thresh\_b10**

If  $\text{thresh\_b11} < \text{sum\_grad} < \text{thresh\_b10}$  then  $\text{fac\_b10}$  is selected (blurring th)

**thresh\_b11**

If  $\text{sum\_grad} < \text{thresh\_b11}$  then  $\text{fac\_b11}$  is selected (blurring th)

**thresh\_sh0**

If  $\text{thresh\_sh0} < \text{sum\_grad} < \text{thresh\_sh1}$  then  $\text{thresh\_sh0}$  is selected (sharpening th)

**thresh\_sh1**

If thresh\_sh1 < sum\_grad then thresh\_sh1 is selected (sharpening th)

**lum\_weight**

Parameters for luminance weight function.

**fac\_sh1**

filter factor for sharp1 level

**fac\_sh0**

filter factor for sharp0 level

**fac\_mid**

filter factor for mid level and for static filter mode

**fac\_b10**

filter factor for blur 0 level

**fac\_b11**

filter factor for blur 1 level (max blur)

**Description**

All 4 threshold fields (thresh\_\*) are 10 bits. All 6 factor fields (fac\_\*) are 6 bits.

**struct rkisp1\_cif\_isp\_bdm\_config**

Configuration used by Bayer DeMosaic

**Definition:**

```
struct rkisp1_cif_isp_bdm_config {
    __u8 demosaic_th;
};
```

**Members****demosaic\_th**

threshold for bayer demosaicing texture detection

**struct rkisp1\_cif\_isp\_ctk\_config**

Configuration used by Cross Talk correction

**Definition:**

```
struct rkisp1_cif_isp_ctk_config {
    __u16 coeff[3][3];
    __u16 ct_offset[3];
};
```

**Members****coeff**

color correction matrix. Values are 11-bit signed fixed-point numbers with 4 bit integer and 7 bit fractional part, ranging from -8 (0x400) to +7.992 (0x3FF). 0 is represented by 0x000 and a coefficient value of 1 as 0x080.

**ct\_offset**

Red, Green, Blue offsets for the crosstalk correction matrix

### struct rkisp1\_cif\_isp\_goc\_config

Configuration used by Gamma Out correction

#### Definition:

```
struct rkisp1_cif_isp_goc_config {  
    __u32 mode;  
    __u16 gamma_y[RKISP1_CIF_ISP_GAMMA_OUT_MAX_SAMPLES];  
};
```

#### Members

##### mode

goc mode (from enum rkisp1\_cif\_isp\_goc\_mode)

##### gamma\_y

gamma out curve y-axis for all color components

#### Description

The number of entries of **gamma\_y** depends on the hardware revision as is reported by the `hw_revision` field of the struct `media_device_info` that is returned by ioctl `MEDIA_IOC_DEVICE_INFO`.

Versions  $\leq$  V11 have `RKISP1_CIF_ISP_GAMMA_OUT_MAX_SAMPLES_V10` entries, versions  $\geq$  V12 have `RKISP1_CIF_ISP_GAMMA_OUT_MAX_SAMPLES_V12` entries. `RKISP1_CIF_ISP_GAMMA_OUT_MAX_SAMPLES` is equal to the maximum of the two.

### struct rkisp1\_cif\_isp\_hst\_config

Configuration for Histogram statistics

#### Definition:

```
struct rkisp1_cif_isp_hst_config {  
    __u32 mode;  
    __u8 histogram_predivider;  
    struct rkisp1_cif_isp_window meas_window;  
    __u8 hist_weight[RKISP1_CIF_ISP_HISTOGRAM_WEIGHT_GRIDS_SIZE];  
};
```

#### Members

##### mode

histogram mode (from enum rkisp1\_cif\_isp\_histogram\_mode)

##### histogram\_predivider

process every stepsize pixel, all other pixels are skipped

##### meas\_window

coordinates of the measure window

##### hist\_weight

weighting factor for sub-windows

#### Description

The number of entries of **hist\_weight** depends on the hardware revision as is reported

by the `hw_revision` field of the `struct media_device_info` that is returned by ioctl `ME-DIA_IOC_DEVICE_INFO`.

Versions <= V11 have `RKISP1_CIF_ISP_HISTOGRAM_WEIGHT_GRIDS_SIZE_V10` entries, versions >= V12 have `RKISP1_CIF_ISP_HISTOGRAM_WEIGHT_GRIDS_SIZE_V12` entries. `RKISP1_CIF_ISP_HISTOGRAM_WEIGHT_GRIDS_SIZE` is equal to the maximum of the two.

### `struct rkisp1_cif_isp_aec_config`

Configuration for Auto Exposure statistics

#### Definition:

```
struct rkisp1_cif_isp_aec_config {
    __u32 mode;
    __u32 autostop;
    struct rkisp1_cif_isp_window meas_window;
};
```

### Members

#### `mode`

Exposure measure mode (from `enum rkisp1_cif_isp_exp_meas_mode`)

#### `autostop`

stop mode (from `enum rkisp1_cif_isp_exp_ctrl_autostop`)

#### `meas_window`

coordinates of the measure window

### `struct rkisp1_cif_isp_afc_config`

Configuration for the Auto Focus statistics

#### Definition:

```
struct rkisp1_cif_isp_afc_config {
    __u8 num_afm_win;
    struct rkisp1_cif_isp_window afm_win[RKISP1_CIF_ISP_AFM_MAX_WINDOWS];
    __u32 thres;
    __u32 var_shift;
};
```

### Members

#### `num_afm_win`

max `RKISP1_CIF_ISP_AFM_MAX_WINDOWS`

#### `afm_win`

coordinates of the meas window

#### `thres`

threshold used for minimizing the influence of noise

#### `var_shift`

the number of bits for the shift operation at the end of the calculation chain.

### `enum rkisp1_cif_isp_dpf_gain_usage`

dpf gain usage

## Constants

**RKISP1\_CIF\_ISP\_DPF\_GAIN\_USAGE\_DISABLED**

don't use any gains in preprocessing stage

**RKISP1\_CIF\_ISP\_DPF\_GAIN\_USAGE\_NF\_GAINS**

use only the noise function gains from registers DPF\_NF\_GAIN\_R, ...

**RKISP1\_CIF\_ISP\_DPF\_GAIN\_USAGE\_LSC\_GAINS**

use only the gains from LSC module

**RKISP1\_CIF\_ISP\_DPF\_GAIN\_USAGE\_NF\_LSC\_GAINS**

use the noise function gains and the gains from LSC module

**RKISP1\_CIF\_ISP\_DPF\_GAIN\_USAGE\_AWB\_GAINS**

use only the gains from AWB module

**RKISP1\_CIF\_ISP\_DPF\_GAIN\_USAGE\_AWB\_LSC\_GAINS**

use the gains from AWB and LSC module

**RKISP1\_CIF\_ISP\_DPF\_GAIN\_USAGE\_MAX**

upper border (only for an internal evaluation)

enum **rkisp1\_cif\_isp\_dpf\_rb\_filtersize**

Red and blue filter sizes

## Constants

**RKISP1\_CIF\_ISP\_DPF\_RB\_FILTERSIZE\_13x9**

red and blue filter kernel size 13x9 (means 7x5 active pixel)

**RKISP1\_CIF\_ISP\_DPF\_RB\_FILTERSIZE\_9x9**

red and blue filter kernel size 9x9 (means 5x5 active pixel)

enum **rkisp1\_cif\_isp\_dpf\_nll\_scale\_mode**

dpf noise level scale mode

## Constants

**RKISP1\_CIF\_ISP\_NLL\_SCALE\_LINEAR**

use a linear scaling

**RKISP1\_CIF\_ISP\_NLL\_SCALE\_LOGARITHMIC**

use a logarithmic scaling

struct **rkisp1\_cif\_isp\_dpf\_nll**

Noise level lookup

## Definition:

```
struct rkisp1_cif_isp_dpf_nll {
    __u16 coeff[RKISP1_CIF_ISP_DPF_MAX_NLF_COEFFS];
    __u32 scale_mode;
};
```

## Members

**coeff**

Noise level Lookup coefficient

**scale\_mode**

dpf noise level scale mode (from [enum rkisp1\\_cif\\_isp\\_dpf\\_nll\\_scale\\_mode](#))

**struct rkisp1\_cif\_isp\_dpf\_rb\_flt**

Red blue filter config

**Definition:**

```
struct rkisp1_cif_isp_dpf_rb_flt {
    __u32 fltsize;
    __u8 spatial_coeff[RKISP1_CIF_ISP_DPF_MAX_SPATIAL_COEFFS];
    __u8 r_enable;
    __u8 b_enable;
};
```

**Members****fltsize**

The filter size for the red and blue pixels (from [enum rkisp1\\_cif\\_isp\\_dpf\\_rb\\_filtersize](#))

**spatial\_coeff**

Spatial weights

**r\_enable**

enable filter processing for red pixels

**b\_enable**

enable filter processing for blue pixels

**struct rkisp1\_cif\_isp\_dpf\_g\_flt**

Green filter Configuration

**Definition:**

```
struct rkisp1_cif_isp_dpf_g_flt {
    __u8 spatial_coeff[RKISP1_CIF_ISP_DPF_MAX_SPATIAL_COEFFS];
    __u8 gr_enable;
    __u8 gb_enable;
};
```

**Members****spatial\_coeff**

Spatial weights

**gr\_enable**

enable filter processing for green pixels in green/red lines

**gb\_enable**

enable filter processing for green pixels in green/blue lines

**struct rkisp1\_cif\_isp\_dpf\_gain**

Noise function Configuration

**Definition:**

```
struct rkisp1_cif_isp_dpf_gain {
    __u32 mode;
    __u16 nf_r_gain;
    __u16 nf_b_gain;
    __u16 nf_gr_gain;
    __u16 nf_gb_gain;
};
```

**Members****mode**

dpf gain usage (from *enum rkisp1\_cif\_isp\_dpf\_gain\_usage*)

**nf\_r\_gain**

Noise function Gain that replaces the AWB gain for red pixels

**nf\_b\_gain**

Noise function Gain that replaces the AWB gain for blue pixels

**nf\_gr\_gain**

Noise function Gain that replaces the AWB gain for green pixels in a red line

**nf\_gb\_gain**

Noise function Gain that replaces the AWB gain for green pixels in a blue line

**struct rkisp1\_cif\_isp\_dpf\_config**

Configuration used by De-noising pre-filter

**Definition:**

```
struct rkisp1_cif_isp_dpf_config {
    struct rkisp1_cif_isp_dpf_gain gain;
    struct rkisp1_cif_isp_dpf_g_flt g_flt;
    struct rkisp1_cif_isp_dpf_rb_flt rb_flt;
    struct rkisp1_cif_isp_dpf_nll nll;
};
```

**Members****gain**

noise function gain

**g\_flt**

green filter config

**rb\_flt**

red blue filter config

**nll**

noise level lookup

**struct rkisp1\_cif\_isp\_dpf\_strength\_config**

strength of the filter

**Definition:**

```
struct rkisp1_cif_isp_dpf_strength_config {
    __u8 r;
    __u8 g;
    __u8 b;
};
```

## Members

**r**  
filter strength of the RED filter

**g**  
filter strength of the GREEN filter

**b**  
filter strength of the BLUE filter

**struct rkisp1\_cif\_isp\_isp\_other\_cfg**

Parameters for some blocks in rockchip isp1

## Definition:

```
struct rkisp1_cif_isp_isp_other_cfg {
    struct rkisp1_cif_isp_dpcc_config dpcc_config;
    struct rkisp1_cif_isp_bls_config bls_config;
    struct rkisp1_cif_isp_sdg_config sdg_config;
    struct rkisp1_cif_isp_lsc_config lsc_config;
    struct rkisp1_cif_isp_awb_gain_config awb_gain_config;
    struct rkisp1_cif_isp_flt_config flt_config;
    struct rkisp1_cif_isp_bdm_config bdm_config;
    struct rkisp1_cif_isp_ctk_config ctk_config;
    struct rkisp1_cif_isp_goc_config goc_config;
    struct rkisp1_cif_isp_dpf_config dpf_config;
    struct rkisp1_cif_isp_dpf_strength_config dpf_strength_config;
    struct rkisp1_cif_isp_cproc_config cproc_config;
    struct rkisp1_cif_isp_ie_config ie_config;
};
```

## Members

**dpcc\_config**  
Defect Pixel Cluster Correction config

**bls\_config**  
black level subtraction config

**sdg\_config**  
sensor degamma config

**lsc\_config**  
Lens Shade config

**awb\_gain\_config**  
Auto White balance gain config

```

flt_config
    filter config

bdm_config
    demosaic config

ctk_config
    cross talk config

goc_config
    gamma out config

dpf_config
    De-noising pre-filter config

dpf_strength_config
    dpf strength config

cproc_config
    color process config

ie_config
    image effects config

struct rkisp1_cif_isp_isp_meas_cfg
    Rockchip ISP1 Measure Parameters

```

**Definition:**

```

struct rkisp1_cif_isp_isp_meas_cfg {
    struct rkisp1_cif_isp_awb_meas_config awb_meas_config;
    struct rkisp1_cif_isp_hst_config hst_config;
    struct rkisp1_cif_isp_aec_config aec_config;
    struct rkisp1_cif_isp_afc_config afc_config;
};

```

**Members**

```

awb_meas_config
    auto white balance config

hst_config
    histogram config

aec_config
    auto exposure config

afc_config
    auto focus config

struct rkisp1_params_cfg
    Rockchip ISP1 Input Parameters Meta Data

```

**Definition:**

```

struct rkisp1_params_cfg {
    __u32 module_en_update;
    __u32 module_ens;
    __u32 module_cfg_update;
}

```

```

    struct rkisp1_cif_isp_isp_meas_cfg meas;
    struct rkisp1_cif_isp_isp_other_cfg others;
};
```

**Members****module\_en\_update**

mask the enable bits of which module should be updated

**module\_ens**

mask the enable value of each module, only update the module which correspond bit was set in module\_en\_update

**module\_cfg\_update**

mask the config bits of which module should be updated

**meas**

measurement config

**others**

other config

**struct rkisp1\_cif\_isp\_awb\_meas**

AWB measured values

**Definition:**

```

struct rkisp1_cif_isp_awb_meas {
    __u32 cnt;
    __u8 mean_y_or_g;
    __u8 mean_cb_or_b;
    __u8 mean_cr_or_r;
};
```

**Members****cnt**

White pixel count, number of "white pixels" found during last measurement

**mean\_y\_or\_g**

Mean value of Y within window and frames, Green if RGB is selected.

**mean\_cb\_or\_b**

Mean value of Cb within window and frames, Blue if RGB is selected.

**mean\_cr\_or\_r**

Mean value of Cr within window and frames, Red if RGB is selected.

**struct rkisp1\_cif\_isp\_awb\_stat**

statistics automatic white balance data

**Definition:**

```

struct rkisp1_cif_isp_awb_stat {
    struct rkisp1_cif_isp_awb_meas awb_mean[RKISP1_CIF_ISP_AWB_MAX_GRID];
};
```

**Members****awb\_mean**

Mean measured data

**struct rkisp1\_cif\_isp\_bls\_meas\_val**

BLS measured values

**Definition:**

```
struct rkisp1_cif_isp_bls_meas_val {
    __u16 meas_r;
    __u16 meas_gr;
    __u16 meas_gb;
    __u16 meas_b;
};
```

**Members****meas\_r**

Mean measured value for Bayer pattern R

**meas\_gr**

Mean measured value for Bayer pattern Gr

**meas\_gb**

Mean measured value for Bayer pattern Gb

**meas\_b**

Mean measured value for Bayer pattern B

**struct rkisp1\_cif\_isp\_ae\_stat**

statistics auto exposure data

**Definition:**

```
struct rkisp1_cif_isp_ae_stat {
    __u8 exp_mean[RKISP1_CIF_ISP_AE_MEAN_MAX];
    struct rkisp1_cif_isp_bls_meas_val bls_val;
};
```

**Members****exp\_mean**

Mean luminance value of block xx

**bls\_val**

BLS measured values

**Description**

The number of entries of **exp\_mean** depends on the hardware revision as is reported by the `hw_revision` field of the `struct media_device_info` that is returned by `ioctl MEDIA_IOC_DEVICE_INFO`.

Versions  $\leq$  V11 have `RKISP1_CIF_ISP_AE_MEAN_MAX_V10` entries, versions  $\geq$  V12 have `RKISP1_CIF_ISP_AE_MEAN_MAX_V12` entries. `RKISP1_CIF_ISP_AE_MEAN_MAX` is equal to the maximum of the two.

Image is divided into 5x5 blocks on V10 and 9x9 blocks on V12.

### struct rkisp1\_cif\_isp\_af\_meas\_val

AF measured values

#### Definition:

```
struct rkisp1_cif_isp_af_meas_val {
    __u32 sum;
    __u32 lum;
};
```

#### Members

##### sum

sharpness value

##### lum

luminance value

### struct rkisp1\_cif\_isp\_af\_stat

statistics auto focus data

#### Definition:

```
struct rkisp1_cif_isp_af_stat {
    struct rkisp1_cif_isp_af_meas_val window[RKISP1_CIF_ISP_AF_MAX_WINDOWS];
};
```

#### Members

##### window

AF measured value of window x

#### Description

The module measures the sharpness in 3 windows of selectable size via register settings(ISP\_AF\*\_A/B/C)

### struct rkisp1\_cif\_isp\_hist\_stat

statistics histogram data

#### Definition:

```
struct rkisp1_cif_isp_hist_stat {
    __u32 hist_bins[RKISP1_CIF_ISP_HIST_BIN_N_MAX];
};
```

#### Members

##### hist\_bins

measured bin counters. Each bin is a 20 bits unsigned fixed point type. Bits 0-4 are the fractional part and bits 5-19 are the integer part.

#### Description

The window of the measurements area is divided to 5x5 sub-windows for V10/V11 and to 9x9 sub-windows for V12. The histogram is then computed for each sub-window independently and

the final result is a weighted average of the histogram measurements on all sub-windows. The window of the measurements area and the weight of each sub-window are configurable using struct **rkisp1\_cif\_isp\_hst\_config**.

The histogram contains 16 bins in V10/V11 and 32 bins in V12/V13.

The number of entries of **hist\_bins** depends on the hardware revision as is reported by the `hw_revision` field of the struct `media_device_info` that is returned by ioctl `MEDIA_IOC_DEVICE_INFO`.

Versions <= V11 have `RKISP1_CIF_ISP_HIST_BIN_N_MAX_V10` entries, versions >= V12 have `RKISP1_CIF_ISP_HIST_BIN_N_MAX_V12` entries. `RKISP1_CIF_ISP_HIST_BIN_N_MAX` is equal to the maximum of the two.

### struct **rkisp1\_cif\_isp\_stat**

Rockchip ISP1 Statistics Data

#### Definition:

```
struct rkisp1_cif_isp_stat {
    struct rkisp1_cif_isp_awb_stat awb;
    struct rkisp1_cif_isp_ae_stat ae;
    struct rkisp1_cif_isp_af_stat af;
    struct rkisp1_cif_isp_hist_stat hist;
};
```

#### Members

##### **awb**

statistics data for automatic white balance

##### **ae**

statistics data for auto exposure

##### **af**

statistics data for auto focus

##### **hist**

statistics histogram data

### struct **rkisp1\_stat\_buffer**

Rockchip ISP1 Statistics Meta Data

#### Definition:

```
struct rkisp1_stat_buffer {
    __u32 meas_type;
    __u32 frame_id;
    struct rkisp1_cif_isp_stat params;
};
```

#### Members

##### **meas\_type**

measurement types (`RKISP1_CIF_ISP_STAT_*` definitions)

##### **frame\_id**

frame ID for sync

**params**

statistics data

**V4L2\_META\_FMT\_UVC ('UVCH')**

UVC Payload Header Data

**Description**

This format describes standard UVC metadata, extracted from UVC packet headers and provided by the UVC driver through metadata video nodes. That data includes exact copies of the standard part of UVC Payload Header contents and auxiliary timing information, required for precise interpretation of timestamps, contained in those headers. See section "2.4.3.3 Video and Still Image Payload Headers" of the "UVC 1.5 Class specification" for details.

Each UVC payload header can be between 2 and 12 bytes large. Buffers can contain multiple headers, if multiple such headers have been transmitted by the camera for the respective frame. However, the driver may drop headers when the buffer is full, when they contain no useful information (e.g. those without the SCR field or with that field identical to the previous header), or generally to perform rate limiting when the device sends a large number of headers.

Each individual block contains the following fields:

Table 106: UVC Metadata Block

Field	Description
<code>_u64 ts;</code>	system timestamp in host byte order, measured by the driver upon reception of the payload
<code>_u16 sof;</code>	USB Frame Number in host byte order, also obtained by the driver as close as possible to the above timestamp to enable correlation between them
<i>The rest is an exact copy of the UVC payload header:</i>	
<code>_u8 length;</code>	length of the rest of the block, including this field
<code>_u8 flags;</code>	Flags, indicating presence of other standard UVC fields
<code>_u8 buf[];</code>	The rest of the header, possibly including UVC PTS and SCR fields

**V4L2\_META\_FMT\_VSP1\_HGO ('VSPH')**

Renesas R-Car VSP1 1-D Histogram Data

## Description

This format describes histogram data generated by the Renesas R-Car VSP1 1-D Histogram (HGO) engine.

The VSP1 HGO is a histogram computation engine that can operate on RGB, YCrCb or HSV data. It operates on a possibly cropped and subsampled input image and computes the minimum, maximum and sum of all pixels as well as per-channel histograms.

The HGO can compute histograms independently per channel, on the maximum of the three channels (RGB data only) or on the Y channel only (YCbCr only). It can additionally output the histogram with 64 or 256 bins, resulting in four possible modes of operation.

- In *64 bins normal mode*, the HGO operates on the three channels independently to compute three 64-bins histograms. RGB, YCbCr and HSV image formats are supported.
- In *64 bins maximum mode*, the HGO operates on the maximum of the (R, G, B) channels to compute a single 64-bins histogram. Only the RGB image format is supported.
- In *256 bins normal mode*, the HGO operates on the Y channel to compute a single 256-bins histogram. Only the YCbCr image format is supported.
- In *256 bins maximum mode*, the HGO operates on the maximum of the (R, G, B) channels to compute a single 256-bins histogram. Only the RGB image format is supported.

**Byte Order.** All data is stored in memory in little endian format. Each cell in the tables contains one byte.

Table 107: VSP1 HGO Data - 64 Bins, Normal Mode  
(792 bytes)

Offset	Memory			
	[31:24]	[23:16]	[15:8]	[7:0]
0		R/Cr/H max [7:0]		R/Cr/H min [7:0]
4		G/Y/S max [7:0]		G/Y/S min [7:0]
8		B/Cb/V max [7:0]		B/Cb/V min [7:0]
12	R/Cr/H sum [31:0]			
16	G/Y/S sum [31:0]			
20	B/Cb/V sum [31:0]			
24	R/Cr/H bin 0 [31:0]			
	...			
276	R/Cr/H bin 63 [31:0]			
280	G/Y/S bin 0 [31:0]			
	...			
532	G/Y/S bin 63 [31:0]			
536	B/Cb/V bin 0 [31:0]			
	...			
788	B/Cb/V bin 63 [31:0]			

Table 108: VSP1 HGO Data - 64 Bins, Max Mode (264 bytes)

Offset	Memory			
	[31:24]	[23:16]	[15:8]	[7:0]
0		max(R,G,B) max [7:0]		max(R,G,B) min [7:0]
4	max(R,G,B) sum [31:0]			
8	max(R,G,B) bin 0 [31:0]			
	...			
260	max(R,G,B) bin 63 [31:0]			

Table 109: VSP1 HGO Data - 256 Bins, Normal Mode (1032 bytes)

Offset	Memory			
	[31:24]	[23:16]	[15:8]	[7:0]
0		Y max [7:0]		Y min [7:0]
4	Y sum [31:0]			
8	Y bin 0 [31:0]			
	...			
1028	Y bin 255 [31:0]			

Table 110: VSP1 HGO Data - 256 Bins, Max Mode (1032 bytes)

Offset	Memory			
	[31:24]	[23:16]	[15:8]	[7:0]
0		max(R,G,B) max [7:0]		max(R,G,B) min [7:0]
4	max(R,G,B) sum [31:0]			
8	max(R,G,B) bin 0 [31:0]			
	...			
1028	max(R,G,B) bin 255 [31:0]			

## V4L2\_META\_FMT\_VSP1\_HGT ('VSPT')

Renesas R-Car VSP1 2-D Histogram Data

### Description

This format describes histogram data generated by the Renesas R-Car VSP1 2-D Histogram (HGT) engine.

The VSP1 HGT is a histogram computation engine that operates on HSV data. It operates on a possibly cropped and subsampled input image and computes the sum, maximum and minimum of the S component as well as a weighted frequency histogram based on the H and S components.

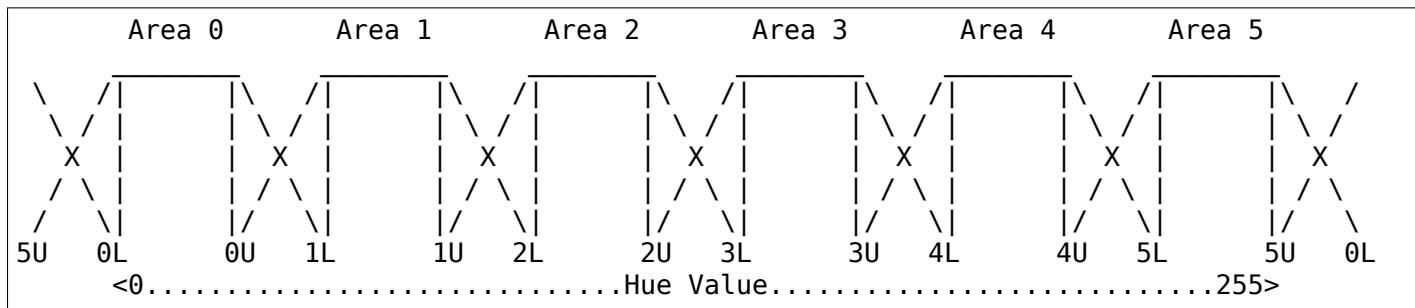
The histogram is a matrix of 6 Hue and 32 Saturation buckets, 192 in total. Each HSV value is added to one or more buckets with a weight between 1 and 16 depending on the Hue areas

configuration. Finding the corresponding buckets is done by inspecting the H and S value independently.

The Saturation position **n** (0 - 31) of the bucket in the matrix is found by the expression:

$$n = S / 8$$

The Hue position **m** (0 - 5) of the bucket in the matrix depends on how the HGT Hue areas are configured. There are 6 user configurable Hue Areas which can be configured to cover overlapping Hue values:



When two consecutive areas don't overlap ( $n+1L$  is equal to  $nU$ ) the boundary value is considered as part of the lower area.

Pixels with a hue value included in the centre of an area (between  $nL$  and  $nU$  included) are attributed to that single area and given a weight of 16. Pixels with a hue value included in the overlapping region between two areas (between  $n+1L$  and  $nU$  excluded) are attributed to both areas and given a weight for each of these areas proportional to their position along the diagonal lines (rounded down).

The Hue area setup must match one of the following constraints:

```
0L <= 0U <= 1L <= 1U <= 2L <= 2U <= 3L <= 3U <= 4L <= 4U <= 5L <= 5U
```

```
0U <= 1L <= 1U <= 2L <= 2U <= 3L <= 3U <= 4L <= 4U <= 5L <= 5U <= 0L
```

**Byte Order.** All data is stored in memory in little endian format. Each cell in the tables contains one byte.

Table 111: VSP1 HGT Data - (776 bytes)

Offset	Memory			
	[31:24]	[23:16]	[15:8]	[7:0]
0	•	S max [7:0]	•	S min [7:0]
4	S sum [31:0]			
8	Histogram bucket (m=0, n=0) [31:0]			
12	Histogram bucket (m=0, n=1) [31:0]			
	...			
132	Histogram bucket (m=0, n=31) [31:0]			
136	Histogram bucket (m=1, n=0) [31:0]			
	...			
264	Histogram bucket (m=2, n=0) [31:0]			
	...			
392	Histogram bucket (m=3, n=0) [31:0]			
	...			
520	Histogram bucket (m=4, n=0) [31:0]			
	...			
648	Histogram bucket (m=5, n=0) [31:0]			
	...			
772	Histogram bucket (m=5, n=31) [31:0]			

## V4L2\_META\_FMT\_VIVID ('VIVD')

VIVID Metadata Format

### Description

This describes metadata format used by the vivid driver.

It sets Brightness, Saturation, Contrast and Hue, each of which maps to corresponding controls of the vivid driver with respect to the range and default values.

It contains the following fields:

Table 112: VIVID Metadata

Field	Description
u16 brightness;	Image brightness, the value is in the range 0 to 255, with the default value as 128.
u16 contrast;	Image contrast, the value is in the range 0 to 255, with the default value as 128.
u16 saturation;	Image color saturation, the value is in the range 0 to 255, with the default value as 128.
s16 hue;	Image color balance, the value is in the range -128 to 128, with the default value as 0.

## Reserved Format Identifiers

These formats are not defined by this specification, they are just listed for reference and to avoid naming conflicts. If you want to register your own format, send an e-mail to the linux-media mailing list <https://linuxtv.org/lists.php> for inclusion in the `videodev2.h` file. If you want to share your format with other developers add a link to your documentation and send a copy to the linux-media mailing list for inclusion in this section. If you think your format should be listed in a standard format section please make a proposal on the linux-media mailing list.

Table 113: Reserved Image Formats

Identifier	Code	Details
V4L2_PIX_FMT_DV	'dvsd'	unknown
V4L2_PIX_FMT_ET61X251	'E625'	Compressed format of the ET61X251 driver.
V4L2_PIX_FMT_HI240	'HI24'	8 bit RGB format used by the BTTV driver.
V4L2_PIX_FMT_CPIA1	'CPIA'	YUV format used by the gspca cpiapl driver.
V4L2_PIX_FMT_JPGL	'JPGL'	JPEG-Light format (Pegasus Lossless JPEG) used in Divio webcams NW 80x.
V4L2_PIX_FMT_SPCA501	'S501'	YUYV per line used by the gspca driver.
V4L2_PIX_FMT_SPCA505	'S505'	YYUV per line used by the gspca driver.
V4L2_PIX_FMT_SPCA508	'S508'	YUVY per line used by the gspca driver.
V4L2_PIX_FMT_SPCA561	'S561'	Compressed GBRG Bayer format used by the gspca driver.
V4L2_PIX_FMT_PAC207	'P207'	Compressed BGGR Bayer format used by the gspca driver.
V4L2_PIX_FMT_MR97310A	'M310'	Compressed BGGR Bayer format used by the gspca driver.
V4L2_PIX_FMT_JL2005BCD	'JL20'	JPEG compressed RGGB Bayer format used by the gspca driver.
V4L2_PIX_FMT_OV511	'O511'	OV511 JPEG format used by the gspca driver.
V4L2_PIX_FMT_OV518	'O518'	OV518 JPEG format used by the gspca driver.
V4L2_PIX_FMT_PJPG	'PJPG'	Pixart 73xx JPEG format used by the gspca driver.
V4L2_PIX_FMT_SE401	'S401'	Compressed RGB format used by the gspca se401 driver
V4L2_PIX_FMT_SQ905C	'905C'	Compressed RGGB bayer format used by the gspca driver.
V4L2_PIX_FMT_MJPEG	'MJPG'	Compressed format used by the Zoran driver
V4L2_PIX_FMT_PWC1	'PWC1'	Compressed format of the PWC driver.
V4L2_PIX_FMT_PWC2	'PWC2'	Compressed format of the PWC driver.
V4L2_PIX_FMT_SN9C10X	'S910'	Compressed format of the SN9C102 driver.
V4L2_PIX_FMT_SN9C20X_I420	'S920'	YUV 4:2:0 format of the gspca sn9c20x driver.
V4L2_PIX_FMT_SN9C2028	'SONX'	Compressed GBRG bayer format of the gspca sn9c2028 driver.
V4L2_PIX_FMT_STV0680	'S680'	Bayer format of the gspca stv0680 driver.
V4L2_PIX_FMT_WNVA	'WNVA'	Used by the Winnov Videum driver, <a href="http://www.thedirks.org/winnov/">http://www.thedirks.org/winnov/</a>
V4L2_PIX_FMT_TM6000	'TM60'	Used by Trident tm6000
V4L2_PIX_FMT_CIT_YYYYUY	'CITV'	Used by xirlink CIT, found at IBM webcams. Uses one line of Y then 1 line of VYUY
V4L2_PIX_FMT_KONICA420	'KONI'	Used by Konica webcams. YUV420 planar in blocks of 256 pixels.
V4L2_PIX_FMT_YYUV	'YYUV'	unknown

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Table 113 – continued from previous page

Identifier	Code	Details
V4L2_PIX_FMT_Y4	'Y04'	Old 4-bit greyscale format. Only the most significant 4 bits of each byte are used, the other bits are set to 0.
V4L2_PIX_FMT_Y6	'Y06'	Old 6-bit greyscale format. Only the most significant 6 bits of each byte are used, the other bits are set to 0.
V4L2_PIX_FMT_S5C_UYVY_JPG	'S5CI'	<p>Two-planar format used by Samsung S5C73MX cameras. The first plane contains interleaved JPEG and UYVY image data, followed by meta data in form of an array of offsets to the UYVY data blocks. The actual pointer array follows immediately after the interleaved JPEG/UYVY data, the number of entries in this array equals the height of the UYVY image. Each entry is a 4-byte unsigned integer in big endian order and it's an offset to a single pixel line of the UYVY image. The first plane can start either with JPEG or UYVY data chunk. The size of a single UYVY block equals the UYVY image's width multiplied by 2. The size of a JPEG chunk depends on the image and can vary with each line.</p> <p>The second plane, at an offset of 4084 bytes, contains a 4-byte offset to the pointer array in the first plane. This offset is followed by a 4-byte value indicating size of the pointer array. All numbers in the second plane are also in big endian order. Remaining data in the second plane is undefined. The information in the second plane allows to easily find location of the pointer array, which can be different for each frame. The size of the pointer array is constant for given UYVY image height.</p> <p>In order to extract UYVY and JPEG frames an application can initially set a data pointer to the start of first plane and then add an offset from the first entry of the pointers table. Such a pointer indicates start of an UYVY image pixel line. Whole UYVY line can be copied to a separate buffer. These steps should be repeated for each line, i.e. the number of entries in the pointer array. Anything what's in between the UYVY lines is JPEG data and should be concatenated to form the JPEG stream.</p>
V4L2_PIX_FMT_MT21C	'MT21'	Compressed two-planar YVU420 format used by Mediatek MT8173, MT8192, MT8195 and more. The compression is lossless. This format has similitude with V4L2_PIX_FMT_MM21 in term of alignment and tiling. It remains an opaque intermediate format and the MDP hardware must be used to convert V4L2_PIX_FMT_MT21C to V4L2_PIX_FMT_NV12M, V4L2_PIX_FMT_YUV420M or V4L2_PIX_FMT_YVU420.

continues on next page

Table 113 – continued from previous page

Identifier	Code	Details
V4L2_PIX_FMT_QC08C	'QC08C'	Compressed Macro-tile 8-Bit YUV420 format used by Qualcomm platforms. It is an opaque intermediate format. The used compression is lossless and it is used by various multimedia hardware blocks like GPU, display controllers, ISP and video accelerators. It contains four planes for progressive video and eight planes for interlaced video.
V4L2_PIX_FMT_QC10C	'QC10C'	Compressed Macro-tile 10-Bit YUV420 format used by Qualcomm platforms. It is an opaque intermediate format. The used compression is lossless and it is used by various multimedia hardware blocks like GPU, display controllers, ISP and video accelerators. It contains four planes for progressive video.
V4L2_PIX_FMT_AJPG	'AJPG'	ASPEED JPEG format used by the aspeed-video driver on Aspeed platforms, which is generally adapted for remote KVM. On each frame compression, I will compare the new frame with previous one to decide which macroblock's data is changed, and only the changed macroblocks will be compressed. The implementation is based on AST2600 A3 datasheet, revision 0.9, which is not publicly available. Or you can reference Video stream data format - ASPEED mode compression of <a href="#">SDK_User_Guide</a> which available on <a href="#">github</a> . Decoder's implementation can be found here, <a href="#">aspeed_codec</a>
V4L2_PIX_FMT_MT2110T	'MT2110T'	This format is two-planar 10-Bit tile mode and having similitude with V4L2_PIX_FMT_MM21 in term of alignment and tiling. Used for VP9, AV1 and HEVC.
V4L2_PIX_FMT_MT2110R	'MT2110R'	This format is two-planar 10-Bit raster mode and having similitude with V4L2_PIX_FMT_MM21 in term of alignment and tiling. Used for AVC.
V4L2_PIX_FMT_HEXTILE	'HXTL'	Compressed format used by Nuvoton NPCM video driver. This format is defined in Remote Framebuffer Protocol (RFC 6143, chapter 7.7.4 Hextile Encoding).

## Colorspaces

'Color' is a very complex concept and depends on physics, chemistry and biology. Just because you have three numbers that describe the 'red', 'green' and 'blue' components of the color of a pixel does not mean that you can accurately display that color. A colorspace defines what it actually *means* to have an RGB value of e.g. (255, 0, 0). That is, which color should be reproduced on the screen in a perfectly calibrated environment.

In order to do that we first need to have a good definition of color, i.e. some way to uniquely and unambiguously define a color so that someone else can reproduce it. Human color vision is trichromatic since the human eye has color receptors that are sensitive to three different wavelengths of light. Hence the need to use three numbers to describe color. Be glad you are not a mantis shrimp as those are sensitive to 12 different wavelengths, so instead of RGB we

would be using the ABCDEFGHIJKL colorspace...

Color exists only in the eye and brain and is the result of how strongly color receptors are stimulated. This is based on the Spectral Power Distribution (SPD) which is a graph showing the intensity (radianc power) of the light at wavelengths covering the visible spectrum as it enters the eye. The science of colorimetry is about the relationship between the SPD and color as perceived by the human brain.

Since the human eye has only three color receptors it is perfectly possible that different SPDs will result in the same stimulation of those receptors and are perceived as the same color, even though the SPD of the light is different.

In the 1920s experiments were devised to determine the relationship between SPDs and the perceived color and that resulted in the CIE 1931 standard that defines spectral weighting functions that model the perception of color. Specifically that standard defines functions that can take an SPD and calculate the stimulus for each color receptor. After some further mathematical transforms these stimuli are known as the *CIE XYZ tristimulus* values and these X, Y and Z values describe a color as perceived by a human unambiguously. These X, Y and Z values are all in the range [0...1].

The Y value in the CIE XYZ colorspace corresponds to luminance. Often the CIE XYZ colorspace is transformed to the normalized CIE xyY colorspace:

$$x = X / (X + Y + Z)$$

$$y = Y / (X + Y + Z)$$

The x and y values are the chromaticity coordinates and can be used to define a color without the luminance component Y. It is very confusing to have such similar names for these colorspace. Just be aware that if colors are specified with lower case 'x' and 'y', then the CIE xyY colorspace is used. Upper case 'X' and 'Y' refer to the CIE XYZ colorspace. Also, y has nothing to do with luminance. Together x and y specify a color, and Y the luminance. That is really all you need to remember from a practical point of view. At the end of this section you will find reading resources that go into much more detail if you are interested.

A monitor or TV will reproduce colors by emitting light at three different wavelengths, the combination of which will stimulate the color receptors in the eye and thus cause the perception of color. Historically these wavelengths were defined by the red, green and blue phosphors used in the displays. These *color primaries* are part of what defines a colorspace.

Different display devices will have different primaries and some primaries are more suitable for some display technologies than others. This has resulted in a variety of colorspace that are used for different display technologies or uses. To define a colorspace you need to define the three color primaries (these are typically defined as x, y chromaticity coordinates from the CIE xyY colorspace) but also the white reference: that is the color obtained when all three primaries are at maximum power. This determines the relative power or energy of the primaries. This is usually chosen to be close to daylight which has been defined as the CIE D65 Illuminant.

To recapitulate: the CIE XYZ colorspace uniquely identifies colors. Other colorspace are defined by three chromaticity coordinates defined in the CIE xyY colorspace. Based on those a 3x3 matrix can be constructed that transforms CIE XYZ colors to colors in the new colorspace.

Both the CIE XYZ and the RGB colorspace that are derived from the specific chromaticity primaries are linear colorspace. But neither the eye, nor display technology is linear. Doubling the values of all components in the linear colorspace will not be perceived as twice the intensity of the color. So each colorspace also defines a transfer function that takes a linear color component value and transforms it to the non-linear component value, which is a closer match to

the non-linear performance of both the eye and displays. Linear component values are denoted RGB, non-linear are denoted as R'G'B'. In general colors used in graphics are all R'G'B', except in OpenGL which uses linear RGB. Special care should be taken when dealing with OpenGL to provide linear RGB colors or to use the built-in OpenGL support to apply the inverse transfer function.

The final piece that defines a colorspace is a function that transforms non-linear R'G'B' to non-linear Y'CbCr. This function is determined by the so-called luma coefficients. There may be multiple possible Y'CbCr encodings allowed for the same colorspace. Many encodings of color prefer to use luma (Y') and chroma (CbCr) instead of R'G'B'. Since the human eye is more sensitive to differences in luminance than in color this encoding allows one to reduce the amount of color information compared to the luma data. Note that the luma (Y') is unrelated to the Y in the CIE XYZ colorspace. Also note that Y'CbCr is often called YCbCr or YUV even though these are strictly speaking wrong.

Sometimes people confuse Y'CbCr as being a colorspace. This is not correct, it is just an encoding of an R'G'B' color into luma and chroma values. The underlying colorspace that is associated with the R'G'B' color is also associated with the Y'CbCr color.

The final step is how the RGB, R'G'B' or Y'CbCr values are quantized. The CIE XYZ colorspace where X, Y and Z are in the range [0...1] describes all colors that humans can perceive, but the transform to another colorspace will produce colors that are outside the [0...1] range. Once clamped to the [0...1] range those colors can no longer be reproduced in that colorspace. This clamping is what reduces the extent or gamut of the colorspace. How the range of [0...1] is translated to integer values in the range of [0...255] (or higher, depending on the color depth) is called the quantization. This is *not* part of the colorspace definition. In practice RGB or R'G'B' values are full range, i.e. they use the full [0...255] range. Y'CbCr values on the other hand are limited range with Y' using [16...235] and Cb and Cr using [16...240].

Unfortunately, in some cases limited range RGB is also used where the components use the range [16...235]. And full range Y'CbCr also exists using the [0...255] range.

In order to correctly interpret a color you need to know the quantization range, whether it is R'G'B' or Y'CbCr, the used Y'CbCr encoding and the colorspace. From that information you can calculate the corresponding CIE XYZ color and map that again to whatever colorspace your display device uses.

The colorspace definition itself consists of the three chromaticity primaries, the white reference chromaticity, a transfer function and the luma coefficients needed to transform R'G'B' to Y'CbCr. While some colorspace standards correctly define all four, quite often the colorspace standard only defines some, and you have to rely on other standards for the missing pieces. The fact that colorspaces are often a mix of different standards also led to very confusing naming conventions where the name of a standard was used to name a colorspace when in fact that standard was part of various other colorspaces as well.

If you want to read more about colors and colorspace, then the following resources are useful: [poynton](#) is a good practical book for video engineers, [colimg](#) has a much broader scope and describes many more aspects of color (physics, chemistry, biology, etc.). The <http://www.brucelindbloom.com> website is an excellent resource, especially with respect to the mathematics behind colorspace conversions. The wikipedia [CIE 1931 colorspace](#) article is also very useful.

## Defining Colorspaces in V4L2

In V4L2 colorspaces are defined by four values. The first is the colorspace identifier (enum `v4l2_colorspace`) which defines the chromaticities, the default transfer function, the default Y'CbCr encoding and the default quantization method. The second is the transfer function identifier (enum `v4l2_xfer_func`) to specify non-standard transfer functions. The third is the Y'CbCr encoding identifier (enum `v4l2_ycbcr_encoding`) to specify non-standard Y'CbCr encodings and the fourth is the quantization identifier (enum `v4l2_quantization`) to specify non-standard quantization methods. Most of the time only the colorspace field of struct `v4l2_pix_format` or struct `v4l2_pix_format_mplane` needs to be filled in.

On *HSV formats* the *Hue* is defined as the angle on the cylindrical color representation. Usually this angle is measured in degrees, i.e. 0-360. When we map this angle value into 8 bits, there are two basic ways to do it: Divide the angular value by 2 (0-179), or use the whole range, 0-255, dividing the angular value by 1.41. The enum `v4l2_hsv_encoding` specifies which encoding is used.

---

**Note:** The default R'G'B' quantization is full range for all colorspaces. HSV formats are always full range.

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### type `v4l2_colorspace`

Table 114: V4L2 Colorspaces

Identifier	Details
<code>V4L2_COLORSPACE_DEFAULT</code>	The default colorspace. This can be used by applications to let the driver fill in the colorspace.
<code>V4L2_COLORSPACE_SMPTE170M</code>	See <i>Colorspace SMPTE 170M (V4L2_COLORSPACE_SMPTE170M)</i> .
<code>V4L2_COLORSPACE_REC709</code>	See <i>Colorspace Rec. 709 (V4L2_COLORSPACE_REC709)</i> .
<code>V4L2_COLORSPACE_SRGB</code>	See <i>Colorspace sRGB (V4L2_COLORSPACE_SRGB)</i> .
<code>V4L2_COLORSPACE_OPRGB</code>	See <i>Colorspace opRGB (V4L2_COLORSPACE_OPRGB)</i> .
<code>V4L2_COLORSPACE_BT2020</code>	See <i>Colorspace BT.2020 (V4L2_COLORSPACE_BT2020)</i> .
<code>V4L2_COLORSPACE_DCI_P3</code>	See <i>Colorspace DCI-P3 (V4L2_COLORSPACE_DCI_P3)</i> .
<code>V4L2_COLORSPACE_SMPTE240M</code>	See <i>Colorspace SMPTE 240M (V4L2_COLORSPACE_SMPTE240M)</i> .
<code>V4L2_COLORSPACE_470_SYSTEM_M</code>	See <i>Colorspace NTSC 1953 (V4L2_COLORSPACE_470_SYSTEM_M)</i> .
<code>V4L2_COLORSPACE_470_SYSTEM_BG</code>	See <i>Colorspace EBU Tech. 3213 (V4L2_COLORSPACE_470_SYSTEM_BG)</i> .
<code>V4L2_COLORSPACE_JPEG</code>	See <i>Colorspace JPEG (V4L2_COLORSPACE_JPEG)</i> .
<code>V4L2_COLORSPACE_RAW</code>	The raw colorspace. This is used for raw image capture where the image is minimally processed and is using the internal colorspace of the device. The software that processes an image using this 'colorspace' will have to know the internals of the capture device.

### type `v4l2_xfer_func`

Table 115: V4L2 Transfer Function

Identifier	Details
V4L2_XFER_FUNC_DEFAULT	Use the default transfer function as defined by the colorspace.
V4L2_XFER_FUNC_709	Use the Rec. 709 transfer function.
V4L2_XFER_FUNC_SRGB	Use the sRGB transfer function.
V4L2_XFER_FUNC_OPRGB	Use the opRGB transfer function.
V4L2_XFER_FUNC SMPTE240M	Use the SMPTE 240M transfer function.
V4L2_XFER_FUNC_NONE	Do not use a transfer function (i.e. use linear RGB values).
V4L2_XFER_FUNC_DCI_P3	Use the DCI-P3 transfer function.
V4L2_XFER_FUNC SMPTE2084	Use the SMPTE 2084 transfer function. See <a href="#">TransferFunction SMPTE 2084 (V4L2_XFER_FUNC SMPTE2084)</a> .

type **v4l2\_ycbcr\_encoding**

Table 116: V4L2 Y'CbCr Encodings

Identifier	Details
V4L2_YCBCR_ENC_DEFAULT	Use the default Y'CbCr encoding as defined by the colorspace.
V4L2_YCBCR_ENC_601	Use the BT.601 Y'CbCr encoding.
V4L2_YCBCR_ENC_709	Use the Rec. 709 Y'CbCr encoding.
V4L2_YCBCR_ENC_XV601	Use the extended gamut xvYCC BT.601 encoding.
V4L2_YCBCR_ENC_XV709	Use the extended gamut xvYCC Rec. 709 encoding.
V4L2_YCBCR_ENC_BT2020	Use the default non-constant luminance BT.2020 Y'CbCr encoding.
V4L2_YCBCR_ENC_BT2020_CONST_LUM	Use the constant luminance BT.2020 Yc'CbcCrc encoding.
V4L2_YCBCR_ENC SMPTE_240M	Use the SMPTE 240M Y'CbCr encoding.

type **v4l2\_hsv\_encoding**

Table 117: V4L2 HSV Encodings

Identifier	Details
V4L2_HSV_ENC_180	For the Hue, each LSB is two degrees.
V4L2_HSV_ENC_256	For the Hue, the 360 degrees are mapped into 8 bits, i.e. each LSB is roughly 1.41 degrees.

type **v4l2\_quantization**

Table 118: V4L2 Quantization Methods

Identifier	Details
V4L2_QUANTIZATION_DEFAULT	Use the default quantization encoding as defined by the colorspace. This is always full range for R'G'B' and HSV. It is usually limited range for Y'CbCr.
V4L2_QUANTIZATION_FULL_RANGE	Use the full range quantization encoding. I.e. the range [0...1] is mapped to [0...255] (with possible clipping to [1...254] to avoid the 0x00 and 0xff values). Cb and Cr are mapped from [-0.5...0.5] to [0...255] (with possible clipping to [1...254] to avoid the 0x00 and 0xff values).
V4L2_QUANTIZATION_LIM_RANGE	Use the limited range quantization encoding. I.e. the range [0...1] is mapped to [16...235]. Cb and Cr are mapped from [-0.5...0.5] to [16...240]. Limited Range cannot be used with HSV.

## Detailed Colorspace Descriptions

### Colorspace SMPTE 170M (V4L2\_COLORSPACE\_SMPTE170M)

The *SMPTE 170M* standard defines the colorspace used by NTSC and PAL and by SDTV in general. The default transfer function is V4L2\_XFER\_FUNC\_709. The default Y'CbCr encoding is V4L2\_YCBCR\_ENC\_601. The default Y'CbCr quantization is limited range. The chromaticities of the primary colors and the white reference are:

Table 119: SMPTE 170M Chromaticities

Color	x	y
Red	0.630	0.340
Green	0.310	0.595
Blue	0.155	0.070
White Reference (D65)	0.3127	0.3290

The red, green and blue chromaticities are also often referred to as the SMPTE C set, so this colorspace is sometimes called SMPTE C as well.

The transfer function defined for SMPTE 170M is the same as the one defined in Rec. 709.

$$\begin{aligned} L' &= -1.099(-L)^{0.45} + 0.099, \text{ for } L \leq -0.018 \\ L' &= 4.5L, \text{ for } -0.018 < L < 0.018 \\ L' &= 1.099L^{0.45} - 0.099, \text{ for } L \geq 0.018 \end{aligned}$$

Inverse Transfer function:

$$\begin{aligned} L &= -\left(\frac{L' - 0.099}{-1.099}\right)^{\frac{1}{0.45}}, \text{ for } L' \leq -0.081 \\ L &= \frac{L'}{4.5}, \text{ for } -0.081 < L' < 0.081 \\ L &= \left(\frac{L' + 0.099}{1.099}\right)^{\frac{1}{0.45}}, \text{ for } L' \geq 0.081 \end{aligned}$$

The luminance ( $Y'$ ) and color difference ( $Cb$  and  $Cr$ ) are obtained with the following V4L2\_YCBCR\_ENC\_601 encoding:

$$\begin{aligned} Y' &= 0.2990R' + 0.5870G' + 0.1140B' \\ Cb &= -0.1687R' - 0.3313G' + 0.5B' \\ Cr &= 0.5R' - 0.4187G' - 0.0813B' \end{aligned}$$

$Y'$  is clamped to the range [0...1] and  $Cb$  and  $Cr$  are clamped to the range [-0.5...0.5]. This conversion to Y'CbCr is identical to the one defined in the [ITU BT.601](#) standard and this colorspace is sometimes called BT.601 as well, even though BT.601 does not mention any color primaries.

The default quantization is limited range, but full range is possible although rarely seen.

### **Colorspace Rec. 709 (V4L2\_COLORSPACE\_REC709)**

The [ITU BT.709](#) standard defines the colorspace used by HDTV in general. The default transfer function is V4L2\_XFER\_FUNC\_709. The default Y'CbCr encoding is V4L2\_YCBCR\_ENC\_709. The default Y'CbCr quantization is limited range. The chromaticities of the primary colors and the white reference are:

Table 120: Rec. 709 Chromaticities

Color	x	y
Red	0.640	0.330
Green	0.300	0.600
Blue	0.150	0.060
White Reference (D65)	0.3127	0.3290

The full name of this standard is Rec. ITU-R BT.709-5.

Transfer function. Normally  $L$  is in the range [0...1], but for the extended gamut xvYCC encoding values outside that range are allowed.

$$\begin{aligned} L' &= -1.099(-L)^{0.45} + 0.099, \text{ for } L \leq -0.018 \\ L' &= 4.5L, \text{ for } -0.018 < L < 0.018 \\ L' &= 1.099L^{0.45} - 0.099, \text{ for } L \geq 0.018 \end{aligned}$$

Inverse Transfer function:

$$\begin{aligned} L &= -\left(\frac{L' - 0.099}{-1.099}\right)^{\frac{1}{0.45}}, \text{ for } L' \leq -0.081 \\ L &= \frac{L'}{4.5}, \text{ for } -0.081 < L' < 0.081 \\ L &= \left(\frac{L' + 0.099}{1.099}\right)^{\frac{1}{0.45}}, \text{ for } L' \geq 0.081 \end{aligned}$$

The luminance ( $Y'$ ) and color difference ( $Cb$  and  $Cr$ ) are obtained with the following

V4L2\_YCBCR\_ENC\_709 encoding:

$$\begin{aligned} Y' &= 0.2126R' + 0.7152G' + 0.0722B' \\ Cb &= -0.1146R' - 0.3854G' + 0.5B' \\ Cr &= 0.5R' - 0.4542G' - 0.0458B' \end{aligned}$$

$Y'$  is clamped to the range [0...1] and  $Cb$  and  $Cr$  are clamped to the range [-0.5...0.5].

The default quantization is limited range, but full range is possible although rarely seen.

The V4L2\_YCBCR\_ENC\_709 encoding described above is the default for this colorspace, but it can be overridden with V4L2\_YCBCR\_ENC\_601, in which case the BT.601 Y'CbCr encoding is used.

Two additional extended gamut Y'CbCr encodings are also possible with this colorspace:

The xvYCC 709 encoding (V4L2\_YCBCR\_ENC\_XV709, [xvYCC](#)) is similar to the Rec. 709 encoding, but it allows for  $R'$ ,  $G'$  and  $B'$  values that are outside the range [0...1]. The resulting  $Y'$ ,  $Cb$  and  $Cr$  values are scaled and offset according to the limited range formula:

$$\begin{aligned} Y' &= \frac{219}{256} * (0.2126R' + 0.7152G' + 0.0722B') + \frac{16}{256} \\ Cb &= \frac{224}{256} * (-0.1146R' - 0.3854G' + 0.5B') \\ Cr &= \frac{224}{256} * (0.5R' - 0.4542G' - 0.0458B') \end{aligned}$$

The xvYCC 601 encoding (V4L2\_YCBCR\_ENC\_XV601, [xvYCC](#)) is similar to the BT.601 encoding, but it allows for  $R'$ ,  $G'$  and  $B'$  values that are outside the range [0...1]. The resulting  $Y'$ ,  $Cb$  and  $Cr$  values are scaled and offset according to the limited range formula:

$$\begin{aligned} Y' &= \frac{219}{256} * (0.2990R' + 0.5870G' + 0.1140B') + \frac{16}{256} \\ Cb &= \frac{224}{256} * (-0.1687R' - 0.3313G' + 0.5B') \\ Cr &= \frac{224}{256} * (0.5R' - 0.4187G' - 0.0813B') \end{aligned}$$

$Y'$  is clamped to the range [0...1] and  $Cb$  and  $Cr$  are clamped to the range [-0.5...0.5] and quantized without further scaling or offsets. The non-standard xvYCC 709 or xvYCC 601 encodings can be used by selecting V4L2\_YCBCR\_ENC\_XV709 or V4L2\_YCBCR\_ENC\_XV601. As seen by the xvYCC formulas these encodings always use limited range quantization, there is no full range variant. The whole point of these extended gamut encodings is that values outside the limited range are still valid, although they map to  $R'$ ,  $G'$  and  $B'$  values outside the [0...1] range and are therefore outside the Rec. 709 colorspace gamut.

## Colorspace sRGB (V4L2\_COLORSPACE\_SRGB)

The [sRGB](#) standard defines the colorspace used by most webcams and computer graphics. The default transfer function is V4L2\_XFER\_FUNC\_SRGB. The default Y'CbCr encoding is V4L2\_YCBCR\_ENC\_601. The default Y'CbCr quantization is limited range.

Note that the [sYCC](#) standard specifies full range quantization, however all current capture hardware supported by the kernel convert R'G'B' to limited range Y'CbCr. So choosing full range as the default would break how applications interpret the quantization range.

The chromaticities of the primary colors and the white reference are:

Table 121: sRGB Chromaticities

Color	x	y
Red	0.640	0.330
Green	0.300	0.600
Blue	0.150	0.060
White Reference (D65)	0.3127	0.3290

These chromaticities are identical to the Rec. 709 colorspace.

Transfer function. Note that negative values for L are only used by the Y'CbCr conversion.

$$\begin{aligned}L' &= -1.055(-L)^{\frac{1}{2.4}} + 0.055, \text{ for } L < -0.0031308 \\L' &= 12.92L, \text{ for } -0.0031308 \leq L \leq 0.0031308 \\L' &= 1.055L^{\frac{1}{2.4}} - 0.055, \text{ for } 0.0031308 < L \leq 1\end{aligned}$$

Inverse Transfer function:

$$\begin{aligned}L &= -((-L' + 0.055)/1.055)^{2.4}, \text{ for } L' < -0.04045 \\L &= L'/12.92, \text{ for } -0.04045 \leq L' \leq 0.04045 \\L &= ((L' + 0.055)/1.055)^{2.4}, \text{ for } L' > 0.04045\end{aligned}$$

The luminance (Y') and color difference (Cb and Cr) are obtained with the following V4L2\_YCBCR\_ENC\_601 encoding as defined by [sYCC](#):

$$\begin{aligned}Y' &= 0.2990R' + 0.5870G' + 0.1140B' \\Cb &= -0.1687R' - 0.3313G' + 0.5B' \\Cr &= 0.5R' - 0.4187G' - 0.0813B'\end{aligned}$$

Y' is clamped to the range [0...1] and Cb and Cr are clamped to the range [-0.5...0.5]. This transform is identical to one defined in SMPTE 170M/BT.601. The Y'CbCr quantization is limited range.

## Colorspace opRGB (V4L2\_COLORSPACE\_OPRGB)

The [opRGB](#) standard defines the colorspace used by computer graphics that use the opRGB colorspace. The default transfer function is V4L2\_XFER\_FUNC\_OPRGB. The default Y'CbCr encoding is V4L2\_YCBCR\_ENC\_601. The default Y'CbCr quantization is limited range.

Note that the [opRGB](#) standard specifies full range quantization, however all current capture hardware supported by the kernel convert R'G'B' to limited range Y'CbCr. So choosing full range as the default would break how applications interpret the quantization range.

The chromaticities of the primary colors and the white reference are:

Table 122: opRGB Chromaticities

Color	x	y
Red	0.6400	0.3300
Green	0.2100	0.7100
Blue	0.1500	0.0600
White Reference (D65)	0.3127	0.3290

Transfer function:

$$L' = L^{\frac{1}{2.19921875}}$$

Inverse Transfer function:

$$L = L'^{(2.19921875)}$$

The luminance ( $Y'$ ) and color difference ( $Cb$  and  $Cr$ ) are obtained with the following V4L2\_YCBCR\_ENC\_601 encoding:

$$\begin{aligned} Y' &= 0.2990R' + 0.5870G' + 0.1140B' \\ Cb &= -0.1687R' - 0.3313G' + 0.5B' \\ Cr &= 0.5R' - 0.4187G' - 0.0813B' \end{aligned}$$

$Y'$  is clamped to the range [0...1] and  $Cb$  and  $Cr$  are clamped to the range [-0.5...0.5]. This transform is identical to one defined in SMPTE 170M/BT.601. The  $Y'CbCr$  quantization is limited range.

## Colorspace BT.2020 (V4L2\_COLORSPACE\_BT2020)

The [ITU BT.2020](#) standard defines the colorspace used by Ultra-high definition television (UHDTV). The default transfer function is V4L2\_XFER\_FUNC\_709. The default  $Y'CbCr$  encoding is V4L2\_YCBCR\_ENC\_BT2020. The default  $Y'CbCr$  quantization is limited range. The chromaticities of the primary colors and the white reference are:

Table 123: BT.2020 Chromaticities

Color	x	y
Red	0.708	0.292
Green	0.170	0.797
Blue	0.131	0.046
White Reference (D65)	0.3127	0.3290

Transfer function (same as Rec. 709):

$$\begin{aligned} L' &= 4.5L, \text{ for } 0 \leq L < 0.018 \\ L' &= 1.099L^{0.45} - 0.099, \text{ for } 0.018 \leq L \leq 1 \end{aligned}$$

Inverse Transfer function:

$$L = L'/4.5, \text{ for } L' < 0.081$$

$$L = \left( \frac{L' + 0.099}{1.099} \right)^{\frac{1}{0.45}}, \text{ for } L' \geq 0.081$$

Please note that while Rec. 709 is defined as the default transfer function by the [ITU BT.2020](#) standard, in practice this colorspace is often used with the [Transfer Function SMPTE 2084 \(V4L2\\_XFER\\_FUNC\\_SMPTE2084\)](#). In particular Ultra HD Blu-ray discs use this combination.

The luminance ( $Y'$ ) and color difference ( $Cb$  and  $Cr$ ) are obtained with the following V4L2\_YCBCR\_ENC\_BT2020 encoding:

$$Y' = 0.2627R' + 0.6780G' + 0.0593B'$$

$$Cb = -0.1396R' - 0.3604G' + 0.5B'$$

$$Cr = 0.5R' - 0.4598G' - 0.0402B'$$

$Y'$  is clamped to the range [0...1] and  $Cb$  and  $Cr$  are clamped to the range [-0.5...0.5]. The  $Y'CbCr$  quantization is limited range.

There is also an alternate constant luminance  $R'G'B'$  to  $Y'CbCr$  (V4L2\_YCBCR\_ENC\_BT2020\_CONST\_LUM) encoding:

Luma:

$$Yc' = (0.2627R + 0.6780G + 0.0593B)'$$

$$B' - Yc' \leq 0 : Cbc = (B' - Yc')/1.9404$$

$$B' - Yc' > 0 : Cbc = (B' - Yc')/1.5816$$

$$R' - Yc' \leq 0 : Crc = (R' - Y')/1.7184$$

$$R' - Yc' > 0 : Crc = (R' - Y')/0.9936$$

$Yc'$  is clamped to the range [0...1] and  $Cbc$  and  $Crc$  are clamped to the range [-0.5...0.5]. The  $Y'CbCr$  quantization is limited range.

## Colorspace DCI-P3 (V4L2\_COLORSPACE\_DCI\_P3)

The [SMPTE RP 431-2](#) standard defines the colorspace used by cinema projectors that use the DCI-P3 colorspace. The default transfer function is V4L2\_XFER\_FUNC\_DCI\_P3. The default  $Y'CbCr$  encoding is V4L2\_YCBCR\_ENC\_709. The default  $Y'CbCr$  quantization is limited range.

---

**Note:** Note that this colorspace standard does not specify a  $Y'CbCr$  encoding since it is not meant to be encoded to  $Y'CbCr$ . So this default  $Y'CbCr$  encoding was picked because it is the HDTV encoding.

---

The chromaticities of the primary colors and the white reference are:

Table 124: DCI-P3 Chromaticities

Color	x	y
Red	0.6800	0.3200
Green	0.2650	0.6900
Blue	0.1500	0.0600
White Reference	0.3140	0.3510

Transfer function:

$$L' = L^{\frac{1}{2.6}}$$

Inverse Transfer function:

$$L = L'^{(2.6)}$$

Y'CbCr encoding is not specified. V4L2 defaults to Rec. 709.

### Colorspace SMPTE 240M (V4L2\_COLORSPACE\_SMPTE240M)

The [SMPTE 240M](#) standard was an interim standard used during the early days of HDTV (1988-1998). It has been superseded by Rec. 709. The default transfer function is V4L2\_XFER\_FUNC\_SMPTE240M. The default Y'CbCr encoding is V4L2\_YCBCR\_ENC\_SMPTE240M. The default Y'CbCr quantization is limited range. The chromaticities of the primary colors and the white reference are:

Table 125: SMPTE 240M Chromaticities

Color	x	y
Red	0.630	0.340
Green	0.310	0.595
Blue	0.155	0.070
White Reference (D65)	0.3127	0.3290

These chromaticities are identical to the SMPTE 170M colorspace.

Transfer function:

$$L' = 4L, \text{ for } 0 \leq L < 0.0228$$

$$L' = 1.1115L^{0.45} - 0.1115, \text{ for } 0.0228 \leq L \leq 1$$

Inverse Transfer function:

$$L = \frac{L'}{4}, \text{ for } 0 \leq L' < 0.0913$$

$$L = \left( \frac{L' + 0.1115}{1.1115} \right)^{\frac{1}{0.45}}, \text{ for } L' \geq 0.0913$$

The luminance (Y') and color difference (Cb and Cr) are obtained with the following

V4L2\_YCBCR\_ENC\_SMPTE240M encoding:

$$Y' = 0.2122R' + 0.7013G' + 0.0865B'$$

$$Cb = -0.1161R' - 0.3839G' + 0.5B'$$

$$Cr = 0.5R' - 0.4451G' - 0.0549B'$$

$Y'$  is clamped to the range [0...1] and  $Cb$  and  $Cr$  are clamped to the range [-0.5...0.5]. The  $Y'CbCr$  quantization is limited range.

### Colorspace NTSC 1953 (V4L2\_COLORSPACE\_470\_SYSTEM\_M)

This standard defines the colorspace used by NTSC in 1953. In practice this colorspace is obsolete and SMPTE 170M should be used instead. The default transfer function is V4L2\_XFER\_FUNC\_709. The default  $Y'CbCr$  encoding is V4L2\_YCBCR\_ENC\_601. The default  $Y'CbCr$  quantization is limited range. The chromaticities of the primary colors and the white reference are:

Table 126: NTSC 1953 Chromaticities

Color	x	y
Red	0.67	0.33
Green	0.21	0.71
Blue	0.14	0.08
White Reference (C)	0.310	0.316

---

**Note:** This colorspace uses Illuminant C instead of D65 as the white reference. To correctly convert an image in this colorspace to another that uses D65 you need to apply a chromatic adaptation algorithm such as the Bradford method.

---

The transfer function was never properly defined for NTSC 1953. The Rec. 709 transfer function is recommended in the literature:

$$L' = 4.5L, \text{ for } 0 \leq L < 0.018$$

$$L' = 1.099L^{0.45} - 0.099, \text{ for } 0.018 \leq L \leq 1$$

Inverse Transfer function:

$$L = \frac{L'}{4.5}, \text{ for } L' < 0.081$$

$$L = \left( \frac{L' + 0.099}{1.099} \right)^{\frac{1}{0.45}}, \text{ for } L' \geq 0.081$$

The luminance ( $Y'$ ) and color difference ( $Cb$  and  $Cr$ ) are obtained with the following V4L2\_YCBCR\_ENC\_601 encoding:

$$Y' = 0.2990R' + 0.5870G' + 0.1140B'$$

$$Cb = -0.1687R' - 0.3313G' + 0.5B'$$

$$Cr = 0.5R' - 0.4187G' - 0.0813B'$$

$Y'$  is clamped to the range [0...1] and  $Cb$  and  $Cr$  are clamped to the range [-0.5...0.5]. The  $Y'CbCr$  quantization is limited range. This transform is identical to one defined in SMPTE 170M/BT.601.

### Colorspace EBU Tech. 3213 (V4L2\_COLORSPACE\_470\_SYSTEM\_BG)

The [EBU Tech 3213](#) standard defines the colorspace used by PAL/SECAM in 1975. Note that this colorspace is not supported by the HDMI interface. Instead [EBU Tech 3321](#) recommends that Rec. 709 is used instead for HDMI. The default transfer function is V4L2\_XFER\_FUNC\_709. The default  $Y'CbCr$  encoding is V4L2\_YCBCR\_ENC\_601. The default  $Y'CbCr$  quantization is limited range. The chromaticities of the primary colors and the white reference are:

Table 127: EBU Tech. 3213 Chromaticities

Color	x	y
Red	0.64	0.33
Green	0.29	0.60
Blue	0.15	0.06
White Reference (D65)	0.3127	0.3290

The transfer function was never properly defined for this colorspace. The Rec. 709 transfer function is recommended in the literature:

$$L' = 4.5L, \text{ for } 0 \leq L < 0.018$$

$$L' = 1.099L^{0.45} - 0.099, \text{ for } 0.018 \leq L \leq 1$$

Inverse Transfer function:

$$L = \frac{L'}{4.5}, \text{ for } L' < 0.081$$

$$L = \left( \frac{L' + 0.099}{1.099} \right)^{\frac{1}{0.45}}, \text{ for } L' \geq 0.081$$

The luminance ( $Y'$ ) and color difference ( $Cb$  and  $Cr$ ) are obtained with the following V4L2\_YCBCR\_ENC\_601 encoding:

$$Y' = 0.2990R' + 0.5870G' + 0.1140B'$$

$$Cb = -0.1687R' - 0.3313G' + 0.5B'$$

$$Cr = 0.5R' - 0.4187G' - 0.0813B'$$

$Y'$  is clamped to the range [0...1] and  $Cb$  and  $Cr$  are clamped to the range [-0.5...0.5]. The  $Y'CbCr$  quantization is limited range. This transform is identical to one defined in SMPTE 170M/BT.601.

## **Colorspace JPEG (V4L2\_COLORSPACE\_JPEG)**

This colorspace defines the colorspace used by most (Motion-)JPEG formats. The chromaticities of the primary colors and the white reference are identical to sRGB. The transfer function use is V4L2\_XFER\_FUNC\_SRGB. The Y'CbCr encoding is V4L2\_YCBCR\_ENC\_601 with full range quantization where Y' is scaled to [0...255] and Cb/Cr are scaled to [-128...128] and then clipped to [-128...127].

---

**Note:** The JPEG standard does not actually store colorspace information. So if something other than sRGB is used, then the driver will have to set that information explicitly. Effectively V4L2\_COLORSPACE\_JPEG can be considered to be an abbreviation for V4L2\_COLORSPACE\_SRGB, V4L2\_XFER\_FUNC\_SRGB, V4L2\_YCBCR\_ENC\_601 and V4L2\_QUANTIZATION\_FULL\_RANGE.

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## **Detailed Transfer Function Descriptions**

### **Transfer Function SMPTE 2084 (V4L2\_XFER\_FUNC\_SMPTE2084)**

The *SMPTE ST 2084* standard defines the transfer function used by High Dynamic Range content.

#### **Constants:**

$$m1 = (2610 / 4096) / 4$$

$$m2 = (2523 / 4096) * 128$$

$$c1 = 3424 / 4096$$

$$c2 = (2413 / 4096) * 32$$

$$c3 = (2392 / 4096) * 32$$

#### **Transfer function:**

$$L' = ((c1 + c2 * L^{m1}) / (1 + c3 * L^{m1}))^{m2}$$

#### **Inverse Transfer function:**

$$L = (\max(L'^{1/m2} - c1, 0) / (c2 - c3 * L'^{1/m2}))^{1/m1}$$

Take care when converting between this transfer function and non-HDR transfer functions: the linear RGB values [0...1] of HDR content map to a luminance range of 0 to 10000 cd/m<sup>2</sup> whereas the linear RGB values of non-HDR (aka Standard Dynamic Range or SDR) map to a luminance range of 0 to 100 cd/m<sup>2</sup>.

To go from SDR to HDR you will have to divide L by 100 first. To go in the other direction you will have to multiply L by 100. Of course, this clamps all luminance values over 100 cd/m<sup>2</sup> to 100 cd/m<sup>2</sup>.

There are better methods, see e.g. [colimg](#) for more in-depth information about this.

### 13.2.3 Input/Output

The V4L2 API defines several different methods to read from or write to a device. All drivers exchanging data with applications must support at least one of them.

The classic I/O method using the `read()` and `write()` function is automatically selected after opening a V4L2 device. When the driver does not support this method attempts to read or write will fail at any time.

Other methods must be negotiated. To select the streaming I/O method with memory mapped or user buffers applications call the `ioctl VIDIOC_REQBUFS` ioctl.

Video overlay can be considered another I/O method, although the application does not directly receive the image data. It is selected by initiating video overlay with the `VIDIOC_S_FMT` ioctl. For more information see [Video Overlay Interface](#).

Generally exactly one I/O method, including overlay, is associated with each file descriptor. The only exceptions are applications not exchanging data with a driver ("panel applications", see [Opening and Closing Devices](#)) and drivers permitting simultaneous video capturing and overlay using the same file descriptor, for compatibility with V4L and earlier versions of V4L2.

`VIDIOC_S_FMT` and `ioctl VIDIOC_REQBUFS` would permit this to some degree, but for simplicity drivers need not support switching the I/O method (after first switching away from read/write) other than by closing and reopening the device.

The following sections describe the various I/O methods in more detail.

#### Read/Write

Input and output devices support the `read()` and `write()` function, respectively, when the `V4L2_CAP_READWRITE` flag in the `capabilities` field of struct `v4l2_capability` returned by the `ioctl VIDIOC_QUERYCAP` ioctl is set.

Drivers may need the CPU to copy the data, but they may also support DMA to or from user memory, so this I/O method is not necessarily less efficient than other methods merely exchanging buffer pointers. It is considered inferior though because no meta-information like frame counters or timestamps are passed. This information is necessary to recognize frame dropping and to synchronize with other data streams. However this is also the simplest I/O method, requiring little or no setup to exchange data. It permits command line stunts like this (the vidctrl tool is fictitious):

```
$ vidctrl /dev/video --input=0 --format=YUYV --size=352x288
$ dd if=/dev/video of=myimage.422 bs=202752 count=1
```

To read from the device applications use the `read()` function, to write the `write()` function. Drivers must implement one I/O method if they exchange data with applications, but it need not be this.<sup>1</sup> When reading or writing is supported, the driver must also support the `select()` and `poll()` function.<sup>2</sup>

<sup>1</sup> It would be desirable if applications could depend on drivers supporting all I/O interfaces, but as much as the complex memory mapping I/O can be inadequate for some devices we have no reason to require this interface, which is most useful for simple applications capturing still images.

<sup>2</sup> At the driver level `select()` and `poll()` are the same, and `select()` is too important to be optional.

## Streaming I/O (Memory Mapping)

Input and output devices support this I/O method when the `V4L2_CAP_STREAMING` flag in the `capabilities` field of struct `v4l2_capability` returned by the `ioctl VIDIOC_QUERYCAP` ioctl is set. There are two streaming methods, to determine if the memory mapping flavor is supported applications must call the `ioctl VIDIOC_REQBUFS` ioctl with the memory type set to `V4L2_MEMORY_MMAP`.

Streaming is an I/O method where only pointers to buffers are exchanged between application and driver, the data itself is not copied. Memory mapping is primarily intended to map buffers in device memory into the application's address space. Device memory can be for example the video memory on a graphics card with a video capture add-on. However, being the most efficient I/O method available for a long time, many other drivers support streaming as well, allocating buffers in DMA-able main memory.

A driver can support many sets of buffers. Each set is identified by a unique buffer type value. The sets are independent and each set can hold a different type of data. To access different sets at the same time different file descriptors must be used.<sup>1</sup>

To allocate device buffers applications call the `ioctl VIDIOC_REQBUFS` ioctl with the desired number of buffers and buffer type, for example `V4L2_BUF_TYPE_VIDEO_CAPTURE`. This ioctl can also be used to change the number of buffers or to free the allocated memory, provided none of the buffers are still mapped.

Before applications can access the buffers they must map them into their address space with the `mmap()` function. The location of the buffers in device memory can be determined with the `ioctl VIDIOC_QUERYBUF` ioctl. In the single-planar API case, the `m.offset` and `length` returned in a struct `v4l2_buffer` are passed as sixth and second parameter to the `mmap()` function. When using the multi-planar API, struct `v4l2_buffer` contains an array of struct `v4l2_plane` structures, each containing its own `m.offset` and `length`. When using the multi-planar API, every plane of every buffer has to be mapped separately, so the number of calls to `mmap()` should be equal to number of buffers times number of planes in each buffer. The offset and length values must not be modified. Remember, the buffers are allocated in physical memory, as opposed to virtual memory, which can be swapped out to disk. Applications should free the buffers as soon as possible with the `munmap()` function.

### Example: Mapping buffers in the single-planar API

```
struct v4l2_requestbuffers reqbuf;
struct {
    void *start;
    size_t length;
} *buffers;
unsigned int i;

memset(&reqbuf, 0, sizeof(reqbuf));
reqbuf.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
reqbuf.memory = V4L2_MEMORY_MMAP;
```

<sup>1</sup> One could use one file descriptor and set the buffer type field accordingly when calling `ioctl VIDIOC_QBUF`, `VIDIOC_DQBUF` etc., but it makes the `select()` function ambiguous. We also like the clean approach of one file descriptor per logical stream. Video overlay for example is also a logical stream, although the CPU is not needed for continuous operation.

```

reqbuf.count = 20;

if (-1 == ioctl (fd, VIDIOC_REQBUFS, &reqbuf)) {
    if (errno == EINVAL)
        printf("Video capturing or mmap-streaming is not supported\n");
    else
        perror("VIDIOC_REQBUFS");

    exit(EXIT_FAILURE);
}

/* We want at least five buffers. */

if (reqbuf.count < 5) {
    /* You may need to free the buffers here. */
    printf("Not enough buffer memory\n");
    exit(EXIT_FAILURE);
}

buffers = calloc(reqbuf.count, sizeof(*buffers));
assert(buffers != NULL);

for (i = 0; i < reqbuf.count; i++) {
    struct v4l2_buffer buffer;

    memset(&buffer, 0, sizeof(buffer));
    buffer.type = reqbuf.type;
    buffer.memory = V4L2_MEMORY_MMAP;
    buffer.index = i;

    if (-1 == ioctl (fd, VIDIOC_QUERYBUF, &buffer)) {
        perror("VIDIOC_QUERYBUF");
        exit(EXIT_FAILURE);
    }

    buffers[i].length = buffer.length; /* remember for munmap() */

    buffers[i].start = mmap(NULL, buffer.length,
                           PROT_READ | PROT_WRITE, /* recommended */
                           MAP_SHARED, /* recommended */
                           fd, buffer.m.offset);

    if (MAP_FAILED == buffers[i].start) {
        /* If you do not exit here you should unmap() and free()
           the buffers mapped so far. */
        perror("mmap");
        exit(EXIT_FAILURE);
    }
}

```

```
/* Cleanup. */

for (i = 0; i < reqbuf.count; i++)
    munmap(buffers[i].start, buffers[i].length);
```

**Example: Mapping buffers in the multi-planar API**

```
struct v4l2_requestbuffers reqbuf;
/* Our current format uses 3 planes per buffer */
#define FMT_NUM_PLANES = 3

struct {
    void *start[FMT_NUM_PLANES];
    size_t length[FMT_NUM_PLANES];
} *buffers;
unsigned int i, j;

memset(&reqbuf, 0, sizeof(reqbuf));
reqbuf.type = V4L2_BUF_TYPE_VIDEO_CAPTURE_MPLANE;
reqbuf.memory = V4L2_MEMORY_MMAP;
reqbuf.count = 20;

if (ioctl(fd, VIDIOC_REQBUFS, &reqbuf) < 0) {
    if (errno == EINVAL)
        printf("Video capturing or mmap-streaming is not supported\n");
    else
        perror("VIDIOC_REQBUFS");

    exit(EXIT_FAILURE);
}

/* We want at least five buffers. */

if (reqbuf.count < 5) {
    /* You may need to free the buffers here. */
    printf("Not enough buffer memory\n");
    exit(EXIT_FAILURE);
}

buffers = calloc(reqbuf.count, sizeof(*buffers));
assert(buffers != NULL);

for (i = 0; i < reqbuf.count; i++) {
    struct v4l2_buffer buffer;
    struct v4l2_plane planes[FMT_NUM_PLANES];

    memset(&buffer, 0, sizeof(buffer));
    buffer.type = reqbuf.type;
    buffer.memory = V4L2_MEMORY_MMAP;
```

```

buffer.index = i;
/* length in struct v4l2_buffer in multi-planar API stores the size
 * of planes array. */
buffer.length = FMT_NUM_PLANES;
buffer.m.planes = planes;

if (ioctl(fd, VIDIOC_QUERYBUF, &buffer) < 0) {
    perror("VIDIOC_QUERYBUF");
    exit(EXIT_FAILURE);
}

/* Every plane has to be mapped separately */
for (j = 0; j < FMT_NUM_PLANES; j++) {
    buffers[i].length[j] = buffer.m.planes[j].length; /* remember for
munmap() */

    buffers[i].start[j] = mmap(NULL, buffer.m.planes[j].length,
        PROT_READ | PROT_WRITE, /* recommended */
        MAP_SHARED, /* recommended */
        fd, buffer.m.planes[j].m.offset);

    if (MAP_FAILED == buffers[i].start[j]) {
        /* If you do not exit here you should unmap() and free()
         * the buffers and planes mapped so far. */
        perror("mmap");
        exit(EXIT_FAILURE);
    }
}
}

/* Cleanup. */

for (i = 0; i < reqbuf.count; i++)
    for (j = 0; j < FMT_NUM_PLANES; j++)
        munmap(buffers[i].start[j], buffers[i].length[j]);

```

Conceptually streaming drivers maintain two buffer queues, an incoming and an outgoing queue. They separate the synchronous capture or output operation locked to a video clock from the application which is subject to random disk or network delays and preemption by other processes, thereby reducing the probability of data loss. The queues are organized as FIFOs, buffers will be output in the order enqueued in the incoming FIFO, and were captured in the order dequeued from the outgoing FIFO.

The driver may require a minimum number of buffers enqueued at all times to function, apart of this no limit exists on the number of buffers applications can enqueue in advance, or dequeue and process. They can also enqueue in a different order than buffers have been dequeued, and the driver can *fill* enqueued *empty* buffers in any order.<sup>2</sup> The index number of a buffer (struct *v4l2\_buffer* *index*) plays no role here, it only identifies the buffer.

---

<sup>2</sup> Random enqueue order permits applications processing images out of order (such as video codecs) to return buffers earlier, reducing the probability of data loss. Random fill order allows drivers to reuse buffers on a LIFO-basis, taking advantage of caches holding scatter-gather lists and the like.

Initially all mapped buffers are in dequeued state, inaccessible by the driver. For capturing applications it is customary to first enqueue all mapped buffers, then to start capturing and enter the read loop. Here the application waits until a filled buffer can be dequeued, and re-enqueues the buffer when the data is no longer needed. Output applications fill and enqueue buffers, when enough buffers are stacked up the output is started with [VIDIOC\\_STREAMON](#). In the write loop, when the application runs out of free buffers, it must wait until an empty buffer can be dequeued and reused.

To enqueue and dequeue a buffer applications use the [VIDIOC\\_QBUF](#) and [VIDIOC\\_DQBUF](#) ioctl. The status of a buffer being mapped, enqueued, full or empty can be determined at any time using the *ioctl VIDIOC\_QUERYBUF* ioctl. Two methods exist to suspend execution of the application until one or more buffers can be dequeued. By default [VIDIOC\\_DQBUF](#) blocks when no buffer is in the outgoing queue. When the `O_NONBLOCK` flag was given to the [open\(\)](#) function, [VIDIOC\\_DQBUF](#) returns immediately with an `EAGAIN` error code when no buffer is available. The [select\(\)](#) or [poll\(\)](#) functions are always available.

To start and stop capturing or output applications call the [VIDIOC\\_STREAMON](#) and [VIDIOC\\_STREAMOFF](#) ioctl.

Drivers implementing memory mapping I/O must support the [VIDIOC\\_REQBUFS](#), [VIDIOC\\_QUERYBUF](#), [VIDIOC\\_QBUF](#), [VIDIOC\\_DQBUF](#), [VIDIOC\\_STREAMON](#) and [VIDIOC\\_STREAMOFF](#) ioctls, the [mmap\(\)](#), [munmap\(\)](#), [select\(\)](#) and [poll\(\)](#) function.<sup>3</sup>

[capture example]

## Streaming I/O (User Pointers)

Input and output devices support this I/O method when the `V4L2_CAP_STREAMING` flag in the `capabilities` field of struct [`v4l2\_capability`](#) returned by the *ioctl VIDIOC\_QUERYCAP* ioctl is set. If the particular user pointer method (not only memory mapping) is supported must be determined by calling the *ioctl VIDIOC\_REQBUFS* ioctl with the memory type set to `V4L2_MEMORY_USERPTR`.

This I/O method combines advantages of the read/write and memory mapping methods. Buffers (planes) are allocated by the application itself, and can reside for example in virtual or shared memory. Only pointers to data are exchanged, these pointers and meta-information are passed in struct [`v4l2\_buffer`](#) (or in struct [`v4l2\_plane`](#) in the multi-planar API case). The driver must be switched into user pointer I/O mode by calling the *ioctl VIDIOC\_REQBUFS* with the desired buffer type. No buffers (planes) are allocated beforehand, consequently they are not indexed and cannot be queried like mapped buffers with the [VIDIOC\\_QUERYBUF](#) ioctl.

---

<sup>3</sup> At the driver level [select\(\)](#) and [poll\(\)](#) are the same, and [select\(\)](#) is too important to be optional. The rest should be evident.

## Example: Initiating streaming I/O with user pointers

```
struct v4l2_requestbuffers reqbuf;

memset (&reqbuf, 0, sizeof (reqbuf));
reqbuf.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
reqbuf.memory = V4L2_MEMORY_USERPTR;

if (ioctl (fd, VIDIOC_REQBUFS, &reqbuf) == -1) {
    if (errno == EINVAL)
        printf ("Video capturing or user pointer streaming is not supported\\n"
    );
    else
        perror ("VIDIOC_REQBUFS");

    exit (EXIT_FAILURE);
}
```

Buffer (plane) addresses and sizes are passed on the fly with the [VIDIOC\\_QBUF](#) ioctl. Although buffers are commonly cycled, applications can pass different addresses and sizes at each [VIDIOC\\_QBUF](#) call. If required by the hardware the driver swaps memory pages within physical memory to create a continuous area of memory. This happens transparently to the application in the virtual memory subsystem of the kernel. When buffer pages have been swapped out to disk they are brought back and finally locked in physical memory for DMA.<sup>1</sup>

Filled or displayed buffers are dequeued with the [VIDIOC\\_DQBUF](#) ioctl. The driver can unlock the memory pages at any time between the completion of the DMA and this ioctl. The memory is also unlocked when [VIDIOC\\_STREAMOFF](#) is called, [ioctl VIDIOC\\_REQBUFS](#), or when the device is closed. Applications must take care not to free buffers without dequeuing. Firstly, the buffers remain locked for longer, wasting physical memory. Secondly the driver will not be notified when the memory is returned to the application's free list and subsequently reused for other purposes, possibly completing the requested DMA and overwriting valuable data.

For capturing applications it is customary to enqueue a number of empty buffers, to start capturing and enter the read loop. Here the application waits until a filled buffer can be dequeued, and re-enqueues the buffer when the data is no longer needed. Output applications fill and enqueue buffers, when enough buffers are stacked up output is started. In the write loop, when the application runs out of free buffers it must wait until an empty buffer can be dequeued and reused. Two methods exist to suspend execution of the application until one or more buffers can be dequeued. By default [VIDIOC\\_DQBUF](#) blocks when no buffer is in the outgoing queue. When the `O_NONBLOCK` flag was given to the [open\(\)](#) function, [VIDIOC\\_DQBUF](#) returns immediately with an `EAGAIN` error code when no buffer is available. The [select\(\)](#) or [poll\(\)](#) function are always available.

To start and stop capturing or output applications call the [VIDIOC\\_STREAMON](#) and [VIDIOC\\_STREAMOFF](#) ioctl.

<sup>1</sup> We expect that frequently used buffers are typically not swapped out. Anyway, the process of swapping, locking or generating scatter-gather lists may be time consuming. The delay can be masked by the depth of the incoming buffer queue, and perhaps by maintaining caches assuming a buffer will be soon enqueued again. On the other hand, to optimize memory usage drivers can limit the number of buffers locked in advance and recycle the most recently used buffers first. Of course, the pages of empty buffers in the incoming queue need not be saved to disk. Output buffers must be saved on the incoming and outgoing queue because an application may share them with other processes.

---

**Note:** `VIDIOC_STREAMOFF` removes all buffers from both queues and unlocks all buffers as a side effect. Since there is no notion of doing anything "now" on a multitasking system, if an application needs to synchronize with another event it should examine the struct `v4l2_buffer` timestamp of captured or outputted buffers.

---

Drivers implementing user pointer I/O must support the `VIDIOC_REQBUFS`, `VIDIOC_QBUF`, `VIDIOC_DQBUF`, `VIDIOC_STREAMON` and `VIDIOC_STREAMOFF` ioctls, the `select()` and `poll()` function.<sup>2</sup>

## Streaming I/O (DMA buffer importing)

The DMABUF framework provides a generic method for sharing buffers between multiple devices. Device drivers that support DMABUF can export a DMA buffer to userspace as a file descriptor (known as the exporter role), import a DMA buffer from userspace using a file descriptor previously exported for a different or the same device (known as the importer role), or both. This section describes the DMABUF importer role API in V4L2.

Refer to [DMABUF exporting](#) for details about exporting V4L2 buffers as DMABUF file descriptors.

Input and output devices support the streaming I/O method when the `V4L2_CAP_STREAMING` flag in the `capabilities` field of struct `v4l2_capability` returned by the `VIDIOC_QUERYCAP` ioctl is set. Whether importing DMA buffers through DMABUF file descriptors is supported is determined by calling the `VIDIOC_REQBUFS` ioctl with the memory type set to `V4L2_MEMORY_DMABUF`.

This I/O method is dedicated to sharing DMA buffers between different devices, which may be V4L devices or other video-related devices (e.g. DRM). Buffers (planes) are allocated by a driver on behalf of an application. Next, these buffers are exported to the application as file descriptors using an API which is specific for an allocator driver. Only such file descriptor are exchanged. The descriptors and meta-information are passed in struct `v4l2_buffer` (or in struct `v4l2_plane` in the multi-planar API case). The driver must be switched into DMABUF I/O mode by calling the `VIDIOC_REQBUFS` with the desired buffer type.

## Example: Initiating streaming I/O with DMABUF file descriptors

```
struct v4l2_requestbuffers reqbuf;

memset(&reqbuf, 0, sizeof (reqbuf));
reqbuf.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
reqbuf.memory = V4L2_MEMORY_DMABUF;
reqbuf.count = 1;

if (ioctl(fd, VIDIOC_REQBUFS, &reqbuf) == -1) {
    if (errno == EINVAL)
        printf("Video capturing or DMABUF streaming is not supported\n");
    else
        perror("VIDIOC_REQBUFS");
```

---

<sup>2</sup> At the driver level `select()` and `poll()` are the same, and `select()` is too important to be optional. The rest should be evident.

```

    exit(EXIT_FAILURE);
}
}
```

The buffer (plane) file descriptor is passed on the fly with the `VIDIOC_QBUF` ioctl. In case of multiplanar buffers, every plane can be associated with a different DMABUF descriptor. Although buffers are commonly cycled, applications can pass a different DMABUF descriptor at each `VIDIOC_QBUF` call.

### Example: Queueing DMABUF using single plane API

```

int buffer_queue(int v4lfd, int index, int dmafd)
{
    struct v4l2_buffer buf;

    memset(&buf, 0, sizeof buf);
    buf.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
    buf.memory = V4L2_MEMORY_DMABUF;
    buf.index = index;
    buf.m.fd = dmafd;

    if (ioctl(v4lfd, VIDIOC_QBUF, &buf) == -1) {
        perror("VIDIOC_QBUF");
        return -1;
    }

    return 0;
}
```

### Example 3.6. Queueing DMABUF using multi plane API

```

int buffer_queue_mp(int v4lfd, int index, int dmafd[], int n_planes)
{
    struct v4l2_buffer buf;
    struct v4l2_plane planes[VIDEO_MAX_PLANES];
    int i;

    memset(&buf, 0, sizeof buf);
    buf.type = V4L2_BUF_TYPE_VIDEO_CAPTURE_MPLANE;
    buf.memory = V4L2_MEMORY_DMABUF;
    buf.index = index;
    buf.m.planes = planes;
    buf.length = n_planes;

    memset(&planes, 0, sizeof planes);

    for (i = 0; i < n_planes; ++i)
        buf.m.planes[i].m.fd = dmafd[i];
```

```

if (ioctl(v4lfd, VIDIOC_QBUF, &buf) == -1) {
    perror("VIDIOC_QBUF");
    return -1;
}

return 0;
}

```

Captured or displayed buffers are dequeued with the `VIDIOC_DQBUF` ioctl. The driver can unlock the buffer at any time between the completion of the DMA and this ioctl. The memory is also unlocked when `VIDIOC_STREAMOFF` is called, `VIDIOC_REQBUFS`, or when the device is closed.

For capturing applications it is customary to enqueue a number of empty buffers, to start capturing and enter the read loop. Here the application waits until a filled buffer can be dequeued, and re-enqueues the buffer when the data is no longer needed. Output applications fill and enqueue buffers, when enough buffers are stacked up output is started. In the write loop, when the application runs out of free buffers it must wait until an empty buffer can be dequeued and reused. Two methods exist to suspend execution of the application until one or more buffers can be dequeued. By default `VIDIOC_DQBUF` blocks when no buffer is in the outgoing queue. When the `O_NONBLOCK` flag was given to the `open()` function, `VIDIOC_DQBUF` returns immediately with an `EAGAIN` error code when no buffer is available. The `select()` and `poll()` functions are always available.

To start and stop capturing or displaying applications call the `VIDIOC_STREAMON` and `VIDIOC_STREAMOFF` ioctls.

---

**Note:** `VIDIOC_STREAMOFF` removes all buffers from both queues and unlocks all buffers as a side effect. Since there is no notion of doing anything "now" on a multitasking system, if an application needs to synchronize with another event it should examine the struct `v4l2_buffer` timestamp of captured or outputted buffers.

Drivers implementing DMABUF importing I/O must support the `VIDIOC_REQBUFS`, `VIDIOC_QBUF`, `VIDIOC_DQBUF`, `VIDIOC_STREAMON` and `VIDIOC_STREAMOFF` ioctls, and the `select()` and `poll()` functions.

## Buffers

A buffer contains data exchanged by application and driver using one of the Streaming I/O methods. In the multi-planar API, the data is held in planes, while the buffer structure acts as a container for the planes. Only pointers to buffers (planes) are exchanged, the data itself is not copied. These pointers, together with meta-information like timestamps or field parity, are stored in a struct `v4l2_buffer`, argument to the `ioctl VIDIOC_QUERYBUF`, `VIDIOC_QBUF` and `VIDIOC_DQBUF` ioctl. In the multi-planar API, some plane-specific members of struct `v4l2_buffer`, such as pointers and sizes for each plane, are stored in struct `v4l2_plane` instead. In that case, struct `v4l2_buffer` contains an array of plane structures.

Dequeued video buffers come with timestamps. The driver decides at which part of the frame and with which clock the timestamp is taken. Please see flags in the masks `V4L2_BUF_FLAG_TIMESTAMP_MASK` and `V4L2_BUF_FLAG_TSTAMP_SRC_MASK` in `Buffer Flags`. These

flags are always valid and constant across all buffers during the whole video stream. Changes in these flags may take place as a side effect of `VIDIOC_S_INPUT` or `VIDIOC_S_OUTPUT` however. The `V4L2_BUF_FLAG_TIMESTAMP_COPY` timestamp type which is used by e.g. on mem-to-mem devices is an exception to the rule: the timestamp source flags are copied from the OUTPUT video buffer to the CAPTURE video buffer.

## Interactions between formats, controls and buffers

V4L2 exposes parameters that influence the buffer size, or the way data is laid out in the buffer. Those parameters are exposed through both formats and controls. One example of such a control is the `V4L2_CID_ROTATE` control that modifies the direction in which pixels are stored in the buffer, as well as the buffer size when the selected format includes padding at the end of lines.

The set of information needed to interpret the content of a buffer (e.g. the pixel format, the line stride, the tiling orientation or the rotation) is collectively referred to in the rest of this section as the buffer layout.

Controls that can modify the buffer layout shall set the `V4L2_CTRL_FLAG MODIFY_LAYOUT` flag.

Modifying formats or controls that influence the buffer size or layout require the stream to be stopped. Any attempt at such a modification while the stream is active shall cause the ioctl setting the format or the control to return the `EBUSY` error code. In that case drivers shall also set the `V4L2_CTRL_FLAG_GRABBED` flag when calling `VIDIOC_QUERYCTRL()` or `VIDIOC_QUERY_EXT_CTRL()` for such a control while the stream is active.

---

**Note:** The `VIDIOC_S_SELECTION()` ioctl can, depending on the hardware (for instance if the device doesn't include a scaler), modify the format in addition to the selection rectangle. Similarly, the `VIDIOC_S_INPUT()`, `VIDIOC_S_OUTPUT()`, `VIDIOC_S_STD()` and `VIDIOC_S_DV_TIMINGS()` ioctls can also modify the format and selection rectangles. When those ioctls result in a buffer size or layout change, drivers shall handle that condition as they would handle it in the `VIDIOC_S_FMT()` ioctl in all cases described in this section.

Controls that only influence the buffer layout can be modified at any time when the stream is stopped. As they don't influence the buffer size, no special handling is needed to synchronize those controls with buffer allocation and the `V4L2_CTRL_FLAG_GRABBED` flag is cleared once the stream is stopped.

Formats and controls that influence the buffer size interact with buffer allocation. The simplest way to handle this is for drivers to always require buffers to be reallocated in order to change those formats or controls. In that case, to perform such changes, userspace applications shall first stop the video stream with the `VIDIOC_STREAMOFF()` ioctl if it is running and free all buffers with the `VIDIOC_REQBUFS()` ioctl if they are allocated. After freeing all buffers the `V4L2_CTRL_FLAG_GRABBED` flag for controls is cleared. The format or controls can then be modified, and buffers shall then be reallocated and the stream restarted. A typical ioctl sequence is

1. `VIDIOC_STREAMOFF`
2. `VIDIOC_REQBUFS(0)`
3. `VIDIOC_S_EXT_CTRLS`

4. VIDIOC\_S\_FMT
5. VIDIOC\_REQBUFS(n)
6. VIDIOC\_QBUF
7. VIDIOC\_STREAMON

The second `VIDIOC_REQBUFS()` call will take the new format and control value into account to compute the buffer size to allocate. Applications can also retrieve the size by calling the `VIDIOC_G_FMT()` ioctl if needed.

---

**Note:** The API doesn't mandate the above order for control (3.) and format (4.) changes. Format and controls can be set in a different order, or even interleaved, depending on the device and use case. For instance some controls might behave differently for different pixel formats, in which case the format might need to be set first.

When reallocation is required, any attempt to modify format or controls that influences the buffer size while buffers are allocated shall cause the format or control set ioctl to return the `EBUSY` error. Any attempt to queue a buffer too small for the current format or controls shall cause the `VIDIOC_QBUF()` ioctl to return a `EINVAL` error.

Buffer reallocation is an expensive operation. To avoid that cost, drivers can (and are encouraged to) allow format or controls that influence the buffer size to be changed with buffers allocated. In that case, a typical ioctl sequence to modify format and controls is

1. VIDIOC\_STREAMOFF
2. VIDIOC\_S\_EXT\_CTRLS
3. VIDIOC\_S\_FMT
4. VIDIOC\_QBUF
5. VIDIOC\_STREAMON

For this sequence to operate correctly, queued buffers need to be large enough for the new format or controls. Drivers shall return a `ENOSPC` error in response to format change (`VIDIOC_S_FMT()`) or control changes (`VIDIOC_S_CTRL()` or `VIDIOC_S_EXT_CTRLS()`) if buffers too small for the new format are currently queued. As a simplification, drivers are allowed to return a `EBUSY` error from these ioctls if any buffer is currently queued, without checking the queued buffers sizes.

Additionally, drivers shall return a `EINVAL` error from the `VIDIOC_QBUF()` ioctl if the buffer being queued is too small for the current format or controls. Together, these requirements ensure that queued buffers will always be large enough for the configured format and controls.

Userspace applications can query the buffer size required for a given format and controls by first setting the desired control values and then trying the desired format. The `VIDIOC_TRY_FMT()` ioctl will return the required buffer size.

1. VIDIOC\_S\_EXT\_CTRLS(x)
2. VIDIOC\_TRY\_FMT()
3. VIDIOC\_S\_EXT\_CTRLS(y)
4. VIDIOC\_TRY\_FMT()

The `VIDIOC_CREATE_BUFS()` ioctl can then be used to allocate buffers based on the queried sizes (for instance by allocating a set of buffers large enough for all the desired formats and controls, or by allocating separate set of appropriately sized buffers for each use case).

type `v4l2_buffer`

**struct v4l2\_buffer**

Table 128: struct v4l2\_buffer

<code>_u32</code>	<code>index</code>	Number of the buffer, set by the application except when calling <code>VIDIOC_DQBUF</code> , then it is set by the driver. This field can range from zero to the number of buffers allocated with the <i>ioctl VIDIOC_REQBUFS</i> ioctl (struct <code>v4l2_requestbuffers</code> count), plus any buffers allocated with <i>ioctl VIDIOC_CREATE_BUFS</i> minus one.
<code>_u32</code>	<code>type</code>	Type of the buffer, same as struct <code>v4l2_format</code> type or struct <code>v4l2_requestbuffers</code> type, set by the application. See <code>v4l2_buf_type</code>
<code>_u32</code>	<code>bytesused</code>	The number of bytes occupied by the data in the buffer. It depends on the negotiated data format and may change with each buffer for compressed variable size data like JPEG images. Drivers must set this field when type refers to a capture stream, applications when it refers to an output stream. For multiplanar formats this field is ignored and the planes pointer is used instead.
<code>_u32</code>	<code>flags</code>	Flags set by the application or driver, see <i>Buffer Flags</i> .
<code>_u32</code>	<code>field</code>	Indicates the field order of the image in the buffer, see <code>v4l2_field</code> . This field is not used when the buffer contains VBI data. Drivers must set it when type refers to a capture stream, applications when it refers to an output stream.
<code>struct timeval</code>	<code>timestamp</code>	For capture streams this is time when the first data byte was captured, as returned by the <code>clock_gettime()</code> function for the relevant clock id; see <code>V4L2_BUF_FLAG_TIMESTAMP_*</code> in <i>Buffer Flags</i> . For output streams the driver stores the time at which the last data byte was actually sent out in the <code>timestamp</code> field. This permits applications to monitor the drift between the video and system clock. For output streams that use <code>V4L2_BUF_FLAG_TIMESTAMP_COPY</code> the application has to fill in the timestamp which will be copied by the driver to the capture stream.
<code>struct v4l2_timecode</code>	<code>timecode</code>	When the <code>V4L2_BUF_FLAG_TIMECODE</code> flag is set in <code>flags</code> , this structure contains a frame timecode. In <code>V4L2_FIELD_ALTERNATE</code> mode the top and bottom field contain the same timecode. Timecodes are intended to help video editing and are typically recorded on video tapes, but also embedded in compressed formats like MPEG. This field is independent of the <code>timestamp</code> and <code>sequence</code> fields.

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Table 128 – continued from previous page

<code>_u32</code>	<code>sequence</code>	Set by the driver, counting the frames (not fields!) in sequence. This field is set for both input and output devices.
-------------------	-----------------------	--

In `V4L2_FIELD_ALTERNATE` mode the top and bottom field have the same sequence number. The count starts at zero and includes dropped or repeated frames. A dropped frame was received by an input device but could not be stored due to lack of free buffer space. A repeated frame was displayed again by an output device because the application did not pass new data in time.

**Note:** This may count the frames received e.g. over USB, without taking into account the frames dropped by the remote hardware due to limited compression throughput or bus bandwidth. These devices identify by not enumerating any video standards, see [Video Standards](#).

<code>_u32</code>	<code>memory</code>	This field must be set by applications and/or drivers in accordance with the selected I/O method. See <code>v4l2_memory</code>
<code>union {</code>	<code>m</code>	
<code>_u32</code>	<code>offset</code>	For the single-planar API and when <code>memory</code> is <code>V4L2_MEMORY_MMAP</code> this is the offset of the buffer from the start of the device memory. The value is returned by the driver and apart of serving as parameter to the <code>mmap()</code> function not useful for applications. See <a href="#">Streaming I/O (Memory Mapping)</a> for details
<code>unsigned long</code>	<code>userptr</code>	For the single-planar API and when <code>memory</code> is <code>V4L2_MEMORY_USERPTR</code> this is a pointer to the buffer (casted to <code>unsigned long</code> type) in virtual memory, set by the application. See <a href="#">Streaming I/O (User Pointers)</a> for details.
<code>struct v4l2_plane</code>	<code>*planes</code>	When using the multi-planar API, contains a userspace pointer to an array of <code>struct v4l2_plane</code> . The size of the array should be put in the <code>length</code> field of this <code>struct v4l2_buffer</code> structure.
<code>int</code>	<code>fd</code>	For the single-plane API and when <code>memory</code> is <code>V4L2_MEMORY_DMABUF</code> this is the file descriptor associated with a DMABUF buffer.
<code>}</code>		
<code>_u32</code>	<code>length</code>	Size of the buffer (not the payload) in bytes for the single-planar API. This is set by the driver based on the calls to <code>ioctl VIDIOC_REQBUFS</code> and/or <code>ioctl VIDIOC_CREATE_BUFS</code> . For the multi-planar API the application sets this to the number of elements in the <code>planes</code> array. The driver will fill in the actual number of valid elements in that array.
<code>_u32</code>	<code>reserved2</code>	A place holder for future extensions. Drivers and applications must set this to 0.

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Table 128 – continued from previous page

<u>u32</u>     	<b>request_fd</b>	<p>The file descriptor of the request to queue the buffer to. If the flag <code>V4L2_BUF_FLAG_REQUEST_FD</code> is set, then the buffer will be queued to this request. If the flag is not set, then this field will be ignored.</p> <p>The <code>V4L2_BUF_FLAG_REQUEST_FD</code> flag and this field are only used by <code>ioctl VIDIOC_QBUF</code> and ignored by other ioctls that take a <code>v4l2_buffer</code> as argument.</p> <p>Applications should not set <code>V4L2_BUF_FLAG_REQUEST_FD</code> for any ioctls other than <code>VIDIOC_QBUF</code>.</p> <p>If the device does not support requests, then <code>EBADR</code> will be returned. If requests are supported but an invalid request file descriptor is given, then <code>EINVAL</code> will be returned.</p>
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type **v4l2\_plane**

### **struct v4l2\_plane**

<u>u32</u>     	<b>bytesused</b>	<p>The number of bytes occupied by data in the plane (its payload). Drivers must set this field when type refers to a capture stream, applications when it refers to an output stream.</p> <hr/> <p><b>Note:</b> Note that the actual image data starts at <code>data_offset</code> which may not be 0.</p> <hr/>
<u>u32</u>     	<b>length</b>	<p>Size in bytes of the plane (not its payload). This is set by the driver based on the calls to <code>ioctl VIDIOC_REQBUFS</code> and/or <code>ioctl VIDIOC_CREATE_BUFS</code>.</p>
<b>union {</b>  	<b>m</b>	
<u>u32</u>     	<b>mem_offset</b>	<p>When the memory type in the containing struct <code>v4l2_buffer</code> is <code>V4L2_MEMORY_MMAP</code>, this is the value that should be passed to <code>mmap()</code>, similar to the offset field in struct <code>v4l2_buffer</code>.</p>
unsigned long  	<b>userptr</b>	<p>When the memory type in the containing struct <code>v4l2_buffer</code> is <code>V4L2_MEMORY_USERPTR</code>, this is a userspace pointer to the memory allocated for this plane by an application.</p>
int  	<b>fd</b>	<p>When the memory type in the containing struct <code>v4l2_buffer</code> is <code>V4L2_MEMORY_DMABUF</code>, this is a file descriptor associated with a DMABUF buffer, similar to the <code>fd</code> field in struct <code>v4l2_buffer</code>.</p>
<b>}</b>		

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Table 129 – continued from previous page

__u32	data_offset	<p>Offset in bytes to video data in the plane. Drivers must set this field when type refers to a capture stream, applications when it refers to an output stream.</p> <p><b>Note:</b> That data_offset is included in bytesused. So the size of the image in the plane is bytesused - data_offset at offset data_offset from the start of the plane.</p>
__u32	reserved[11]	Reserved for future use. Should be zeroed by drivers and applications.

type **v4l2\_buf\_type**

#### enum v4l2\_buf\_type

V4L2_BUF_TYPE_VIDEO_CAPTURE	1	Buffer of a single-planar video capture stream, see <a href="#">Video Capture Interface</a> .
V4L2_BUF_TYPE_VIDEO_CAPTURE_MPLANE	9	Buffer of a multi-planar video capture stream, see <a href="#">Video Capture Interface</a> .
V4L2_BUF_TYPE_VIDEO_OUTPUT	2	Buffer of a single-planar video output stream, see <a href="#">Video Output Interface</a> .
V4L2_BUF_TYPE_VIDEO_OUTPUT_MPLANE	10	Buffer of a multi-planar video output stream, see <a href="#">Video Output Interface</a> .
V4L2_BUF_TYPE_VIDEO_OVERLAY	3	Buffer for video overlay, see <a href="#">Video Overlay Interface</a> .
V4L2_BUF_TYPE_VBI_CAPTURE	4	Buffer of a raw VBI capture stream, see <a href="#">Raw VBI Data Interface</a> .
V4L2_BUF_TYPE_VBI_OUTPUT	5	Buffer of a raw VBI output stream, see <a href="#">Raw VBI Data Interface</a> .
V4L2_BUF_TYPE_SLICED_VBI_CAPTURE	6	Buffer of a sliced VBI capture stream, see <a href="#">Sliced VBI Data Interface</a> .
V4L2_BUF_TYPE_SLICED_VBI_OUTPUT	7	Buffer of a sliced VBI output stream, see <a href="#">Sliced VBI Data Interface</a> .
V4L2_BUF_TYPE_VIDEO_OUTPUT_OVERLAY	8	Buffer for video output overlay (OSD), see <a href="#">Video Output Overlay Interface</a> .
V4L2_BUF_TYPE_SDR_CAPTURE	11	Buffer for Software Defined Radio (SDR) capture stream, see <a href="#">Software Defined Radio Interface (SDR)</a> .
V4L2_BUF_TYPE_SDR_OUTPUT	12	Buffer for Software Defined Radio (SDR) output stream, see <a href="#">Software Defined Radio Interface (SDR)</a> .
V4L2_BUF_TYPE_META_CAPTURE	13	Buffer for metadata capture, see <a href="#">Metadata Interface</a> .
V4L2_BUF_TYPE_META_OUTPUT	14	Buffer for metadata output, see <a href="#">Metadata Interface</a> .

## Buffer Flags

V4L2_BUF_FLAG_MAPPED	0x000000001	The buffer resides in device memory and has been mapped into the application's address space, see <a href="#">Streaming I/O (Memory Mapping)</a> for details. Drivers set or clear this flag when the <code>iocctl VIDIOC_QUERYBUF</code> , <code>iocctl VIDIOC_QBUF</code> , <code>VIDIOC_DQBUF</code> or <code>VIDIOC_DQBUF</code> ioctl is called. Set by the driver.
V4L2_BUF_FLAG_QUEUED	0x000000002	Internally drivers maintain two buffer queues, an incoming and outgoing queue. When this flag is set, the buffer is currently on the incoming queue. It automatically moves to the outgoing queue after the buffer has been filled (capture devices) or displayed (output devices). Drivers set or clear this flag when the <code>VIDIOC_QUERYBUF</code> ioctl is called. After (successful) calling the <code>VIDIOC_QBUF</code> ioctl it is always set and after <code>VIDIOC_DQBUF</code> always cleared.
V4L2_BUF_FLAG_DONE	0x000000004	When this flag is set, the buffer is currently on the outgoing queue, ready to be dequeued from the driver. Drivers set or clear this flag when the <code>VIDIOC_QUERYBUF</code> ioctl is called. After calling the <code>VIDIOC_QBUF</code> or <code>VIDIOC_DQBUF</code> it is always cleared. Of course a buffer cannot be on both queues at the same time, the <code>V4L2_BUF_FLAG_QUEUED</code> and <code>V4L2_BUF_FLAG_DONE</code> flag are mutually exclusive. They can be both cleared however, then the buffer is in "dequeued" state, in the application domain so to say.
V4L2_BUF_FLAG_ERROR	0x000000040	When this flag is set, the buffer has been dequeued successfully, although the data might have been corrupted. This is recoverable, streaming may continue as normal and the buffer may be reused normally. Drivers set this flag when the <code>VIDIOC_DQBUF</code> ioctl is called.
V4L2_BUF_FLAG_IN_REQUEST	0x000000080	This buffer is part of a request that hasn't been queued yet.
V4L2_BUF_FLAG_KEYFRAME	0x000000008	Drivers set or clear this flag when calling the <code>VIDIOC_DQBUF</code> ioctl. It may be set by video capture devices when the buffer contains a compressed image which is a key frame (or field), i. e. can be decompressed on its own. Also known as an I-frame. Applications can set this bit when type refers to an output stream.
V4L2_BUF_FLAG_PFRAME	0x000000010	Similar to <code>V4L2_BUF_FLAG_KEYFRAME</code> this flags predicted frames or fields which contain only differences to a previous key frame. Applications can set this bit when type refers to an output stream.
V4L2_BUF_FLAG_BFRAME	0x000000020	Similar to <code>V4L2_BUF_FLAG_KEYFRAME</code> this flags a bi-directional predicted frame or field which contains only the differences between the current frame and both the preceding and following key frames to specify its content. Applications can set this bit when type refers to an output stream.
V4L2_BUF_FLAG_TIMECODE	0x000000100	The timecode field is valid. Drivers set or clear this flag when the <code>VIDIOC_DQBUF</code> ioctl is called. Applications can set this bit and the corresponding timecode structure when type refers to an output stream.
V4L2_BUF_FLAG_PREPARED	0x000000400	The buffer has been prepared for I/O and can be queued by the application. Drivers set or clear this flag when the <code>VIDIOC_QUERYBUF</code> , <code>VIDIOC_PREPARE_BUF</code> , <code>VIDIOC_QBUF</code> or <code>VIDIOC_DQBUF</code> ioctl is called.

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V4L2_BUF_FLAG_NO_CACHE_INVALIDATE	0x000000800	Caches do not have to be invalidated for this buffer. Typically applications shall use this flag if the data captured in the buffer is not going to be touched by the CPU, instead the buffer will, probably, be passed on to a DMA-capable hardware unit for further processing or output. This flag is ignored unless the queue is used for <i>memory mapping</i> streaming I/O and reports <i>V4L2_BUF_CAP_SUPPORTS_MMAP_CACHE_HINTS</i> capability.
V4L2_BUF_FLAG_NO_CACHE_CLEAN	0x000001000	Caches do not have to be cleaned for this buffer. Typically applications shall use this flag for output buffers if the data in this buffer has not been created by the CPU but by some DMA-capable unit, in which case caches have not been used. This flag is ignored unless the queue is used for <i>memory mapping</i> streaming I/O and reports <i>V4L2_BUF_CAP_SUPPORTS_MMAP_CACHE_HINTS</i> capability.
V4L2_BUF_FLAG_M2M_HOLD_CAPTURE_BUF	0x000002000	Only valid if struct <i>v4l2_requestbuffers</i> flag <i>V4L2_BUF_CAP_SUPPORTS_M2M_HOLD_CAPTURE_BUF</i> is set. It is typically used with stateless decoders where multiple output buffers each decode to a slice of the decoded frame. Applications can set this flag when queueing the output buffer to prevent the driver from dequeuing the capture buffer after the output buffer has been decoded (i.e. the capture buffer is 'held'). If the timestamp of this output buffer differs from that of the previous output buffer, then that indicates the start of a new frame and the previously held capture buffer is dequeued.
V4L2_BUF_FLAG_LAST	0x001000000	Last buffer produced by the hardware. mem2mem codec drivers set this flag on the capture queue for the last buffer when the <i>ioctl VIDIOC_QUERYBUF</i> or <i>VIDIOC_DQBUF</i> ioctl is called. Due to hardware limitations, the last buffer may be empty. In this case the driver will set the bytesused field to 0, regardless of the format. Any subsequent call to the <i>VIDIOC_DQBUF</i> ioctl will not block anymore, but return an EPIPE error code.
V4L2_BUF_FLAG_REQUEST_FD	0x008000000	The request_fd field contains a valid file descriptor.
V4L2_BUF_FLAG_TIMESTAMP_MASK	0x0000e0000	Mask for timestamp types below. To test the timestamp type, mask out bits not belonging to timestamp type by performing a logical and operation with buffer flags and timestamp mask.
V4L2_BUF_FLAG_TIMESTAMP_UNKNOWN	0x000000000	Unknown timestamp type. This type is used by drivers before Linux 3.9 and may be either monotonic (see below) or realtime (wall clock). Monotonic clock has been favoured in embedded systems whereas most of the drivers use the realtime clock. Either kinds of timestamps are available in user space via <i>clock_gettime()</i> using clock IDs <i>CLOCK_MONOTONIC</i> and <i>CLOCK_REALTIME</i> , respectively.
V4L2_BUF_FLAG_TIMESTAMP_MONOTONIC	0x000020000	The buffer timestamp has been taken from the <i>CLOCK_MONOTONIC</i> clock. To access the same clock outside V4L2, use <i>clock_gettime()</i> .
V4L2_BUF_FLAG_TIMESTAMP_COPY	0x000040000	The CAPTURE buffer timestamp has been taken from the corresponding OUTPUT buffer. This flag applies only to mem2mem devices.

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V4L2_BUF_FLAG_TSTAMP_SRC_MASK	0x000070000	Mask for timestamp sources below. The timestamp source defines the point of time the timestamp is taken in relation to the frame. Logical 'and' operation between the <code>flags</code> field and V4L2_BUF_FLAG_TSTAMP_SRC_MASK produces the value of the timestamp source. Applications must set the timestamp source when type refers to an output stream and V4L2_BUF_FLAG_TIMESTAMP_COPY is set.
V4L2_BUF_FLAG_TSTAMP_SRC_EOF	0x000000000	End Of Frame. The buffer timestamp has been taken when the last pixel of the frame has been received or the last pixel of the frame has been transmitted. In practice, software generated timestamps will typically be read from the clock a small amount of time after the last pixel has been received or transmitted, depending on the system and other activity in it.
V4L2_BUF_FLAG_TSTAMP_SRC_SOE	0x000010000	Start Of Exposure. The buffer timestamp has been taken when the exposure of the frame has begun. This is only valid for the V4L2_BUF_TYPE_VIDEO_CAPTURE buffer type.

**enum v4l2\_memory**

V4L2_MEMORY_MMAP	1	The buffer is used for <i>memory mapping</i> I/O.
V4L2_MEMORY_USERPTR	2	The buffer is used for <i>user pointer</i> I/O.
V4L2_MEMORY_OVERLAY	3	[to do]
V4L2_MEMORY_DMABUF	4	The buffer is used for <i>DMA shared buffer</i> I/O.

**Memory Consistency Flags**

V4L2_MEMORY_FLAG_NON_COHERENT	0x000000001	A buffer is allocated either in coherent (it will be automatically coherent between the CPU and the bus) or non-coherent memory. The latter can provide performance gains, for instance the CPU cache sync/flush operations can be avoided if the buffer is accessed by the corresponding device only and the CPU does not read/write to/from that buffer. However, this requires extra care from the driver -- it must guarantee memory consistency by issuing a cache flush/sync when consistency is needed. If this flag is set V4L2 will attempt to allocate the buffer in non-coherent memory. The flag takes effect only if the buffer is used for <i>memory mapping</i> I/O and the queue reports the <code>V4L2_BUF_CAP_SUPPORTS_MMAP_CACHE_HINTS</code> capability.
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## Timecodes

The `v4l2_buffer_timecode` structure is designed to hold a *SMPTE 12M* or similar timecode. (struct `timeval` timestamps are stored in the struct `v4l2_buffer` `timestamp` field.)

type **`v4l2_timecode`**

**`struct v4l2_timecode`**

<code>__u32</code>	<code>type</code>	Frame rate the timecodes are based on, see <a href="#">Timecode Types</a> .
<code>__u32</code>	<code>flags</code>	Timecode flags, see <a href="#">Timecode Flags</a> .
<code>__u8</code>	<code>frames</code>	Frame count, 0 ... 23/24/29/49/59, depending on the type of timecode.
<code>__u8</code>	<code>seconds</code>	Seconds count, 0 ... 59. This is a binary, not BCD number.
<code>__u8</code>	<code>minutes</code>	Minutes count, 0 ... 59. This is a binary, not BCD number.
<code>__u8</code>	<code>hours</code>	Hours count, 0 ... 29. This is a binary, not BCD number.
<code>__u8</code>	<code>userbits[4]</code>	The "user group" bits from the timecode.

## Timecode Types

<code>V4L2_TC_TYPE_24FPS</code>	1	24 frames per second, i. e. film.
<code>V4L2_TC_TYPE_25FPS</code>	2	25 frames per second, i. e. PAL or SECAM video.
<code>V4L2_TC_TYPE_30FPS</code>	3	30 frames per second, i. e. NTSC video.
<code>V4L2_TC_TYPE_50FPS</code>	4	
<code>V4L2_TC_TYPE_60FPS</code>	5	

## Timecode Flags

<code>V4L2_TC_FLAG_DROPFRAME</code>	0x0001	Indicates "drop frame" semantics for counting frames in 29.97 fps material. When set, frame numbers 0 and 1 at the start of each minute, except minutes 0, 10, 20, 30, 40, 50 are omitted from the count.
<code>V4L2_TC_FLAG_COLORFRAME</code>	0x0002	The "color frame" flag.
<code>V4L2_TC_USERBITS_field</code>	0x000C	Field mask for the "binary group flags".
<code>V4L2_TC_USERBITS_USERDEFINED</code>	0x0000	Unspecified format.
<code>V4L2_TC_USERBITS_8BITCHARS</code>	0x0008	8-bit ISO characters.

## Field Order

We have to distinguish between progressive and interlaced video. Progressive video transmits all lines of a video image sequentially. Interlaced video divides an image into two fields, containing only the odd and even lines of the image, respectively. Alternating the so called odd and even field are transmitted, and due to a small delay between fields a cathode ray TV displays the lines interleaved, yielding the original frame. This curious technique was invented because at refresh rates similar to film the image would fade out too quickly. Transmitting fields reduces the flicker without the necessity of doubling the frame rate and with it the bandwidth required for each channel.

It is important to understand a video camera does not expose one frame at a time, merely transmitting the frames separated into fields. The fields are in fact captured at two different instances in time. An object on screen may well move between one field and the next. For applications analysing motion it is of paramount importance to recognize which field of a frame is older, the *temporal order*.

When the driver provides or accepts images field by field rather than interleaved, it is also important applications understand how the fields combine to frames. We distinguish between top (aka odd) and bottom (aka even) fields, the *spatial order*: The first line of the top field is the first line of an interlaced frame, the first line of the bottom field is the second line of that frame.

However because fields were captured one after the other, arguing whether a frame commences with the top or bottom field is pointless. Any two successive top and bottom, or bottom and top fields yield a valid frame. Only when the source was progressive to begin with, e. g. when transferring film to video, two fields may come from the same frame, creating a natural order.

Counter to intuition the top field is not necessarily the older field. Whether the older field contains the top or bottom lines is a convention determined by the video standard. Hence the distinction between temporal and spatial order of fields. The diagrams below should make this clearer.

In V4L it is assumed that all video cameras transmit fields on the media bus in the same order they were captured, so if the top field was captured first (is the older field), the top field is also transmitted first on the bus.

All video capture and output devices must report the current field order. Some drivers may permit the selection of a different order, to this end applications initialize the `field` field of struct `v4l2_pix_format` before calling the `VIDIOC_S_FMT` ioctl. If this is not desired it should have the value `V4L2_FIELD_ANY` (0).

### `enum v4l2_field`

type `v4l2_field`

V4L2_FIELD_ANY	0	Applications request this field order when any field format is acceptable. Drivers choose depending on hardware capabilities or e.g. the requested image size, and return the actual field order. Drivers must never return V4L2_FIELD_ANY. If multiple field orders are possible the driver must choose one of the possible field orders during <a href="#">VIDIOC_S_FMT</a> or <a href="#">VIDIOC_TRY_FMT</a> . struct v4l2_buffer field can never be V4L2_FIELD_ANY.
V4L2_FIELD_NONE	1	Images are in progressive (frame-based) format, not interlaced (field-based).
V4L2_FIELD_TOP	2	Images consist of the top (aka odd) field only.
V4L2_FIELD_BOTTOM	3	Images consist of the bottom (aka even) field only. Applications may wish to prevent a device from capturing interlaced images because they will have "comb" or "feathering" artefacts around moving objects.
V4L2_FIELD_INTERLACED	4	Images contain both fields, interleaved line by line. The temporal order of the fields (whether the top or bottom field is older) depends on the current video standard. In M/NTSC the bottom field is the older field. In all other standards the top field is the older field.
V4L2_FIELD_SEQ_TB	5	Images contain both fields, the top field lines are stored first in memory, immediately followed by the bottom field lines. Fields are always stored in temporal order, the older one first in memory. Image sizes refer to the frame, not fields.
V4L2_FIELD_SEQ_BT	6	Images contain both fields, the bottom field lines are stored first in memory, immediately followed by the top field lines. Fields are always stored in temporal order, the older one first in memory. Image sizes refer to the frame, not fields.
V4L2_FIELD_ALTERNATE	7	The two fields of a frame are passed in separate buffers, in temporal order, i. e. the older one first. To indicate the field parity (whether the current field is a top or bottom field) the driver or application, depending on data direction, must set struct v4l2_buffer field to V4L2_FIELD_TOP or V4L2_FIELD_BOTTOM. Any two successive fields pair to build a frame. If fields are successive, without any dropped fields between them (fields can drop individually), can be determined from the struct v4l2_buffer sequence field. This format cannot be selected when using the read/write I/O method since there is no way to communicate if a field was a top or bottom field.
V4L2_FIELD_INTERLACED_TB	8	Images contain both fields, interleaved line by line, top field first. The top field is the older field.
V4L2_FIELD_INTERLACED_BT	9	Images contain both fields, interleaved line by line, top field first. The bottom field is the older field.

## Field Order, Top Field First Transmitted

## Field Order, Bottom Field First Transmitted

### 13.2.4 Interfaces

#### Video Capture Interface

Video capture devices sample an analog video signal and store the digitized images in memory. Today nearly all devices can capture at full 25 or 30 frames/second. With this interface applications can control the capture process and move images from the driver into user space.

Conventionally V4L2 video capture devices are accessed through character device special files named /dev/video and /dev/video0 to /dev/video63 with major number 81 and minor numbers 0 to 63. /dev/video is typically a symbolic link to the preferred video device.

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**Note:** The same device file names are used for video output devices.

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#### Querying Capabilities

Devices supporting the video capture interface set the V4L2\_CAP\_VIDEO\_CAPTURE or V4L2\_CAP\_VIDEO\_CAPTURE\_MPLANE flag in the capabilities field of struct *v4l2\_capability* returned by the *ioctl VIDIOC\_QUERYCAP* ioctl. As secondary device functions they may also support the *video overlay* (V4L2\_CAP\_VIDEO\_OVERLAY) and the *raw VBI capture* (V4L2\_CAP\_VBI\_CAPTURE) interface. At least one of the read/write or streaming I/O methods must be supported. Tuners and audio inputs are optional.

#### Supplemental Functions

Video capture devices shall support *audio input*, *Tuners and Modulators*, *controls*, *cropping and scaling* and *streaming parameter* ioctls as needed. The *video input* ioctls must be supported by all video capture devices.

#### Image Format Negotiation

The result of a capture operation is determined by cropping and image format parameters. The former select an area of the video picture to capture, the latter how images are stored in memory, i. e. in RGB or YUV format, the number of bits per pixel or width and height. Together they also define how images are scaled in the process.

As usual these parameters are *not* reset at *open()* time to permit Unix tool chains, programming a device and then reading from it as if it was a plain file. Well written V4L2 applications ensure they really get what they want, including cropping and scaling.

Cropping initialization at minimum requires to reset the parameters to defaults. An example is given in *Image Cropping, Insertion and Scaling -- the CROP API*.

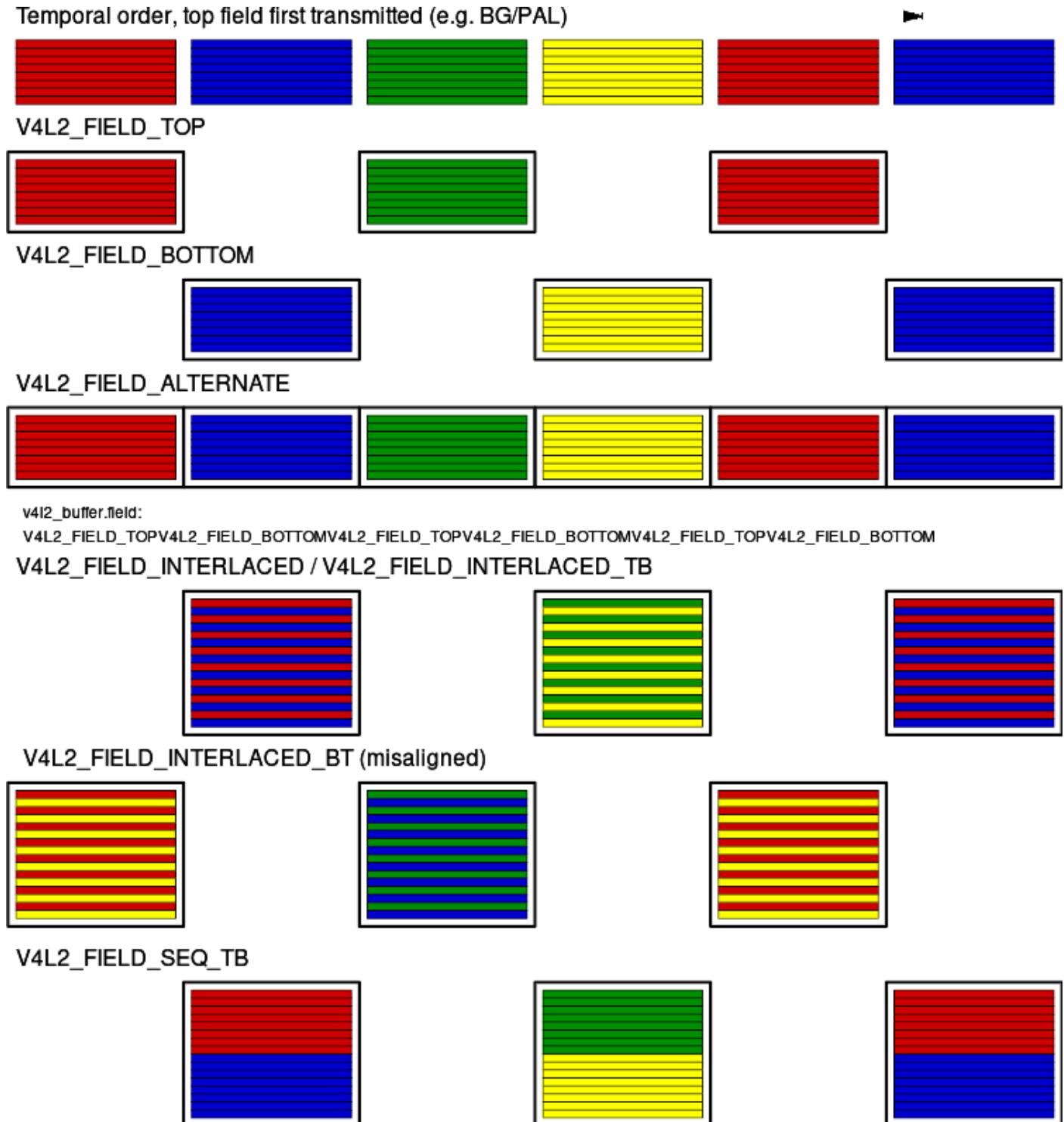


Fig. 6: Field Order, Top Field First Transmitted

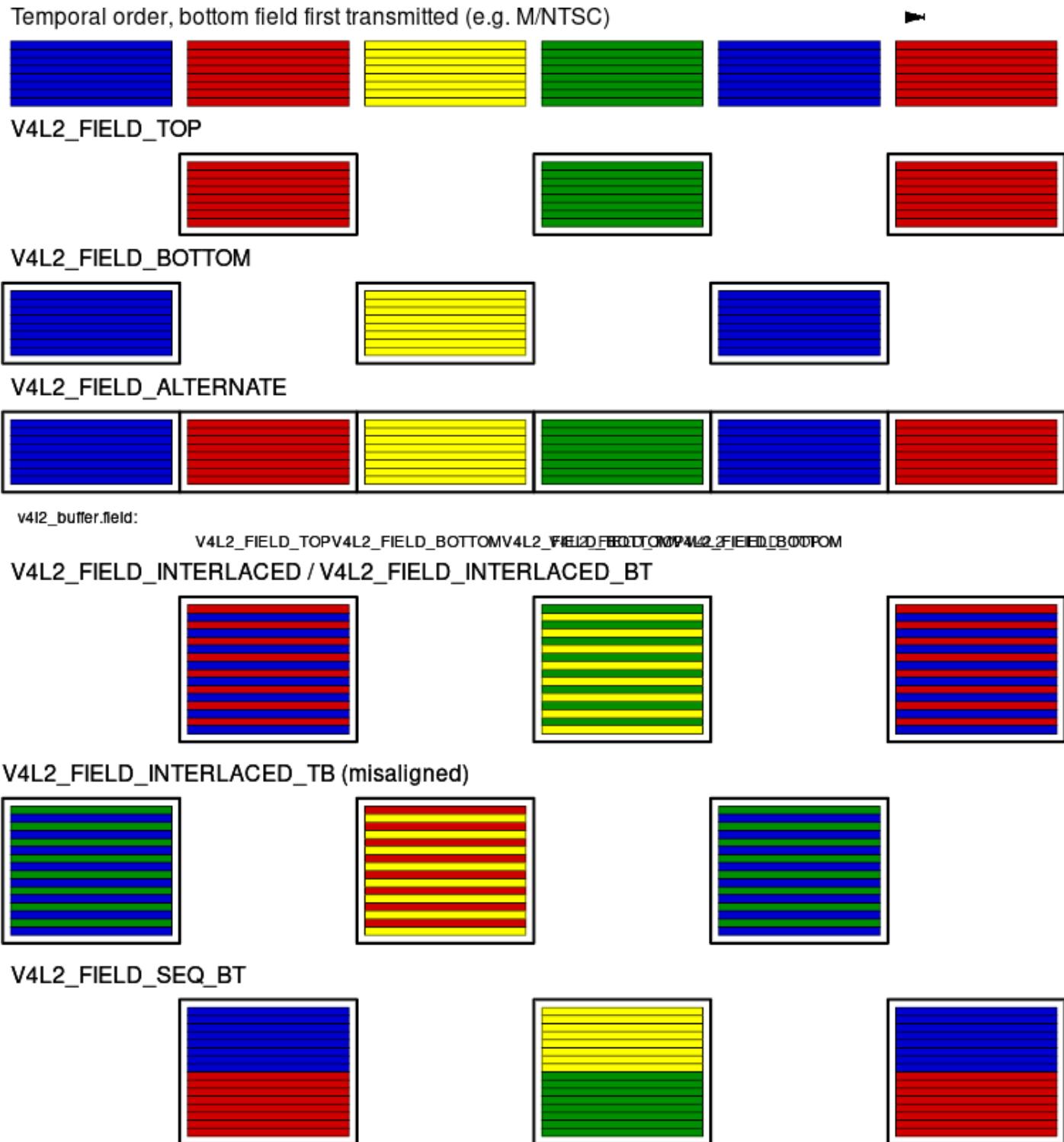


Fig. 7: Field Order, Bottom Field First Transmitted

To query the current image format applications set the type field of a struct `v4l2_format` to `V4L2_BUF_TYPE_VIDEO_CAPTURE` or `V4L2_BUF_TYPE_VIDEO_CAPTURE_MPLANE` and call the `VIDIOC_G_FMT` ioctl with a pointer to this structure. Drivers fill the struct `v4l2_pix_format` pix or the struct `v4l2_pix_format_mplane` pix\_mp member of the fmt union.

To request different parameters applications set the type field of a struct `v4l2_format` as above and initialize all fields of the struct `v4l2_pix_format` vbi member of the fmt union, or better just modify the results of `VIDIOC_G_FMT`, and call the `VIDIOC_S_FMT` ioctl with a pointer to this structure. Drivers may adjust the parameters and finally return the actual parameters as `VIDIOC_G_FMT` does.

Like `VIDIOC_S_FMT` the `VIDIOC_TRY_FMT` ioctl can be used to learn about hardware limitations without disabling I/O or possibly time consuming hardware preparations.

The contents of struct `v4l2_pix_format` and struct `v4l2_pix_format_mplane` are discussed in *Image Formats*. See also the specification of the `VIDIOC_G_FMT`, `VIDIOC_S_FMT` and `VIDIOC_TRY_FMT` ioctls for details. Video capture devices must implement both the `VIDIOC_G_FMT` and `VIDIOC_S_FMT` ioctl, even if `VIDIOC_S_FMT` ignores all requests and always returns default parameters as `VIDIOC_G_FMT` does. `VIDIOC_TRY_FMT` is optional.

## Reading Images

A video capture device may support the `read()` function and/or streaming (*memory mapping* or *user pointer*) I/O. See *Input/Output* for details.

## Video Overlay Interface

### Also known as Framebuffer Overlay or Previewing.

Video overlay devices have the ability to genlock (TV-)video into the (VGA-)video signal of a graphics card, or to store captured images directly in video memory of a graphics card, typically with clipping. This can be considerably more efficient than capturing images and displaying them by other means. In the old days when only nuclear power plants needed cooling towers this used to be the only way to put live video into a window.

Video overlay devices are accessed through the same character special files as *video capture* devices.

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**Note:** The default function of a `/dev/video` device is video capturing. The overlay function is only available after calling the `VIDIOC_S_FMT` ioctl.

---

The driver may support simultaneous overlay and capturing using the read/write and streaming I/O methods. If so, operation at the nominal frame rate of the video standard is not guaranteed. Frames may be directed away from overlay to capture, or one field may be used for overlay and the other for capture if the capture parameters permit this.

Applications should use different file descriptors for capturing and overlay. This must be supported by all drivers capable of simultaneous capturing and overlay. Optionally these drivers may also permit capturing and overlay with a single file descriptor for compatibility with V4L and earlier versions of V4L2.<sup>1</sup>

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<sup>1</sup> In the opinion of the designers of this API, no driver writer taking the efforts to support simultaneous capturing

A common application of two file descriptors is the X11 [Xv/V4L](#) interface driver and a V4L2 application. While the X server controls video overlay, the application can take advantage of memory mapping and DMA.

## Querying Capabilities

Devices supporting the video overlay interface set the `V4L2_CAP_VIDEO_OVERLAY` flag in the `capabilities` field of struct `v4l2_capability` returned by the [`ioctl VIDIOC\_QUERYCAP`](#) ioctl. The overlay I/O method specified below must be supported. Tuners and audio inputs are optional.

## Supplemental Functions

Video overlay devices shall support [\*audio input\*](#), [\*Tuners and Modulators\*](#), [\*controls\*](#), [\*cropping and scaling\*](#) and [\*streaming parameter\*](#) ioctls as needed. The [\*video input\*](#) and [\*video standard\*](#) ioctls must be supported by all video overlay devices.

## Setup

*Note: support for this has been removed.* Before overlay can commence applications must program the driver with frame buffer parameters, namely the address and size of the frame buffer and the image format, for example RGB 5:6:5. The [`VIDIOC\_G\_FBUF`](#) and [`VIDIOC\_S\_FBUF`](#) ioctls are available to get and set these parameters, respectively. The [`VIDIOC\_S\_FBUF`](#) ioctl is privileged because it allows to set up DMA into physical memory, bypassing the memory protection mechanisms of the kernel. Only the superuser can change the frame buffer address and size. Users are not supposed to run TV applications as root or with SUID bit set. A small helper application with suitable privileges should query the graphics system and program the V4L2 driver at the appropriate time.

Some devices add the video overlay to the output signal of the graphics card. In this case the frame buffer is not modified by the video device, and the frame buffer address and pixel format are not needed by the driver. The [`VIDIOC\_S\_FBUF`](#) ioctl is not privileged. An application can check for this type of device by calling the [`VIDIOC\_G\_FBUF`](#) ioctl.

A driver may support any (or none) of five clipping/blending methods:

1. Chroma-keying displays the overlaid image only where pixels in the primary graphics surface assume a certain color.
2. *Note: support for this has been removed.* A bitmap can be specified where each bit corresponds to a pixel in the overlaid image. When the bit is set, the corresponding video pixel is displayed, otherwise a pixel of the graphics surface.
3. *Note: support for this has been removed.* A list of clipping rectangles can be specified. In these regions no video is displayed, so the graphics surface can be seen here.

and overlay will restrict this ability by requiring a single file descriptor, as in V4L and earlier versions of V4L2. Making this optional means applications depending on two file descriptors need backup routines to be compatible with all drivers, which is considerable more work than using two fds in applications which do not. Also two fd's fit the general concept of one file descriptor for each logical stream. Hence as a complexity trade-off drivers *must* support two file descriptors and *may* support single fd operation.

4. The framebuffer has an alpha channel that can be used to clip or blend the framebuffer with the video.
5. A global alpha value can be specified to blend the framebuffer contents with video images.

When simultaneous capturing and overlay is supported and the hardware prohibits different image and frame buffer formats, the format requested first takes precedence. The attempt to capture ([VIDIOC\\_S\\_FMT](#)) or overlay ([VIDIOC\\_S\\_FBUF](#)) may fail with an EBUSY error code or return accordingly modified parameters..

## Overlay Window

The overlaid image is determined by cropping and overlay window parameters. The former select an area of the video picture to capture, the latter how images are overlaid and clipped. Cropping initialization at minimum requires to reset the parameters to defaults. An example is given in [Image Cropping, Insertion and Scaling -- the CROP API](#).

The overlay window is described by a struct [v4l2\\_window](#). It defines the size of the image, its position over the graphics surface and the clipping to be applied. To get the current parameters applications set the type field of a struct [v4l2\\_format](#) to V4L2\_BUF\_TYPE\_VIDEO\_OVERLAY and call the [VIDIOC\\_G\\_FMT](#) ioctl. The driver fills the struct [v4l2\\_window](#) substructure named win. It is not possible to retrieve a previously programmed clipping list or bitmap.

To program the overlay window applications set the type field of a struct [v4l2\\_format](#) to V4L2\_BUF\_TYPE\_VIDEO\_OVERLAY, initialize the win substructure and call the [VIDIOC\\_S\\_FMT](#) ioctl. The driver adjusts the parameters against hardware limits and returns the actual parameters as [VIDIOC\\_G\\_FMT](#) does. Like [VIDIOC\\_S\\_FMT](#), the [VIDIOC\\_TRY\\_FMT](#) ioctl can be used to learn about driver capabilities without actually changing driver state. Unlike [VIDIOC\\_S\\_FMT](#) this also works after the overlay has been enabled.

The scaling factor of the overlaid image is implied by the width and height given in struct [v4l2\\_window](#) and the size of the cropping rectangle. For more information see [Image Cropping, Insertion and Scaling -- the CROP API](#).

When simultaneous capturing and overlay is supported and the hardware prohibits different image and window sizes, the size requested first takes precedence. The attempt to capture or overlay as well ([VIDIOC\\_S\\_FMT](#)) may fail with an EBUSY error code or return accordingly modified parameters.

type **v4l2\_window**

**struct v4l2\_window**

**struct v4l2\_rect w**

Size and position of the window relative to the top, left corner of the frame buffer defined with [VIDIOC\\_S\\_FBUF](#). The window can extend the frame buffer width and height, the x and y coordinates can be negative, and it can lie completely outside the frame buffer. The driver clips the window accordingly, or if that is not possible, modifies its size and/or position.

**enum v4l2\_field field**

Applications set this field to determine which video field shall be overlaid, typically one of

V4L2\_FIELD\_ANY (0), V4L2\_FIELD\_TOP, V4L2\_FIELD\_BOTTOM or V4L2\_FIELD\_INTERLACED. Drivers may have to choose a different field order and return the actual setting here.

### **— u32 chromakey**

When chroma-keying has been negotiated with [VIDIOC\\_S\\_FBUF](#) applications set this field to the desired pixel value for the chroma key. The format is the same as the pixel format of the framebuffer (struct v4l2\_framebuffer fmt.pixelformat field), with bytes in host order. E. g. for [V4L2\\_PIX\\_FMT\\_BGR24](#) the value should be 0xRRGGBB on a little endian, 0xBBGGRR on a big endian host.

### **struct v4l2\_clip \* clips**

*Note: support for this has been removed.* When chroma-keying has *not* been negotiated and [VIDIOC\\_G\\_FBUF](#) indicated this capability, applications can set this field to point to an array of clipping rectangles.

Like the window coordinates w, clipping rectangles are defined relative to the top, left corner of the frame buffer. However clipping rectangles must not extend the frame buffer width and height, and they must not overlap. If possible applications should merge adjacent rectangles. Whether this must create x-y or y-x bands, or the order of rectangles, is not defined. When clip lists are not supported the driver ignores this field. Its contents after calling [VIDIOC\\_S\\_FMT](#) are undefined.

### **— u32 clipcount**

*Note: support for this has been removed.* When the application set the clips field, this field must contain the number of clipping rectangles in the list. When clip lists are not supported the driver ignores this field, its contents after calling [VIDIOC\\_S\\_FMT](#) are undefined. When clip lists are supported but no clipping is desired this field must be set to zero.

### **void \* bitmap**

*Note: support for this has been removed.* When chroma-keying has *not* been negotiated and [VIDIOC\\_G\\_FBUF](#) indicated this capability, applications can set this field to point to a clipping bit mask.

It must be of the same size as the window, w.width and w.height. Each bit corresponds to a pixel in the overlaid image, which is displayed only when the bit is *set*. Pixel coordinates translate to bits like:

```
((__u8 *) bitmap)[w.width * y + x / 8] & (1 << (x & 7))
```

where  $0 \leq x < w.\text{width}$  and  $0 \leq y < w.\text{height}$ .<sup>2</sup>

When a clipping bit mask is not supported the driver ignores this field, its contents after calling [VIDIOC\\_S\\_FMT](#) are undefined. When a bit mask is supported but no clipping is desired this field must be set to NULL.

Applications need not create a clip list or bit mask. When they pass both, or despite negotiating chroma-keying, the results are undefined. Regardless of the chosen method, the clipping abilities of the hardware may be limited in quantity or quality. The results when these limits are exceeded are undefined.<sup>3</sup>

<sup>2</sup> Should we require w.width to be a multiple of eight?

<sup>3</sup> When the image is written into frame buffer memory it will be undesirable if the driver clips out less pixels than expected, because the application and graphics system are not aware these regions need to be refreshed. The driver should clip out more pixels or not write the image at all.

### **— u8 global\_alpha**

The global alpha value used to blend the framebuffer with video images, if global alpha blending has been negotiated (V4L2\_FBUF\_FLAG\_GLOBAL\_ALPHA, see [VIDIOC\\_S\\_FBUF](#), *Frame Buffer Flags*).

---

**Note:** This field was added in Linux 2.6.23, extending the structure. However the [VIDIOC\\_GS TRY FMT](#) ioctls, which take a pointer to a v4l2\_format parent structure with padding bytes at the end, are not affected.

---

type **v4l2\_clip**

### **struct v4l2\_clip**<sup>Page 448, 4</sup>

#### **struct v4l2\_rect c**

Coordinates of the clipping rectangle, relative to the top, left corner of the frame buffer. Only window pixels *outside* all clipping rectangles are displayed.

#### **struct v4l2\_clip \* next**

Pointer to the next clipping rectangle, NULL when this is the last rectangle. Drivers ignore this field, it cannot be used to pass a linked list of clipping rectangles.

type **v4l2\_rect**

### **struct v4l2\_rect**

#### **— s32 left**

Horizontal offset of the top, left corner of the rectangle, in pixels.

#### **— s32 top**

Vertical offset of the top, left corner of the rectangle, in pixels. Offsets increase to the right and down.

#### **— u32 width**

Width of the rectangle, in pixels.

#### **— u32 height**

Height of the rectangle, in pixels.

## **Enabling Overlay**

To start or stop the frame buffer overlay applications call the [ioctl VIDIOC\\_OVERLAY](#) ioctl.

---

<sup>4</sup> The X Window system defines "regions" which are vectors of `struct BoxRec { short x1, y1, x2, y2; }` with `width = x2 - x1` and `height = y2 - y1`, so one cannot pass X11 clip lists directly.

## Video Output Interface

Video output devices encode stills or image sequences as analog video signal. With this interface applications can control the encoding process and move images from user space to the driver.

Conventionally V4L2 video output devices are accessed through character device special files named /dev/video and /dev/video0 to /dev/video63 with major number 81 and minor numbers 0 to 63. /dev/video is typically a symbolic link to the preferred video device.

---

**Note:** The same device file names are used also for video capture devices.

---

## Querying Capabilities

Devices supporting the video output interface set the V4L2\_CAP\_VIDEO\_OUTPUT or V4L2\_CAP\_VIDEO\_OUTPUT\_MPLANE flag in the capabilities field of struct `v4l2_capability` returned by the ioctl VIDIOC\_QUERYCAP ioctl. As secondary device functions they may also support the *raw VBI output* (V4L2\_CAP\_VBI\_OUTPUT) interface. At least one of the read/write or streaming I/O methods must be supported. Modulators and audio outputs are optional.

## Supplemental Functions

Video output devices shall support *audio output, modulator, controls, cropping and scaling* and *streaming parameter* ioctls as needed. The *video output* ioctls must be supported by all video output devices.

## Image Format Negotiation

The output is determined by cropping and image format parameters. The former select an area of the video picture where the image will appear, the latter how images are stored in memory, i. e. in RGB or YUV format, the number of bits per pixel or width and height. Together they also define how images are scaled in the process.

As usual these parameters are *not* reset at `open()` time to permit Unix tool chains, programming a device and then writing to it as if it was a plain file. Well written V4L2 applications ensure they really get what they want, including cropping and scaling.

Cropping initialization at minimum requires to reset the parameters to defaults. An example is given in *Image Cropping, Insertion and Scaling -- the CROP API*.

To query the current image format applications set the type field of a struct `v4l2_format` to V4L2\_BUF\_TYPE\_VIDEO\_OUTPUT or V4L2\_BUF\_TYPE\_VIDEO\_OUTPUT\_MPLANE and call the VIDIOC\_G\_FMT ioctl with a pointer to this structure. Drivers fill the struct `v4l2_pix_format` pix or the struct `v4l2_pix_format_mplane` pix\_mp member of the fmt union.

To request different parameters applications set the type field of a struct `v4l2_format` as above and initialize all fields of the struct `v4l2_pix_format` vbi member of the fmt union, or better just modify the results of VIDIOC\_G\_FMT, and call the VIDIOC\_S\_FMT ioctl with a pointer to this structure. Drivers may adjust the parameters and finally return the actual parameters as VIDIOC\_G\_FMT does.

Like [VIDIOC\\_S\\_FMT](#) the [VIDIOC\\_TRY\\_FMT](#) ioctl can be used to learn about hardware limitations without disabling I/O or possibly time consuming hardware preparations.

The contents of struct [v4l2\\_pix\\_format](#) and struct [v4l2\\_pix\\_format\\_mplane](#) are discussed in [Image Formats](#). See also the specification of the [VIDIOC\\_G\\_FMT](#), [VIDIOC\\_S\\_FMT](#) and [VIDIOC\\_TRY\\_FMT](#) ioctls for details. Video output devices must implement both the [VIDIOC\\_G\\_FMT](#) and [VIDIOC\\_S\\_FMT](#) ioctl, even if [VIDIOC\\_S\\_FMT](#) ignores all requests and always returns default parameters as [VIDIOC\\_G\\_FMT](#) does. [VIDIOC\\_TRY\\_FMT](#) is optional.

## Writing Images

A video output device may support the [write\(\) function](#) and/or streaming ([memory mapping](#) or [user pointer](#)) I/O. See [Input/Output](#) for details.

## Video Output Overlay Interface

### Also known as On-Screen Display (OSD)

Some video output devices can overlay a framebuffer image onto the outgoing video signal. Applications can set up such an overlay using this interface, which borrows structures and ioctls of the [Video Overlay](#) interface.

The OSD function is accessible through the same character special file as the [Video Output](#) function.

---

**Note:** The default function of such a /dev/video device is video capturing or output. The OSD function is only available after calling the [VIDIOC\\_S\\_FMT](#) ioctl.

---

## Querying Capabilities

Devices supporting the [Video Output Overlay](#) interface set the [V4L2\\_CAP\\_VIDEO\\_OUTPUT\\_OVERLAY](#) flag in the capabilities field of struct [v4l2\\_capability](#) returned by the ioctl [VIDIOC\\_QUERYCAP](#).

## Framebuffer

Contrary to the [Video Overlay](#) interface the framebuffer is normally implemented on the TV card and not the graphics card. On Linux it is accessible as a framebuffer device (/dev/fbN). Given a V4L2 device, applications can find the corresponding framebuffer device by calling the [VIDIOC\\_G\\_FBUF](#) ioctl. It returns, amongst other information, the physical address of the framebuffer in the [base](#) field of struct [v4l2\\_framebuffer](#). The framebuffer device ioctl [FBIOGET\\_FSCREENINFO](#) returns the same address in the [smem\\_start](#) field of struct [fb\\_fix\\_screeninfo](#). The [FBIOGET\\_FSCREENINFO](#) ioctl and struct [fb\\_fix\\_screeninfo](#) are defined in the linux/fb.h header file.

The width and height of the framebuffer depends on the current video standard. A V4L2 driver may reject attempts to change the video standard (or any other ioctl which would imply a framebuffer size change) with an EBUSY error code until all applications closed the framebuffer device.

### Example: Finding a framebuffer device for OSD

```
#include <linux/fb.h>

struct v4l2_framebuffer fbuf;
unsigned int i;
int fb_fd;

if (-1 == ioctl(fd, VIDIOC_G_FBUF, &fbuf)) {
    perror("VIDIOC_G_FBUF");
    exit(EXIT_FAILURE);
}

for (i = 0; i < 30; i++) {
    char dev_name[16];
    struct fb_fix_screeninfo si;

    snprintf(dev_name, sizeof(dev_name), "/dev/fb%u", i);

    fb_fd = open(dev_name, O_RDWR);
    if (-1 == fb_fd) {
        switch (errno) {
        case ENOENT: /* no such file */
        case ENXIO: /* no driver */
            continue;
        default:
            perror("open");
            exit(EXIT_FAILURE);
        }
    }

    if (0 == ioctl(fb_fd, FBIOPGET_FSCREENINFO, &si)) {
        if (si.smem_start == (unsigned long)fbuf.base)
            break;
    } else {
        /* Apparently not a framebuffer device. */
    }
    close(fb_fd);
    fb_fd = -1;
}

/* fb_fd is the file descriptor of the framebuffer device
   for the video output overlay, or -1 if no device was found. */
```

## Overlay Window and Scaling

The overlay is controlled by source and target rectangles. The source rectangle selects a subsection of the framebuffer image to be overlaid, the target rectangle an area in the outgoing video signal where the image will appear. Drivers may or may not support scaling, and arbitrary sizes and positions of these rectangles. Further drivers may support any (or none) of the clipping/blending methods defined for the [Video Overlay](#) interface.

A struct `v4l2_window` defines the size of the source rectangle, its position in the framebuffer and the clipping/blending method to be used for the overlay. To get the current parameters applications set the `type` field of a struct `v4l2_format` to `V4L2_BUF_TYPE_VIDEO_OUTPUT_OVERLAY` and call the `VIDIOC_G_FMT` ioctl. The driver fills the struct `v4l2_window` substructure named `win`. It is not possible to retrieve a previously programmed clipping list or bitmap.

To program the source rectangle applications set the `type` field of a struct `v4l2_format` to `V4L2_BUF_TYPE_VIDEO_OUTPUT_OVERLAY`, initialize the `win` substructure and call the `VIDIOC_S_FMT` ioctl. The driver adjusts the parameters against hardware limits and returns the actual parameters as `VIDIOC_G_FMT` does. Like `VIDIOC_S_FMT`, the `VIDIOC_TRY_FMT` ioctl can be used to learn about driver capabilities without actually changing driver state. Unlike `VIDIOC_S_FMT` this also works after the overlay has been enabled.

A struct `v4l2_crop` defines the size and position of the target rectangle. The scaling factor of the overlay is implied by the width and height given in struct `v4l2_window` and struct `v4l2_crop`. The cropping API applies to *Video Output* and *Video Output Overlay* devices in the same way as to *Video Capture* and *Video Overlay* devices, merely reversing the direction of the data flow. For more information see [Image Cropping, Insertion and Scaling -- the CROP API](#).

## Enabling Overlay

There is no V4L2 ioctl to enable or disable the overlay, however the framebuffer interface of the driver may support the `FBIOPBLANK` ioctl.

## Video Memory-To-Memory Interface

A V4L2 memory-to-memory device can compress, decompress, transform, or otherwise convert video data from one format into another format, in memory. Such memory-to-memory devices set the `V4L2_CAP_VIDEO_M2M` or `V4L2_CAP_VIDEO_M2M_MPLANE` capability. Examples of memory-to-memory devices are codecs, scalers, deinterlacers or format converters (i.e. converting from YUV to RGB).

A memory-to-memory video node acts just like a normal video node, but it supports both output (sending frames from memory to the hardware) and capture (receiving the processed frames from the hardware into memory) stream I/O. An application will have to setup the stream I/O for both sides and finally call `VIDIOC_STREAMON` for both capture and output to start the hardware.

Memory-to-memory devices function as a shared resource: you can open the video node multiple times, each application setting up their own properties that are local to the file handle, and each can use it independently from the others. The driver will arbitrate access to the hardware and reprogram it whenever another file handler gets access. This is different from the usual video node behavior where the video properties are global to the device (i.e. changing something through one file handle is visible through another file handle).

One of the most common memory-to-memory device is the codec. Codecs are more complicated than most and require additional setup for their codec parameters. This is done through codec controls. See [Codec Control Reference](#). More details on how to use codec memory-to-memory devices are given in the following sections.

## Memory-to-Memory Stateful Video Decoder Interface

A stateful video decoder takes complete chunks of the bytestream (e.g. Annex-B H.264/HEVC stream, raw VP8/9 stream) and decodes them into raw video frames in display order. The decoder is expected not to require any additional information from the client to process these buffers.

Performing software parsing, processing etc. of the stream in the driver in order to support this interface is strongly discouraged. In case such operations are needed, use of the Stateless Video Decoder Interface (in development) is strongly advised.

## Conventions and Notations Used in This Document

1. The general V4L2 API rules apply if not specified in this document otherwise.
2. The meaning of words "must", "may", "should", etc. is as per [RFC 2119](#).
3. All steps not marked "optional" are required.
4. VIDIOC\_G\_EXT\_CTRLS() and VIDIOC\_S\_EXT\_CTRLS() may be used interchangeably with VIDIOC\_G\_CTRL() and VIDIOC\_S\_CTRL(), unless specified otherwise.
5. Single-planar API (see [Single- and multi-planar APIs](#)) and applicable structures may be used interchangeably with multi-planar API, unless specified otherwise, depending on decoder capabilities and following the general V4L2 guidelines.
6.  $i = [a..b]$ : sequence of integers from a to b, inclusive, i.e.  $i = [0..2]$ :  $i = 0, 1, 2$ .
7. Given an OUTPUT buffer A, then A' represents a buffer on the CAPTURE queue containing data that resulted from processing buffer A.

## Glossary

### CAPTURE

the destination buffer queue; for decoders, the queue of buffers containing decoded frames; for encoders, the queue of buffers containing an encoded bytestream; V4L2\_BUF\_TYPE\_VIDEO\_CAPTURE or V4L2\_BUF\_TYPE\_VIDEO\_CAPTURE\_MPLANE; data is captured from the hardware into CAPTURE buffers.

### client

the application communicating with the decoder or encoder implementing this interface.

### coded format

encoded/compressed video bytestream format (e.g. H.264, VP8, etc.); see also: raw format.

### coded height

height for given coded resolution.

**coded resolution**

stream resolution in pixels aligned to codec and hardware requirements; typically visible resolution rounded up to full macroblocks; see also: visible resolution.

**coded width**

width for given coded resolution.

**coding tree unit**

processing unit of the HEVC codec (corresponds to macroblock units in H.264, VP8, VP9), can use block structures of up to  $64 \times 64$  pixels. Good at sub-partitioning the picture into variable sized structures.

**decode order**

the order in which frames are decoded; may differ from display order if the coded format includes a feature of frame reordering; for decoders, OUTPUT buffers must be queued by the client in decode order; for encoders CAPTURE buffers must be returned by the encoder in decode order.

**destination**

data resulting from the decode process; see CAPTURE.

**display order**

the order in which frames must be displayed; for encoders, OUTPUT buffers must be queued by the client in display order; for decoders, CAPTURE buffers must be returned by the decoder in display order.

**DPB**

Decoded Picture Buffer; an H.264/HEVC term for a buffer that stores a decoded raw frame available for reference in further decoding steps.

**EOS**

end of stream.

**IDR**

Instantaneous Decoder Refresh; a type of a keyframe in an H.264/HEVC-encoded stream, which clears the list of earlier reference frames (DPBs).

**keyframe**

an encoded frame that does not reference frames decoded earlier, i.e. can be decoded fully on its own.

**macroblock**

a processing unit in image and video compression formats based on linear block transforms (e.g. H.264, VP8, VP9); codec-specific, but for most of popular codecs the size is 16x16 samples (pixels). The HEVC codec uses a slightly more flexible processing unit called coding tree unit (CTU).

**OUTPUT**

the source buffer queue; for decoders, the queue of buffers containing an encoded bytestream; for encoders, the queue of buffers containing raw frames; V4L2\_BUF\_TYPE\_VIDEO\_OUTPUT or V4L2\_BUF\_TYPE\_VIDEO\_OUTPUT\_MPLANE; the hardware is fed with data from OUTPUT buffers.

**PPS**

Picture Parameter Set; a type of metadata entity in an H.264/HEVC bytestream.

**raw format**

uncompressed format containing raw pixel data (e.g. YUV, RGB formats).

**resume point**

a point in the bytestream from which decoding may start/continue, without any previous state/data present, e.g.: a keyframe (VP8/VP9) or SPS/PPS/IDR sequence (H.264/HEVC); a resume point is required to start decode of a new stream, or to resume decoding after a seek.

**source**

data fed to the decoder or encoder; see `OUTPUT`.

**source height**

height in pixels for given source resolution; relevant to encoders only.

**source resolution**

resolution in pixels of source frames being source to the encoder and subject to further cropping to the bounds of visible resolution; relevant to encoders only.

**source width**

width in pixels for given source resolution; relevant to encoders only.

**SPS**

Sequence Parameter Set; a type of metadata entity in an H.264/HEVC bytestream.

**stream metadata**

additional (non-visual) information contained inside encoded bytestream; for example: coded resolution, visible resolution, codec profile.

**visible height**

height for given visible resolution; display height.

**visible resolution**

stream resolution of the visible picture, in pixels, to be used for display purposes; must be smaller or equal to coded resolution; display resolution.

**visible width**

width for given visible resolution; display width.

**State Machine****Querying Capabilities**

1. To enumerate the set of coded formats supported by the decoder, the client may call `VIDIOC_ENUM_FMT()` on `OUTPUT`.
  - The full set of supported formats will be returned, regardless of the format set on `CAPTURE`.
  - Check the flags field of `v4l2_fmtdesc` for more information about the decoder's capabilities with respect to each coded format. In particular whether or not the decoder has a full-fledged bytestream parser and if the decoder supports dynamic resolution changes.
2. To enumerate the set of supported raw formats, the client may call `VIDIOC_ENUM_FMT()` on `CAPTURE`.
  - Only the formats supported for the format currently active on `OUTPUT` will be returned.

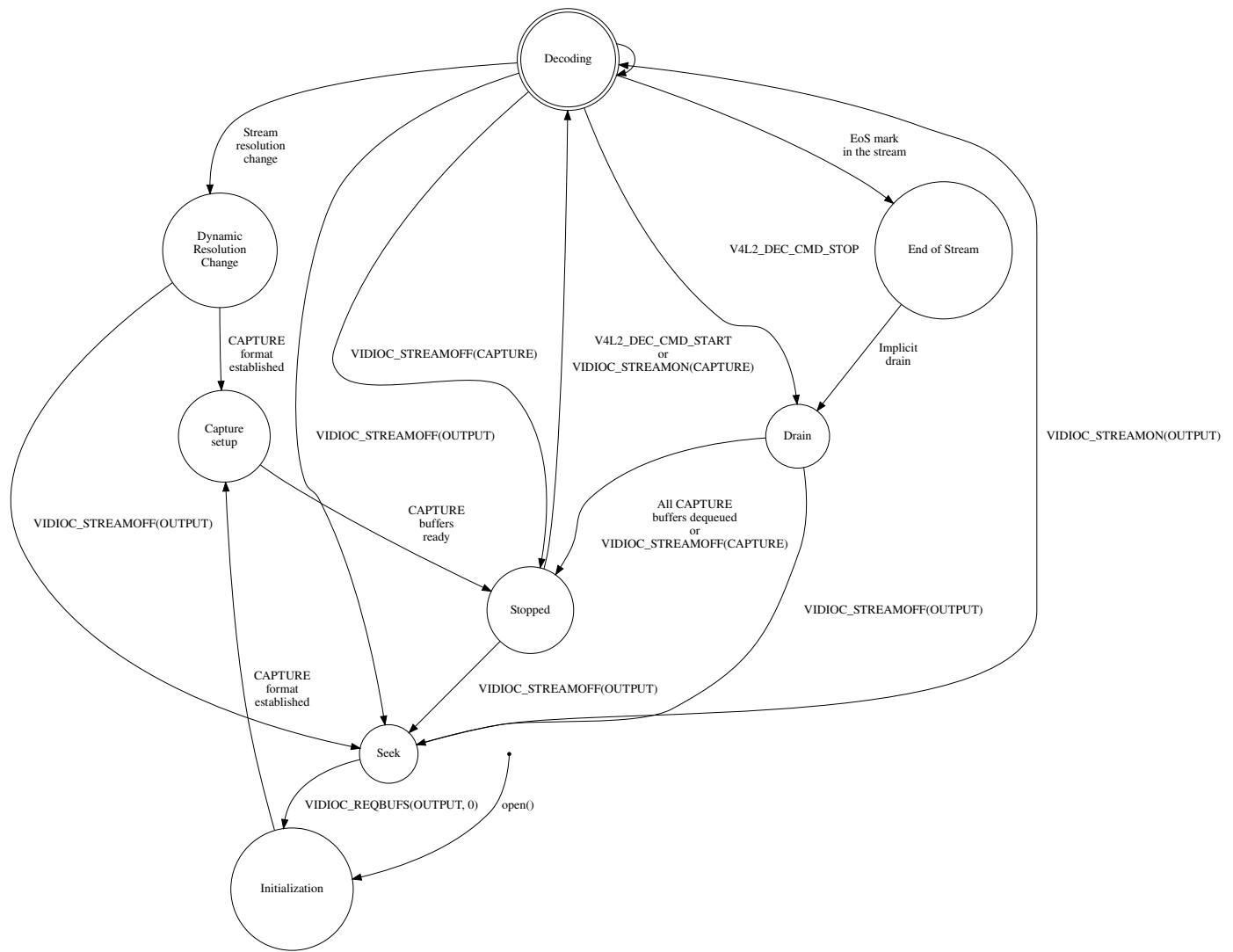


Fig. 8: Decoder State Machine

- In order to enumerate raw formats supported by a given coded format, the client must first set that coded format on OUTPUT and then enumerate formats on CAPTURE.
3. The client may use VIDIOC\_ENUM\_FRAMESIZES() to detect supported resolutions for a given format, passing desired pixel format in `v4l2_frmsizeenum.pixel_format`.
    - Values returned by VIDIOC\_ENUM\_FRAMESIZES() for a coded pixel format will include all possible coded resolutions supported by the decoder for given coded pixel format.
    - Values returned by VIDIOC\_ENUM\_FRAMESIZES() for a raw pixel format will include all possible frame buffer resolutions supported by the decoder for given raw pixel format and the coded format currently set on OUTPUT.
  4. Supported profiles and levels for the coded format currently set on OUTPUT, if applicable, may be queried using their respective controls via VIDIOC\_QUERYCTRL().

## Initialization

1. Set the coded format on OUTPUT via VIDIOC\_S\_FMT().

- **Required fields:**

**type**

a V4L2\_BUF\_TYPE\_\* enum appropriate for OUTPUT.

**pixelformat**

a coded pixel format.

**width, height**

coded resolution of the stream; required only if it cannot be parsed from the stream for the given coded format; otherwise the decoder will use this resolution as a placeholder resolution that will likely change as soon as it can parse the actual coded resolution from the stream.

**sizeimage**

desired size of OUTPUT buffers; the decoder may adjust it to match hardware requirements.

**other fields**

follow standard semantics.

- **Returned fields:**

**sizeimage**

adjusted size of OUTPUT buffers.

- The CAPTURE format will be updated with an appropriate frame buffer resolution instantly based on the width and height returned by VIDIOC\_S\_FMT(). However, for coded formats that include stream resolution information, after the decoder is done parsing the information from the stream, it will update the CAPTURE format with new values and signal a source change event, regardless of whether they match the values set by the client or not.

---

**Important:** Changing the OUTPUT format may change the currently set CAPTURE format. How the new CAPTURE format is determined is up to the decoder and the client must ensure

it matches its needs afterwards.

---

2. Allocate source (bytestream) buffers via VIDIOC\_REQBUFS() on OUTPUT.

- **Required fields:**

**count**

requested number of buffers to allocate; greater than zero.

**type**

a V4L2\_BUF\_TYPE\_\* enum appropriate for OUTPUT.

**memory**

follows standard semantics.

- **Returned fields:**

**count**

the actual number of buffers allocated.

**Warning:** The actual number of allocated buffers may differ from the count given. The client must check the updated value of count after the call returns.

Alternatively, VIDIOC\_CREATE\_BUFS() on the OUTPUT queue can be used to have more control over buffer allocation.

- **Required fields:**

**count**

requested number of buffers to allocate; greater than zero.

**type**

a V4L2\_BUF\_TYPE\_\* enum appropriate for OUTPUT.

**memory**

follows standard semantics.

**format**

follows standard semantics.

- **Returned fields:**

**count**

adjusted to the number of allocated buffers.

**Warning:** The actual number of allocated buffers may differ from the count given. The client must check the updated value of count after the call returns.

3. Start streaming on the OUTPUT queue via VIDIOC\_STREAMON().

4. **This step only applies to coded formats that contain resolution information in the stream.** Continue queuing/dequeuing bytestream buffers to/from the OUTPUT queue via VIDIOC\_QBUF() and VIDIOC\_DQBUF(). The buffers will be processed and returned to the client in order, until required metadata to configure the CAPTURE queue are found. This is

indicated by the decoder sending a V4L2\_EVENT\_SOURCE\_CHANGE event with changes set to V4L2\_EVENT\_SRC\_CH\_RESOLUTION.

- It is not an error if the first buffer does not contain enough data for this to occur. Processing of the buffers will continue as long as more data is needed.
- If data in a buffer that triggers the event is required to decode the first frame, it will not be returned to the client, until the initialization sequence completes and the frame is decoded.
- If the client has not set the coded resolution of the stream on its own, calling VIDIOC\_G\_FMT(), VIDIOC\_S\_FMT(), VIDIOC\_TRY\_FMT() or VIDIOC\_REQBUFS() on the CAPTURE queue will not return the real values for the stream until a V4L2\_EVENT\_SOURCE\_CHANGE event with changes set to V4L2\_EVENT\_SRC\_CH\_RESOLUTION is signaled.

---

**Important:** Any client query issued after the decoder queues the event will return values applying to the just parsed stream, including queue formats, selection rectangles and controls.

---

**Note:** A client capable of acquiring stream parameters from the bytestream on its own may attempt to set the width and height of the OUTPUT format to non-zero values matching the coded size of the stream, skip this step and continue with the *Capture Setup* sequence. However, it must not rely on any driver queries regarding stream parameters, such as selection rectangles and controls, since the decoder has not parsed them from the stream yet. If the values configured by the client do not match those parsed by the decoder, a *Dynamic Resolution Change* will be triggered to reconfigure them.

---

**Note:** No decoded frames are produced during this phase.

---

5. Continue with the *Capture Setup* sequence.

## Capture Setup

1. Call VIDIOC\_G\_FMT() on the CAPTURE queue to get format for the destination buffers parsed/decoded from the bytestream.

- **Required fields:**

**type**

a V4L2\_BUF\_TYPE\_\* enum appropriate for CAPTURE.

- **Returned fields:**

**width, height**

frame buffer resolution for the decoded frames.

**pixelformat**

pixel format for decoded frames.

**num\_planes (for \_MPLANE type only)**

number of planes for pixelformat.

**sizeimage, bytesperline**

as per standard semantics; matching frame buffer format.

---

**Note:** The value of pixelformat may be any pixel format supported by the decoder for the current stream. The decoder should choose a preferred/optimal format for the default configuration. For example, a YUV format may be preferred over an RGB format if an additional conversion step would be required for the latter.

---

2. **Optional.** Acquire the visible resolution via VIDIOC\_G\_SELECTION().

- **Required fields:**

**type**

a V4L2\_BUF\_TYPE\_\* enum appropriate for CAPTURE.

**target**

set to V4L2\_SEL\_TGT\_COMPOSE.

- **Returned fields:**

**r.left, r.top, r.width, r.height**

the visible rectangle; it must fit within the frame buffer resolution returned by VIDIOC\_G\_FMT() on CAPTURE.

- The following selection targets are supported on CAPTURE:

**V4L2\_SEL\_TGT\_CROP\_BOUNDS**

corresponds to the coded resolution of the stream.

**V4L2\_SEL\_TGT\_CROP\_DEFAULT**

the rectangle covering the part of the CAPTURE buffer that contains meaningful picture data (visible area); width and height will be equal to the visible resolution of the stream.

**V4L2\_SEL\_TGT\_CROP**

the rectangle within the coded resolution to be output to CAPTURE; defaults to V4L2\_SEL\_TGT\_CROP\_DEFAULT; read-only on hardware without additional compose/scaling capabilities.

**V4L2\_SEL\_TGT\_COMPOSE\_BOUNDS**

the maximum rectangle within a CAPTURE buffer, which the cropped frame can be composed into; equal to V4L2\_SEL\_TGT\_CROP if the hardware does not support compose/scaling.

**V4L2\_SEL\_TGT\_COMPOSE\_DEFAULT**

equal to V4L2\_SEL\_TGT\_CROP.

**V4L2\_SEL\_TGT\_COMPOSE**

the rectangle inside a CAPTURE buffer into which the cropped frame is written; defaults to V4L2\_SEL\_TGT\_COMPOSE\_DEFAULT; read-only on hardware without additional compose/scaling capabilities.

**V4L2\_SEL\_TGT\_COMPOSE\_PADDED**

the rectangle inside a CAPTURE buffer which is overwritten by the hardware; equal

to V4L2\_SEL\_TGT\_COMPOSE if the hardware does not write padding pixels.

**Warning:** The values are guaranteed to be meaningful only after the decoder successfully parses the stream metadata. The client must not rely on the query before that happens.

3. **Optional.** Enumerate CAPTURE formats via VIDIOC\_ENUM\_FMT() on the CAPTURE queue. Once the stream information is parsed and known, the client may use this ioctl to discover which raw formats are supported for given stream and select one of them via VIDIOC\_S\_FMT().

**Important:** The decoder will return only formats supported for the currently established coded format, as per the OUTPUT format and/or stream metadata parsed in this initialization sequence, even if more formats may be supported by the decoder in general. In other words, the set returned will be a subset of the initial query mentioned in the *Querying Capabilities* section.

For example, a decoder may support YUV and RGB formats for resolutions 1920x1088 and lower, but only YUV for higher resolutions (due to hardware limitations). After parsing a resolution of 1920x1088 or lower, VIDIOC\_ENUM\_FMT() may return a set of YUV and RGB pixel formats, but after parsing resolution higher than 1920x1088, the decoder will not return RGB, unsupported for this resolution.

However, subsequent resolution change event triggered after discovering a resolution change within the same stream may switch the stream into a lower resolution and VIDIOC\_ENUM\_FMT() would return RGB formats again in that case.

4. **Optional.** Set the CAPTURE format via VIDIOC\_S\_FMT() on the CAPTURE queue. The client may choose a different format than selected/suggested by the decoder in VIDIOC\_G\_FMT().

- **Required fields:**

**type**

a V4L2\_BUF\_TYPE\_\* enum appropriate for CAPTURE.

**pixelformat**

a raw pixel format.

**width, height**

frame buffer resolution of the decoded stream; typically unchanged from what was returned with VIDIOC\_G\_FMT(), but it may be different if the hardware supports composition and/or scaling.

- Setting the CAPTURE format will reset the compose selection rectangles to their default values, based on the new resolution, as described in the previous step.

5. **Optional.** Set the compose rectangle via VIDIOC\_S\_SELECTION() on the CAPTURE queue if it is desired and if the decoder has compose and/or scaling capabilities.

- **Required fields:**

**type**

a V4L2\_BUF\_TYPE\_\* enum appropriate for CAPTURE.

**target**

set to V4L2\_SEL\_TGT\_COMPOSE.

**r.left, r.top, r.width, r.height**

the rectangle inside a CAPTURE buffer into which the cropped frame is written; defaults to V4L2\_SEL\_TGT\_COMPOSE\_DEFAULT; read-only on hardware without additional compose/scaling capabilities.

- **Returned fields:**

**r.left, r.top, r.width, r.height**

the visible rectangle; it must fit within the frame buffer resolution returned by VIDIOC\_G\_FMT() on CAPTURE.

**Warning:** The decoder may adjust the compose rectangle to the nearest supported one to meet codec and hardware requirements. The client needs to check the adjusted rectangle returned by VIDIOC\_S\_SELECTION().

6. If all the following conditions are met, the client may resume the decoding instantly:
  - sizeimage of the new format (determined in previous steps) is less than or equal to the size of currently allocated buffers,
  - the number of buffers currently allocated is greater than or equal to the minimum number of buffers acquired in previous steps. To fulfill this requirement, the client may use VIDIOC\_CREATE\_BUFS() to add new buffers.

In that case, the remaining steps do not apply and the client may resume the decoding by one of the following actions:

- if the CAPTURE queue is streaming, call VIDIOC\_DECODER\_CMD() with the V4L2\_DEC\_CMD\_START command,
- if the CAPTURE queue is not streaming, call VIDIOC\_STREAMON() on the CAPTURE queue.

However, if the client intends to change the buffer set, to lower memory usage or for any other reasons, it may be achieved by following the steps below.

7. **If the CAPTURE queue is streaming**, keep queuing and dequeuing buffers on the CAPTURE queue until a buffer marked with the V4L2\_BUF\_FLAG\_LAST flag is dequeued.
8. **If the CAPTURE queue is streaming**, call VIDIOC\_STREAMOFF() on the CAPTURE queue to stop streaming.

**Warning:** The OUTPUT queue must remain streaming. Calling VIDIOC\_STREAMOFF() on it would abort the sequence and trigger a seek.

9. **If the CAPTURE queue has buffers allocated**, free the CAPTURE buffers using VIDIOC\_REQBUFS().

- **Required fields:**

**count**

set to 0.

**type**

a V4L2\_BUF\_TYPE\_\* enum appropriate for CAPTURE.

**memory**

follows standard semantics.

10. Allocate CAPTURE buffers via VIDIOC\_REQBUFS() on the CAPTURE queue.

- **Required fields:**

**count**

requested number of buffers to allocate; greater than zero.

**type**

a V4L2\_BUF\_TYPE\_\* enum appropriate for CAPTURE.

**memory**

follows standard semantics.

- **Returned fields:**

**count**

actual number of buffers allocated.

**Warning:** The actual number of allocated buffers may differ from the count given. The client must check the updated value of count after the call returns.

**Note:** To allocate more than the minimum number of buffers (for pipeline depth), the client may query the V4L2\_CID\_MIN\_BUFFERS\_FOR\_CAPTURE control to get the minimum number of buffers required, and pass the obtained value plus the number of additional buffers needed in the count field to VIDIOC\_REQBUFS().

Alternatively, VIDIOC\_CREATE\_BUFS() on the CAPTURE queue can be used to have more control over buffer allocation. For example, by allocating buffers larger than the current CAPTURE format, future resolution changes can be accommodated.

- **Required fields:**

**count**

requested number of buffers to allocate; greater than zero.

**type**

a V4L2\_BUF\_TYPE\_\* enum appropriate for CAPTURE.

**memory**

follows standard semantics.

**format**

a format representing the maximum framebuffer resolution to be accommodated by newly allocated buffers.

- **Returned fields:**

**count**

adjusted to the number of allocated buffers.

**Warning:** The actual number of allocated buffers may differ from the count given. The client must check the updated value of `count` after the call returns.

---

**Note:** To allocate buffers for a format different than parsed from the stream metadata, the client must proceed as follows, before the metadata parsing is initiated:

- set width and height of the `OUTPUT` format to desired coded resolution to let the decoder configure the `CAPTURE` format appropriately,
- query the `CAPTURE` format using `VIDIOC_G_FMT()` and save it until this step.

The format obtained in the query may be then used with `VIDIOC_CREATE_BUFS()` in this step to allocate the buffers.

---

## 11. Call `VIDIOC_STREAMON()` on the `CAPTURE` queue to start decoding frames.

### Decoding

This state is reached after the *Capture Setup* sequence finishes successfully. In this state, the client queues and dequeues buffers to both queues via `VIDIOC_QBUF()` and `VIDIOC_DQBUF()`, following the standard semantics.

The content of the source `OUTPUT` buffers depends on the active coded pixel format and may be affected by codec-specific extended controls, as stated in the documentation of each format.

Both queues operate independently, following the standard behavior of V4L2 buffer queues and memory-to-memory devices. In addition, the order of decoded frames dequeued from the `CAPTURE` queue may differ from the order of queuing coded frames to the `OUTPUT` queue, due to properties of the selected coded format, e.g. frame reordering.

The client must not assume any direct relationship between `CAPTURE` and `OUTPUT` buffers and any specific timing of buffers becoming available to dequeue. Specifically:

- a buffer queued to `OUTPUT` may result in no buffers being produced on `CAPTURE` (e.g. if it does not contain encoded data, or if only metadata syntax structures are present in it),
- a buffer queued to `OUTPUT` may result in more than one buffer produced on `CAPTURE` (if the encoded data contained more than one frame, or if returning a decoded frame allowed the decoder to return a frame that preceded it in decode, but succeeded it in the display order),
- a buffer queued to `OUTPUT` may result in a buffer being produced on `CAPTURE` later into decode process, and/or after processing further `OUTPUT` buffers, or be returned out of order, e.g. if display reordering is used,
- buffers may become available on the `CAPTURE` queue without additional buffers queued to `OUTPUT` (e.g. during drain or EOS), because of the `OUTPUT` buffers queued in the past whose decoding results are only available at later time, due to specifics of the decoding process.

---

**Note:** To allow matching decoded `CAPTURE` buffers with `OUTPUT` buffers they originated from, the client can set the `timestamp` field of the `v4l2_buffer` struct when queuing an `OUTPUT`

buffer. The CAPTURE buffer(s), which resulted from decoding that OUTPUT buffer will have their timestamp field set to the same value when dequeued.

In addition to the straightforward case of one OUTPUT buffer producing one CAPTURE buffer, the following cases are defined:

- one OUTPUT buffer generates multiple CAPTURE buffers: the same OUTPUT timestamp will be copied to multiple CAPTURE buffers.
  - multiple OUTPUT buffers generate one CAPTURE buffer: timestamp of the OUTPUT buffer queued first will be copied.
  - the decoding order differs from the display order (i.e. the CAPTURE buffers are out-of-order compared to the OUTPUT buffers): CAPTURE timestamps will not retain the order of OUTPUT timestamps.
- 

**Note:** The backing memory of CAPTURE buffers that are used as reference frames by the stream may be read by the hardware even after they are dequeued. Consequently, the client should avoid writing into this memory while the CAPTURE queue is streaming. Failure to observe this may result in corruption of decoded frames.

Similarly, when using a memory type other than V4L2\_MEMORY\_MMAP, the client should make sure that each CAPTURE buffer is always queued with the same backing memory for as long as the CAPTURE queue is streaming. The reason for this is that V4L2 buffer indices can be used by drivers to identify frames. Thus, if the backing memory of a reference frame is submitted under a different buffer ID, the driver may misidentify it and decode a new frame into it while it is still in use, resulting in corruption of the following frames.

---

During the decoding, the decoder may initiate one of the special sequences, as listed below. The sequences will result in the decoder returning all the CAPTURE buffers that originated from all the OUTPUT buffers processed before the sequence started. Last of the buffers will have the V4L2\_BUF\_FLAG\_LAST flag set. To determine the sequence to follow, the client must check if there is any pending event and:

- if a V4L2\_EVENT\_SOURCE\_CHANGE event with changes set to V4L2\_EVENT\_SRC\_CH\_RESOLUTION is pending, the *Dynamic Resolution Change* sequence needs to be followed,
- if a V4L2\_EVENT\_EOS event is pending, the *End of Stream* sequence needs to be followed.

Some of the sequences can be intermixed with each other and need to be handled as they happen. The exact operation is documented for each sequence.

Should a decoding error occur, it will be reported to the client with the level of details depending on the decoder capabilities. Specifically:

- the CAPTURE buffer that contains the results of the failed decode operation will be returned with the V4L2\_BUF\_FLAG\_ERROR flag set,
- if the decoder is able to precisely report the OUTPUT buffer that triggered the error, such buffer will be returned with the V4L2\_BUF\_FLAG\_ERROR flag set.

In case of a fatal failure that does not allow the decoding to continue, any further operations on corresponding decoder file handle will return the -EIO error code. The client may close the

file handle and open a new one, or alternatively reinitialize the instance by stopping streaming on both queues, releasing all buffers and performing the Initialization sequence again.

### Seek

Seek is controlled by the OUTPUT queue, as it is the source of coded data. The seek does not require any specific operation on the CAPTURE queue, but it may be affected as per normal decoder operation.

1. Stop the OUTPUT queue to begin the seek sequence via `VIDIOC_STREAMOFF()`.

- **Required fields:**

**type**

a `V4L2_BUF_TYPE_*` enum appropriate for OUTPUT.

- The decoder will drop all the pending OUTPUT buffers and they must be treated as returned to the client (following standard semantics).

2. Restart the OUTPUT queue via `VIDIOC_STREAMON()`.

- **Required fields:**

**type**

a `V4L2_BUF_TYPE_*` enum appropriate for OUTPUT.

- The decoder will start accepting new source bytestream buffers after the call returns.

3. Start queuing buffers containing coded data after the seek to the OUTPUT queue until a suitable resume point is found.

---

**Note:** There is no requirement to begin queuing coded data starting exactly from a resume point (e.g. SPS or a keyframe). Any queued OUTPUT buffers will be processed and returned to the client until a suitable resume point is found. While looking for a resume point, the decoder should not produce any decoded frames into CAPTURE buffers.

Some hardware is known to mishandle seeks to a non-resume point. Such an operation may result in an unspecified number of corrupted decoded frames being made available on the CAPTURE queue. Drivers must ensure that no fatal decoding errors or crashes occur, and implement any necessary handling and workarounds for hardware issues related to seek operations.

**Warning:** In case of the H.264/HEVC codec, the client must take care not to seek over a change of SPS/PPS. Even though the target frame could be a keyframe, the stale SPS/PPS inside decoder state would lead to undefined results when decoding. Although the decoder must handle that case without a crash or a fatal decode error, the client must not expect a sensible decode output.

If the hardware can detect such corrupted decoded frames, then corresponding buffers will be returned to the client with the `V4L2_BUF_FLAG_ERROR` set. See the *Decoding* section for further description of decode error reporting.

4. After a resume point is found, the decoder will start returning CAPTURE buffers containing decoded frames.

**Important:** A seek may result in the *Dynamic Resolution Change* sequence being initiated, due to the seek target having decoding parameters different from the part of the stream decoded before the seek. The sequence must be handled as per normal decoder operation.

**Warning:** It is not specified when the CAPTURE queue starts producing buffers containing decoded data from the OUTPUT buffers queued after the seek, as it operates independently from the OUTPUT queue.

The decoder may return a number of remaining CAPTURE buffers containing decoded frames originating from the OUTPUT buffers queued before the seek sequence is performed.

The VIDIOC\_STREAMOFF operation discards any remaining queued OUTPUT buffers, which means that not all of the OUTPUT buffers queued before the seek sequence may have matching CAPTURE buffers produced. For example, given the sequence of operations on the OUTPUT queue:

QBUF(A), QBUF(B), STREAMOFF(), STREAMON(), QBUF(G), QBUF(H),

any of the following results on the CAPTURE queue is allowed:

{A', B', G', H'}, {A', G', H'}, {G', H'}.

To determine the CAPTURE buffer containing the first decoded frame after the seek, the client may observe the timestamps to match the CAPTURE and OUTPUT buffers or use V4L2\_DEC\_CMD\_STOP and V4L2\_DEC\_CMD\_START to drain the decoder.

**Note:** To achieve instantaneous seek, the client may restart streaming on the CAPTURE queue too to discard decoded, but not yet dequeued buffers.

## Dynamic Resolution Change

Streams that include resolution metadata in the bytestream may require switching to a different resolution during the decoding.

**Note:** Not all decoders can detect resolution changes. Those that do set the V4L2\_FMT\_FLAG\_DYN\_RESOLUTION flag for the coded format when VIDIOC\_ENUM\_FMT() is called.

The sequence starts when the decoder detects a coded frame with one or more of the following parameters different from those previously established (and reflected by corresponding queries):

- coded resolution (OUTPUT width and height),
- visible resolution (selection rectangles),
- the minimum number of buffers needed for decoding,

- bit-depth of the bitstream has been changed.

Whenever that happens, the decoder must proceed as follows:

1. After encountering a resolution change in the stream, the decoder sends a V4L2\_EVENT\_SOURCE\_CHANGE event with changes set to V4L2\_EVENT\_SRC\_CH\_RESOLUTION.

---

**Important:** Any client query issued after the decoder queues the event will return values applying to the stream after the resolution change, including queue formats, selection rectangles and controls.

---

2. The decoder will then process and decode all remaining buffers from before the resolution change point.
  - The last buffer from before the change must be marked with the V4L2\_BUF\_FLAG\_LAST flag, similarly to the *Drain* sequence above.

**Warning:** The last buffer may be empty (with v4l2\_buffer.bytesused = 0) and in that case it must be ignored by the client, as it does not contain a decoded frame.

---

**Note:** Any attempt to dequeue more CAPTURE buffers beyond the buffer marked with V4L2\_BUF\_FLAG\_LAST will result in a -EPIPE error from VIDIOC\_DQBUF().

---

The client must continue the sequence as described below to continue the decoding process.

1. Dequeue the source change event.

---

**Important:** A source change triggers an implicit decoder drain, similar to the explicit *Drain* sequence. The decoder is stopped after it completes. The decoding process must be resumed with either a pair of calls to VIDIOC\_STREAMOFF() and VIDIOC\_STREAMON() on the CAPTURE queue, or a call to VIDIOC\_DECODER\_CMD() with the V4L2\_DEC\_CMD\_START command.

---

2. Continue with the *Capture Setup* sequence.

---

**Note:** During the resolution change sequence, the OUTPUT queue must remain streaming. Calling VIDIOC\_STREAMOFF() on the OUTPUT queue would abort the sequence and initiate a seek.

In principle, the OUTPUT queue operates separately from the CAPTURE queue and this remains true for the duration of the entire resolution change sequence as well.

The client should, for best performance and simplicity, keep queuing/dequeuing buffers to/from the OUTPUT queue even while processing this sequence.

---

## Drain

To ensure that all queued OUTPUT buffers have been processed and related CAPTURE buffers are given to the client, the client must follow the drain sequence described below. After the drain sequence ends, the client has received all decoded frames for all OUTPUT buffers queued before the sequence was started.

1. Begin drain by issuing VIDIOC\_DECODER\_CMD().

- **Required fields:**

**cmd**

set to V4L2\_DEC\_CMD\_STOP.

**flags**

set to 0.

**pts**

set to 0.

**Warning:** The sequence can be only initiated if both OUTPUT and CAPTURE queues are streaming. For compatibility reasons, the call to VIDIOC\_DECODER\_CMD() will not fail even if any of the queues is not streaming, but at the same time it will not initiate the *Drain* sequence and so the steps described below would not be applicable.

2. Any OUTPUT buffers queued by the client before the VIDIOC\_DECODER\_CMD() was issued will be processed and decoded as normal. The client must continue to handle both queues independently, similarly to normal decode operation. This includes:

- handling any operations triggered as a result of processing those buffers, such as the *Dynamic Resolution Change* sequence, before continuing with the drain sequence,
- queuing and dequeuing CAPTURE buffers, until a buffer marked with the V4L2\_BUF\_FLAG\_LAST flag is dequeued,

**Warning:** The last buffer may be empty (with v4l2\_buffer.bytesused = 0) and in that case it must be ignored by the client, as it does not contain a decoded frame.

**Note:** Any attempt to dequeue more CAPTURE buffers beyond the buffer marked with V4L2\_BUF\_FLAG\_LAST will result in a -EPIPE error from VIDIOC\_DQBUF().

- dequeuing processed OUTPUT buffers, until all the buffers queued before the V4L2\_DEC\_CMD\_STOP command are dequeued,
- dequeuing the V4L2\_EVENT\_EOS event, if the client subscribed to it.

**Note:** For backwards compatibility, the decoder will signal a V4L2\_EVENT\_EOS event when the last frame has been decoded and all frames are ready to be dequeued. It is a deprecated

behavior and the client must not rely on it. The `V4L2_BUF_FLAG_LAST` buffer flag should be used instead.

---

3. Once all the `OUTPUT` buffers queued before the `V4L2_DEC_CMD_STOP` call are dequeued and the last `CAPTURE` buffer is dequeued, the decoder is stopped and it will accept, but not process, any newly queued `OUTPUT` buffers until the client issues any of the following operations:
  - `V4L2_DEC_CMD_START` - the decoder will not be reset and will resume operation normally, with all the state from before the drain,
  - a pair of `VIDIOC_STREAMOFF()` and `VIDIOC_STREAMON()` on the `CAPTURE` queue - the decoder will resume the operation normally, however any `CAPTURE` buffers still in the queue will be returned to the client,
  - a pair of `VIDIOC_STREAMOFF()` and `VIDIOC_STREAMON()` on the `OUTPUT` queue - any pending source buffers will be returned to the client and the *Seek* sequence will be triggered.

---

**Note:** Once the drain sequence is initiated, the client needs to drive it to completion, as described by the steps above, unless it aborts the process by issuing `VIDIOC_STREAMOFF()` on any of the `OUTPUT` or `CAPTURE` queues. The client is not allowed to issue `V4L2_DEC_CMD_START` or `V4L2_DEC_CMD_STOP` again while the drain sequence is in progress and they will fail with `-EBUSY` error code if attempted.

Although not mandatory, the availability of decoder commands may be queried using `VIDIOC_TRY_DECODER_CMD()`.

---

### End of Stream

If the decoder encounters an end of stream marking in the stream, the decoder will initiate the *Drain* sequence, which the client must handle as described above, skipping the initial `VIDIOC_DECODER_CMD()`.

### Commit Points

Setting formats and allocating buffers trigger changes in the behavior of the decoder.

1. Setting the format on the `OUTPUT` queue may change the set of formats supported/advertised on the `CAPTURE` queue. In particular, it also means that the `CAPTURE` format may be reset and the client must not rely on the previously set format being preserved.
2. Enumerating formats on the `CAPTURE` queue always returns only formats supported for the current `OUTPUT` format.
3. Setting the format on the `CAPTURE` queue does not change the list of formats available on the `OUTPUT` queue. An attempt to set a `CAPTURE` format that is not supported for the currently selected `OUTPUT` format will result in the decoder adjusting the requested `CAPTURE` format to a supported one.

4. Enumerating formats on the OUTPUT queue always returns the full set of supported coded formats, irrespectively of the current CAPTURE format.
5. While buffers are allocated on any of the OUTPUT or CAPTURE queues, the client must not change the format on the OUTPUT queue. Drivers will return the -EBUSY error code for any such format change attempt.

To summarize, setting formats and allocation must always start with the OUTPUT queue and the OUTPUT queue is the master that governs the set of supported formats for the CAPTURE queue.

## Memory-to-Memory Stateful Video Encoder Interface

A stateful video encoder takes raw video frames in display order and encodes them into a bytestream. It generates complete chunks of the bytestream, including all metadata, headers, etc. The resulting bytestream does not require any further post-processing by the client.

Performing software stream processing, header generation etc. in the driver in order to support this interface is strongly discouraged. In case such operations are needed, use of the Stateless Video Encoder Interface (in development) is strongly advised.

## Conventions and Notations Used in This Document

1. The general V4L2 API rules apply if not specified in this document otherwise.
2. The meaning of words "must", "may", "should", etc. is as per [RFC 2119](#).
3. All steps not marked "optional" are required.
4. VIDIOC\_G\_EXT\_CTRLS() and VIDIOC\_S\_EXT\_CTRLS() may be used interchangeably with VIDIOC\_G\_CTRL() and VIDIOC\_S\_CTRL(), unless specified otherwise.
5. Single-planar API (see [Single- and multi-planar APIs](#)) and applicable structures may be used interchangeably with multi-planar API, unless specified otherwise, depending on encoder capabilities and following the general V4L2 guidelines.
6.  $i = [a..b]$ : sequence of integers from a to b, inclusive, i.e.  $i = [0..2]$ :  $i = 0, 1, 2$ .
7. Given an OUTPUT buffer A, then A' represents a buffer on the CAPTURE queue containing data that resulted from processing buffer A.

## Glossary

Refer to [Glossary](#).

## State Machine

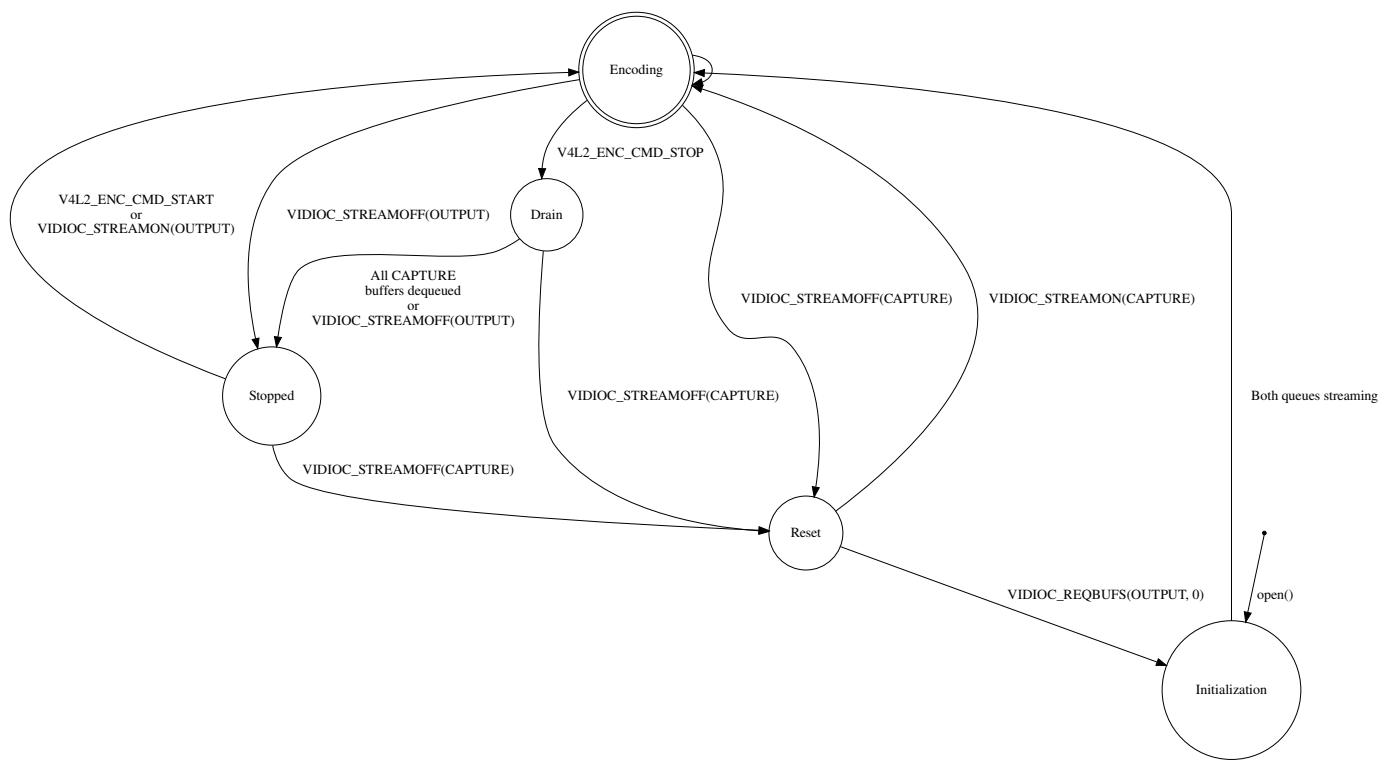


Fig. 9: Encoder State Machine

## Querying Capabilities

1. To enumerate the set of coded formats supported by the encoder, the client may call `VIDIOC_ENUM_FMT()` on CAPTURE.
  - The full set of supported formats will be returned, regardless of the format set on OUTPUT.
2. To enumerate the set of supported raw formats, the client may call `VIDIOC_ENUM_FMT()` on OUTPUT.
  - Only the formats supported for the format currently active on CAPTURE will be returned.
  - In order to enumerate raw formats supported by a given coded format, the client must first set that coded format on CAPTURE and then enumerate the formats on OUTPUT.
3. The client may use `VIDIOC_ENUM_FRAMESIZES()` to detect supported resolutions for a given format, passing the desired pixel format in `v4l2_frmsizeenum.pixel_format`.
  - Values returned by `VIDIOC_ENUM_FRAMESIZES()` for a coded pixel format will include all possible coded resolutions supported by the encoder for the given coded pixel format.
  - Values returned by `VIDIOC_ENUM_FRAMESIZES()` for a raw pixel format will include all possible frame buffer resolutions supported by the encoder for the given raw pixel format and coded format currently set on CAPTURE.

4. The client may use VIDIOC\_ENUM\_FRAMEINTERVALS() to detect supported frame intervals for a given format and resolution, passing the desired pixel format in v4l2\_frmivalenum.pixel\_format and the resolution in v4l2\_frmivalenum.width and v4l2\_frmivalenum.height.
  - Values returned by VIDIOC\_ENUM\_FRAMEINTERVALS() for a coded pixel format and coded resolution will include all possible frame intervals supported by the encoder for the given coded pixel format and resolution.
  - Values returned by VIDIOC\_ENUM\_FRAMEINTERVALS() for a raw pixel format and resolution will include all possible frame intervals supported by the encoder for the given raw pixel format and resolution and for the coded format, coded resolution and coded frame interval currently set on CAPTURE.
  - Support for VIDIOC\_ENUM\_FRAMEINTERVALS() is optional. If it is not implemented, then there are no special restrictions other than the limits of the codec itself.
5. Supported profiles and levels for the coded format currently set on CAPTURE, if applicable, may be queried using their respective controls via VIDIOC\_QUERYCTRL().
6. Any additional encoder capabilities may be discovered by querying their respective controls.

## Initialization

1. Set the coded format on the CAPTURE queue via VIDIOC\_S\_FMT().

- **Required fields:**

**type**

a V4L2\_BUF\_TYPE\_\* enum appropriate for CAPTURE.

**pixelformat**

the coded format to be produced.

**sizeimage**

desired size of CAPTURE buffers; the encoder may adjust it to match hardware requirements.

**width, height**

ignored (read-only).

**other fields**

follow standard semantics.

- **Returned fields:**

**sizeimage**

adjusted size of CAPTURE buffers.

**width, height**

the coded size selected by the encoder based on current state, e.g. OUTPUT format, selection rectangles, etc. (read-only).

---

**Important:** Changing the CAPTURE format may change the currently set OUTPUT format. How the new OUTPUT format is determined is up to the encoder and the client must ensure

it matches its needs afterwards.

---

2. **Optional.** Enumerate supported OUTPUT formats (raw formats for source) for the selected coded format via VIDIOC\_ENUM\_FMT().

- **Required fields:**

**type**

a V4L2\_BUF\_TYPE\_\* enum appropriate for OUTPUT.

**other fields**

follow standard semantics.

- **Returned fields:**

**pixelformat**

raw format supported for the coded format currently selected on the CAPTURE queue.

**other fields**

follow standard semantics.

3. Set the raw source format on the OUTPUT queue via VIDIOC\_S\_FMT().

- **Required fields:**

**type**

a V4L2\_BUF\_TYPE\_\* enum appropriate for OUTPUT.

**pixelformat**

raw format of the source.

**width, height**

source resolution.

**other fields**

follow standard semantics.

- **Returned fields:**

**width, height**

may be adjusted to match encoder minimums, maximums and alignment requirements, as required by the currently selected formats, as reported by VIDIOC\_ENUM\_FRAMESIZES().

**other fields**

follow standard semantics.

- Setting the OUTPUT format will reset the selection rectangles to their default values, based on the new resolution, as described in the next step.

4. Set the raw frame interval on the OUTPUT queue via VIDIOC\_S\_PARM(). This also sets the coded frame interval on the CAPTURE queue to the same value.

- **Required fields:**

**type**

a V4L2\_BUF\_TYPE\_\* enum appropriate for OUTPUT.

**parm.output**

set all fields except parm.output.timeperframe to 0.

**parm.output.timeperframe**

the desired frame interval; the encoder may adjust it to match hardware requirements.

- **Returned fields:**

**parm.output.timeperframe**

the adjusted frame interval.

---

**Important:** Changing the OUTPUT frame interval *also* sets the framerate that the encoder uses to encode the video. So setting the frame interval to 1/24 (or 24 frames per second) will produce a coded video stream that can be played back at that speed. The frame interval for the OUTPUT queue is just a hint, the application may provide raw frames at a different rate. It can be used by the driver to help schedule multiple encoders running in parallel.

In the next step the CAPTURE frame interval can optionally be changed to a different value. This is useful for off-line encoding were the coded frame interval can be different from the rate at which raw frames are supplied.

---



---

**Important:** timeperframe deals with *frames*, not fields. So for interlaced formats this is the time per two fields, since a frame consists of a top and a bottom field.

---

**Note:** It is due to historical reasons that changing the OUTPUT frame interval also changes the coded frame interval on the CAPTURE queue. Ideally these would be independent settings, but that would break the existing API.

---

5. **Optional** Set the coded frame interval on the CAPTURE queue via VIDIOC\_S\_PARM(). This is only necessary if the coded frame interval is different from the raw frame interval, which is typically the case for off-line encoding. Support for this feature is signalled by the [V4L2\\_FMT\\_FLAG\\_ENC\\_CAP\\_FRAME\\_INTERVAL](#) format flag.

- **Required fields:**

**type**

a V4L2\_BUF\_TYPE\_\* enum appropriate for CAPTURE.

**parm.capture**

set all fields except `parm.capture.timeperframe` to 0.

**parm.capture.timeperframe**

the desired coded frame interval; the encoder may adjust it to match hardware requirements.

- **Returned fields:**

**parm.capture.timeperframe**

the adjusted frame interval.

---

**Important:** Changing the CAPTURE frame interval sets the framerate for the coded video. It does *not* set the rate at which buffers arrive on the CAPTURE queue, that depends on how

fast the encoder is and how fast raw frames are queued on the OUTPUT queue.

---

**Important:** `timeperframe` deals with *frames*, not fields. So for interlaced formats this is the time per two fields, since a frame consists of a top and a bottom field.

---

**Note:** Not all drivers support this functionality, in that case just set the desired coded frame interval for the OUTPUT queue.

However, drivers that can schedule multiple encoders based on the OUTPUT frame interval must support this optional feature.

---

6. **Optional.** Set the visible resolution for the stream metadata via `VIDIOC_S_SELECTION()` on the OUTPUT queue if it is desired to be different than the full OUTPUT resolution.

- **Required fields:**

**type**

a `V4L2_BUF_TYPE_*` enum appropriate for OUTPUT.

**target**

set to `V4L2_SEL_TGT_CROP`.

**r.left, r.top, r.width, r.height**

visible rectangle; this must fit within the `V4L2_SEL_TGT_CROP_BOUNDS` rectangle and may be subject to adjustment to match codec and hardware constraints.

- **Returned fields:**

**r.left, r.top, r.width, r.height**

visible rectangle adjusted by the encoder.

- The following selection targets are supported on OUTPUT:

**V4L2\_SEL\_TGT\_CROP\_BOUNDS**

equal to the full source frame, matching the active OUTPUT format.

**V4L2\_SEL\_TGT\_CROP\_DEFAULT**

equal to `V4L2_SEL_TGT_CROP_BOUNDS`.

**V4L2\_SEL\_TGT\_CROP**

rectangle within the source buffer to be encoded into the CAPTURE stream; defaults to `V4L2_SEL_TGT_CROP_DEFAULT`.

---

**Note:** A common use case for this selection target is encoding a source video with a resolution that is not a multiple of a macroblock, e.g. the common 1920x1080 resolution may require the source buffers to be aligned to 1920x1088 for codecs with 16x16 macroblock size. To avoid encoding the padding, the client needs to explicitly configure this selection target to 1920x1080.

---

**Warning:** The encoder may adjust the crop/compose rectangles to the nearest supported ones to meet codec and hardware requirements. The client needs to check the adjusted rectangle returned by VIDIOC\_S\_SELECTION().

7. Allocate buffers for both OUTPUT and CAPTURE via VIDIOC\_REQBUFS(). This may be performed in any order.

- **Required fields:**

**count**

requested number of buffers to allocate; greater than zero.

**type**

a V4L2\_BUF\_TYPE\_\* enum appropriate for OUTPUT or CAPTURE.

**other fields**

follow standard semantics.

- **Returned fields:**

**count**

actual number of buffers allocated.

**Warning:** The actual number of allocated buffers may differ from the count given. The client must check the updated value of count after the call returns.

**Note:** To allocate more than the minimum number of OUTPUT buffers (for pipeline depth), the client may query the V4L2\_CID\_MIN\_BUFFERS\_FOR\_OUTPUT control to get the minimum number of buffers required, and pass the obtained value plus the number of additional buffers needed in the count field to VIDIOC\_REQBUFS().

Alternatively, VIDIOC\_CREATE\_BUFS() can be used to have more control over buffer allocation.

- **Required fields:**

**count**

requested number of buffers to allocate; greater than zero.

**type**

a V4L2\_BUF\_TYPE\_\* enum appropriate for OUTPUT.

**other fields**

follow standard semantics.

- **Returned fields:**

**count**

adjusted to the number of allocated buffers.

8. Begin streaming on both OUTPUT and CAPTURE queues via VIDIOC\_STREAMON(). This may be performed in any order. The actual encoding process starts when both queues start streaming.

**Note:** If the client stops the CAPTURE queue during the encode process and then restarts it again, the encoder will begin generating a stream independent from the stream generated before the stop. The exact constraints depend on the coded format, but may include the following implications:

- encoded frames produced after the restart must not reference any frames produced before the stop, e.g. no long term references for H.264/HEVC,
  - any headers that must be included in a standalone stream must be produced again, e.g. SPS and PPS for H.264/HEVC.
- 

## Encoding

This state is reached after the *Initialization* sequence finishes successfully. In this state, the client queues and dequeues buffers to both queues via VIDIOC\_QBUF() and VIDIOC\_DQBUF(), following the standard semantics.

The content of encoded CAPTURE buffers depends on the active coded pixel format and may be affected by codec-specific extended controls, as stated in the documentation of each format.

Both queues operate independently, following standard behavior of V4L2 buffer queues and memory-to-memory devices. In addition, the order of encoded frames dequeued from the CAPTURE queue may differ from the order of queuing raw frames to the OUTPUT queue, due to properties of the selected coded format, e.g. frame reordering.

The client must not assume any direct relationship between CAPTURE and OUTPUT buffers and any specific timing of buffers becoming available to dequeue. Specifically:

- a buffer queued to OUTPUT may result in more than one buffer produced on CAPTURE (for example, if returning an encoded frame allowed the encoder to return a frame that preceded it in display, but succeeded it in the decode order; however, there may be other reasons for this as well),
- a buffer queued to OUTPUT may result in a buffer being produced on CAPTURE later into encode process, and/or after processing further OUTPUT buffers, or be returned out of order, e.g. if display reordering is used,
- buffers may become available on the CAPTURE queue without additional buffers queued to OUTPUT (e.g. during drain or EOS), because of the OUTPUT buffers queued in the past whose encoding results are only available at later time, due to specifics of the encoding process,
- buffers queued to OUTPUT may not become available to dequeue instantly after being encoded into a corresponding CAPTURE buffer, e.g. if the encoder needs to use the frame as a reference for encoding further frames.

**Note:** To allow matching encoded CAPTURE buffers with OUTPUT buffers they originated from, the client can set the timestamp field of the v4l2\_buffer struct when queuing an OUTPUT buffer. The CAPTURE buffer(s), which resulted from encoding that OUTPUT buffer will have their timestamp field set to the same value when dequeued.

In addition to the straightforward case of one OUTPUT buffer producing one CAPTURE buffer, the following cases are defined:

- one OUTPUT buffer generates multiple CAPTURE buffers: the same OUTPUT timestamp will be copied to multiple CAPTURE buffers,
  - the encoding order differs from the presentation order (i.e. the CAPTURE buffers are out-of-order compared to the OUTPUT buffers): CAPTURE timestamps will not retain the order of OUTPUT timestamps.
- 

**Note:** To let the client distinguish between frame types (keyframes, intermediate frames; the exact list of types depends on the coded format), the CAPTURE buffers will have corresponding flag bits set in their `v4l2_buffer` struct when dequeued. See the documentation of `v4l2_buffer` and each coded pixel format for exact list of flags and their meanings.

---

Should an encoding error occur, it will be reported to the client with the level of details depending on the encoder capabilities. Specifically:

- the CAPTURE buffer (if any) that contains the results of the failed encode operation will be returned with the `V4L2_BUF_FLAG_ERROR` flag set,
  - if the encoder is able to precisely report the OUTPUT buffer(s) that triggered the error, such buffer(s) will be returned with the `V4L2_BUF_FLAG_ERROR` flag set.
- 

**Note:** If a CAPTURE buffer is too small then it is just returned with the `V4L2_BUF_FLAG_ERROR` flag set. More work is needed to detect that this error occurred because the buffer was too small, and to provide support to free existing buffers that were too small.

---

In case of a fatal failure that does not allow the encoding to continue, any further operations on corresponding encoder file handle will return the `-EIO` error code. The client may close the file handle and open a new one, or alternatively reinitialize the instance by stopping streaming on both queues, releasing all buffers and performing the Initialization sequence again.

## Encoding Parameter Changes

The client is allowed to use `VIDIOC_S_CTRL()` to change encoder parameters at any time. The availability of parameters is encoder-specific and the client must query the encoder to find the set of available controls.

The ability to change each parameter during encoding is encoder-specific, as per the standard semantics of the V4L2 control interface. The client may attempt to set a control during encoding and if the operation fails with the `-EBUSY` error code, the CAPTURE queue needs to be stopped for the configuration change to be allowed. To do this, it may follow the *Drain* sequence to avoid losing the already queued/encoded frames.

The timing of parameter updates is encoder-specific, as per the standard semantics of the V4L2 control interface. If the client needs to apply the parameters exactly at specific frame, using the Request API ([Request API](#)) should be considered, if supported by the encoder.

## Drain

To ensure that all the queued OUTPUT buffers have been processed and the related CAPTURE buffers are given to the client, the client must follow the drain sequence described below. After the drain sequence ends, the client has received all encoded frames for all OUTPUT buffers queued before the sequence was started.

1. Begin the drain sequence by issuing VIDIOC\_ENCODER\_CMD().

- **Required fields:**

**cmd**

set to V4L2\_ENC\_CMD\_STOP.

**flags**

set to 0.

**pts**

set to 0.

**Warning:** The sequence can be only initiated if both OUTPUT and CAPTURE queues are streaming. For compatibility reasons, the call to VIDIOC\_ENCODER\_CMD() will not fail even if any of the queues is not streaming, but at the same time it will not initiate the *Drain* sequence and so the steps described below would not be applicable.

2. Any OUTPUT buffers queued by the client before the VIDIOC\_ENCODER\_CMD() was issued will be processed and encoded as normal. The client must continue to handle both queues independently, similarly to normal encode operation. This includes:

- queuing and dequeuing CAPTURE buffers, until a buffer marked with the V4L2\_BUF\_FLAG\_LAST flag is dequeued,

**Warning:** The last buffer may be empty (with v4l2\_buffer.bytesused = 0) and in that case it must be ignored by the client, as it does not contain an encoded frame.

---

**Note:** Any attempt to dequeue more CAPTURE buffers beyond the buffer marked with V4L2\_BUF\_FLAG\_LAST will result in a -EPIPE error from VIDIOC\_DQBUF().

---

- dequeuing processed OUTPUT buffers, until all the buffers queued before the V4L2\_ENC\_CMD\_STOP command are dequeued,
- dequeuing the V4L2\_EVENT\_EOS event, if the client subscribes to it.

---

**Note:** For backwards compatibility, the encoder will signal a V4L2\_EVENT\_EOS event when the last frame has been encoded and all frames are ready to be dequeued. It is deprecated behavior and the client must not rely on it. The V4L2\_BUF\_FLAG\_LAST buffer flag should be used instead.

---

3. Once all OUTPUT buffers queued before the V4L2\_ENC\_CMD\_STOP call are dequeued and the last CAPTURE buffer is dequeued, the encoder is stopped and it will accept, but not process any newly queued OUTPUT buffers until the client issues any of the following operations:

- V4L2\_ENC\_CMD\_START - the encoder will not be reset and will resume operation normally, with all the state from before the drain,
- a pair of VIDIOC\_STREAMOFF() and VIDIOC\_STREAMON() on the CAPTURE queue - the encoder will be reset (see the *Reset* sequence) and then resume encoding,
- a pair of VIDIOC\_STREAMOFF() and VIDIOC\_STREAMON() on the OUTPUT queue - the encoder will resume operation normally, however any source frames queued to the OUTPUT queue between V4L2\_ENC\_CMD\_STOP and VIDIOC\_STREAMOFF() will be discarded.

---

**Note:** Once the drain sequence is initiated, the client needs to drive it to completion, as described by the steps above, unless it aborts the process by issuing VIDIOC\_STREAMOFF() on any of the OUTPUT or CAPTURE queues. The client is not allowed to issue V4L2\_ENC\_CMD\_START or V4L2\_ENC\_CMD\_STOP again while the drain sequence is in progress and they will fail with -EBUSY error code if attempted.

For reference, handling of various corner cases is described below:

- In case of no buffer in the OUTPUT queue at the time the V4L2\_ENC\_CMD\_STOP command was issued, the drain sequence completes immediately and the encoder returns an empty CAPTURE buffer with the V4L2\_BUF\_FLAG\_LAST flag set.
- In case of no buffer in the CAPTURE queue at the time the drain sequence completes, the next time the client queues a CAPTURE buffer it is returned at once as an empty buffer with the V4L2\_BUF\_FLAG\_LAST flag set.
- If VIDIOC\_STREAMOFF() is called on the CAPTURE queue in the middle of the drain sequence, the drain sequence is canceled and all CAPTURE buffers are implicitly returned to the client.
- If VIDIOC\_STREAMOFF() is called on the OUTPUT queue in the middle of the drain sequence, the drain sequence completes immediately and next CAPTURE buffer will be returned empty with the V4L2\_BUF\_FLAG\_LAST flag set.

Although not mandatory, the availability of encoder commands may be queried using VIDIOC\_TRY\_ENCODER\_CMD().

---

## Reset

The client may want to request the encoder to reinitialize the encoding, so that the following stream data becomes independent from the stream data generated before. Depending on the coded format, that may imply that:

- encoded frames produced after the restart must not reference any frames produced before the stop, e.g. no long term references for H.264/HEVC,
- any headers that must be included in a standalone stream must be produced again, e.g. SPS and PPS for H.264/HEVC.

This can be achieved by performing the reset sequence.

1. Perform the *Drain* sequence to ensure all the in-flight encoding finishes and respective buffers are dequeued.
2. Stop streaming on the CAPTURE queue via VIDIOC\_STREAMOFF(). This will return all currently queued CAPTURE buffers to the client, without valid frame data.
3. Start streaming on the CAPTURE queue via VIDIOC\_STREAMON() and continue with regular encoding sequence. The encoded frames produced into CAPTURE buffers from now on will contain a standalone stream that can be decoded without the need for frames encoded before the reset sequence, starting at the first OUTPUT buffer queued after issuing the V4L2\_ENC\_CMD\_STOP of the *Drain* sequence.

This sequence may be also used to change encoding parameters for encoders without the ability to change the parameters on the fly.

### Commit Points

Setting formats and allocating buffers triggers changes in the behavior of the encoder.

1. Setting the format on the CAPTURE queue may change the set of formats supported/advertised on the OUTPUT queue. In particular, it also means that the OUTPUT format may be reset and the client must not rely on the previously set format being preserved.
2. Enumerating formats on the OUTPUT queue always returns only formats supported for the current CAPTURE format.
3. Setting the format on the OUTPUT queue does not change the list of formats available on the CAPTURE queue. An attempt to set the OUTPUT format that is not supported for the currently selected CAPTURE format will result in the encoder adjusting the requested OUTPUT format to a supported one.
4. Enumerating formats on the CAPTURE queue always returns the full set of supported coded formats, irrespective of the current OUTPUT format.
5. While buffers are allocated on any of the OUTPUT or CAPTURE queues, the client must not change the format on the CAPTURE queue. Drivers will return the -EBUSY error code for any such format change attempt.

To summarize, setting formats and allocation must always start with the CAPTURE queue and the CAPTURE queue is the master that governs the set of supported formats for the OUTPUT queue.

### Memory-to-memory Stateless Video Decoder Interface

A stateless decoder is a decoder that works without retaining any kind of state between processed frames. This means that each frame is decoded independently of any previous and future frames, and that the client is responsible for maintaining the decoding state and providing it to the decoder with each decoding request. This is in contrast to the stateful video decoder interface, where the hardware and driver maintain the decoding state and all the client has to do is to provide the raw encoded stream and dequeue decoded frames in display order.

This section describes how user-space ("the client") is expected to communicate with stateless decoders in order to successfully decode an encoded stream. Compared to stateful codecs, the decoder/client sequence is simpler, but the cost of this simplicity is extra complexity in the client which is responsible for maintaining a consistent decoding state.

Stateless decoders make use of the *Request API*. A stateless decoder must expose the V4L2\_BUF\_CAP\_SUPPORTS\_REQUESTS capability on its OUTPUT queue when VIDIOC\_REQBUFS() or VIDIOC\_CREATE\_BUFS() are invoked.

Depending on the encoded formats supported by the decoder, a single decoded frame may be the result of several decode requests (for instance, H.264 streams with multiple slices per frame). Decoders that support such formats must also expose the V4L2\_BUF\_CAP\_SUPPORTS\_M2M\_HOLD\_CAPTURE\_BUF capability on their OUTPUT queue.

## Querying capabilities

1. To enumerate the set of coded formats supported by the decoder, the client calls VIDIOC\_ENUM\_FMT() on the OUTPUT queue.
  - The driver must always return the full set of supported OUTPUT formats, irrespective of the format currently set on the CAPTURE queue.
  - Simultaneously, the driver must restrain the set of values returned by codec-specific capability controls (such as H.264 profiles) to the set actually supported by the hardware.
2. To enumerate the set of supported raw formats, the client calls VIDIOC\_ENUM\_FMT() on the CAPTURE queue.
  - The driver must return only the formats supported for the format currently active on the OUTPUT queue.
  - Depending on the currently set OUTPUT format, the set of supported raw formats may depend on the value of some codec-dependent controls. The client is responsible for making sure that these controls are set before querying the CAPTURE queue. Failure to do so will result in the default values for these controls being used, and a returned set of formats that may not be usable for the media the client is trying to decode.
3. The client may use VIDIOC\_ENUM\_FRAMESIZES() to detect supported resolutions for a given format, passing desired pixel format in v4l2\_frmsizeenum's pixel\_format.
4. Supported profiles and levels for the current OUTPUT format, if applicable, may be queried using their respective controls via VIDIOC\_QUERYCTRL().

## Initialization

1. Set the coded format on the OUTPUT queue via VIDIOC\_S\_FMT().

- **Required fields:**

**type**

a V4L2\_BUF\_TYPE\_\* enum appropriate for OUTPUT.

**pixelformat**

a coded pixel format.

**width, height**

coded width and height parsed from the stream.

**other fields**

follow standard semantics.

---

**Note:** Changing the OUTPUT format may change the currently set CAPTURE format. The driver will derive a new CAPTURE format from the OUTPUT format being set, including resolution, colorimetry parameters, etc. If the client needs a specific CAPTURE format, it must adjust it afterwards.

---

2. Call VIDIOC\_S\_EXT\_CTRLS() to set all the controls (parsed headers, etc.) required by the OUTPUT format to enumerate the CAPTURE formats.
3. Call VIDIOC\_G\_FMT() for CAPTURE queue to get the format for the destination buffers parsed/decoded from the bytearray.

- **Required fields:**

**type**

a V4L2\_BUF\_TYPE\_\* enum appropriate for CAPTURE.

- **Returned fields:**

**width, height**

frame buffer resolution for the decoded frames.

**pixelformat**

pixel format for decoded frames.

**num\_planes (for \_MPLANE type only)**

number of planes for pixelformat.

**sizeimage, bytesperline**

as per standard semantics; matching frame buffer format.

---

**Note:** The value of pixelformat may be any pixel format supported for the OUTPUT format, based on the hardware capabilities. It is suggested that the driver chooses the preferred/optimal format for the current configuration. For example, a YUV format may be preferred over an RGB format, if an additional conversion step would be required for RGB.

---

4. [optional] Enumerate CAPTURE formats via VIDIOC\_ENUM\_FMT() on the CAPTURE queue. The client may use this ioctl to discover which alternative raw formats are supported for the current OUTPUT format and select one of them via VIDIOC\_S\_FMT().

---

**Note:** The driver will return only formats supported for the currently selected OUTPUT format and currently set controls, even if more formats may be supported by the decoder in general.

For example, a decoder may support YUV and RGB formats for resolutions 1920x1088 and lower, but only YUV for higher resolutions (due to hardware limitations). After setting a resolution of 1920x1088 or lower as the OUTPUT format, VIDIOC\_ENUM\_FMT() may return a set of YUV and RGB pixel formats, but after setting a resolution higher than 1920x1088, the driver will not return RGB pixel formats, since they are unsupported for this resolution.

---

5. [optional] Choose a different CAPTURE format than suggested via VIDIOC\_S\_FMT() on CAPTURE queue. It is possible for the client to choose a different format than selected/suggested by the driver in VIDIOC\_G\_FMT().

- **Required fields:**

**type**

a V4L2\_BUF\_TYPE\_\* enum appropriate for CAPTURE.

**pixelformat**

a raw pixel format.

**width, height**

frame buffer resolution of the decoded stream; typically unchanged from what was returned with VIDIOC\_G\_FMT(), but it may be different if the hardware supports composition and/or scaling.

After performing this step, the client must perform step 3 again in order to obtain up-to-date information about the buffers size and layout.

6. Allocate source (bytestream) buffers via VIDIOC\_REQBUFS() on OUTPUT queue.

- **Required fields:**

**count**

requested number of buffers to allocate; greater than zero.

**type**

a V4L2\_BUF\_TYPE\_\* enum appropriate for OUTPUT.

**memory**

follows standard semantics.

- **Returned fields:**

**count**

actual number of buffers allocated.

- If required, the driver will adjust count to be equal or bigger to the minimum of required number of OUTPUT buffers for the given format and requested count. The client must check this value after the ioctl returns to get the actual number of buffers allocated.

7. Allocate destination (raw format) buffers via VIDIOC\_REQBUFS() on the CAPTURE queue.

- **Required fields:**

**count**

requested number of buffers to allocate; greater than zero. The client is responsible for deducing the minimum number of buffers required for the stream to be properly decoded (taking e.g. reference frames into account) and pass an equal or bigger number.

**type**

a V4L2\_BUF\_TYPE\_\* enum appropriate for CAPTURE.

**memory**

follows standard semantics. V4L2\_MEMORY\_USERPTR is not supported for CAPTURE buffers.

- **Returned fields:**

**count**

adjusted to allocated number of buffers, in case the codec requires more buffers than requested.

- The driver must adjust count to the minimum of required number of CAPTURE buffers for the current format, stream configuration and requested count. The client must check this value after the ioctl returns to get the number of buffers allocated.
8. **Allocate requests (likely one per OUTPUT buffer) via `MEDIA_IOC_REQUEST_ALLOC()` on the media device.**
  9. **Start streaming on both OUTPUT and CAPTURE queues via `VIDIOC_STREAMON()`.**

## Decoding

For each frame, the client is responsible for submitting at least one request to which the following is attached:

- The amount of encoded data expected by the codec for its current configuration, as a buffer submitted to the OUTPUT queue. Typically, this corresponds to one frame worth of encoded data, but some formats may allow (or require) different amounts per unit.
- All the metadata needed to decode the submitted encoded data, in the form of controls relevant to the format being decoded.

The amount of data and contents of the source OUTPUT buffer, as well as the controls that must be set on the request, depend on the active coded pixel format and might be affected by codec-specific extended controls, as stated in documentation of each format.

If there is a possibility that the decoded frame will require one or more decode requests after the current one in order to be produced, then the client must set the `V4L2_BUF_FLAG_M2M_HOLD_CAPTURE_BUF` flag on the OUTPUT buffer. This will result in the (potentially partially) decoded CAPTURE buffer not being made available for dequeuing, and reused for the next decode request if the timestamp of the next OUTPUT buffer has not changed.

A typical frame would thus be decoded using the following sequence:

1. Queue an OUTPUT buffer containing one unit of encoded bytestream data for the decoding request, using `VIDIOC_QBUF()`.

- **Required fields:**

**index**

index of the buffer being queued.

**type**

type of the buffer.

**bytesused**

number of bytes taken by the encoded data frame in the buffer.

**flags**

the `V4L2_BUF_FLAG_REQUEST_FD` flag must be set. Additionally, if we are not sure that the current decode request is the last one needed to produce a fully decoded frame, then `V4L2_BUF_FLAG_M2M_HOLD_CAPTURE_BUF` must also be set.

**request\_fd**

must be set to the file descriptor of the decoding request.

**timestamp**

must be set to a unique value per frame. This value will be propagated into the

decoded frame's buffer and can also be used to use this frame as the reference of another. If using multiple decode requests per frame, then the timestamps of all the OUTPUT buffers for a given frame must be identical. If the timestamp changes, then the currently held CAPTURE buffer will be made available for dequeuing and the current request will work on a new CAPTURE buffer.

2. Set the codec-specific controls for the decoding request, using VIDIOC\_S\_EXT\_CTRLS().

- **Required fields:**

**which**

must be V4L2\_CTRL WHICH\_REQUEST\_VAL.

**request\_fd**

must be set to the file descriptor of the decoding request.

**other fields**

other fields are set as usual when setting controls. The controls array must contain all the codec-specific controls required to decode a frame.

---

**Note:** It is possible to specify the controls in different invocations of VIDIOC\_S\_EXT\_CTRLS(), or to overwrite a previously set control, as long as request\_fd and which are properly set. The controls state at the moment of request submission is the one that will be considered.

---

**Note:** The order in which steps 1 and 2 take place is interchangeable.

3. Submit the request by invoking MEDIA\_REQUEST\_IOC\_QUEUE() on the request FD.

If the request is submitted without an OUTPUT buffer, or if some of the required controls are missing from the request, then MEDIA\_REQUEST\_IOC\_QUEUE() will return -ENOENT. If more than one OUTPUT buffer is queued, then it will return -EINVAL. MEDIA\_REQUEST\_IOC\_QUEUE() returning non-zero means that no CAPTURE buffer will be produced for this request.

CAPTURE buffers must not be part of the request, and are queued independently. They are returned in decode order (i.e. the same order as coded frames were submitted to the OUTPUT queue).

Runtime decoding errors are signaled by the dequeued CAPTURE buffers carrying the V4L2\_BUF\_FLAG\_ERROR flag. If a decoded reference frame has an error, then all following decoded frames that refer to it also have the V4L2\_BUF\_FLAG\_ERROR flag set, although the decoder will still try to produce (likely corrupted) frames.

## Buffer management while decoding

Contrary to stateful decoders, a stateless decoder does not perform any kind of buffer management: it only guarantees that dequeued CAPTURE buffers can be used by the client for as long as they are not queued again. "Used" here encompasses using the buffer for compositing or display.

A dequeued capture buffer can also be used as the reference frame of another buffer.

A frame is specified as reference by converting its timestamp into nanoseconds, and storing it into the relevant member of a codec-dependent control structure. The `v4l2_timeval_to_ns()` function must be used to perform that conversion. The timestamp of a frame can be used to reference it as soon as all its units of encoded data are successfully submitted to the OUTPUT queue.

A decoded buffer containing a reference frame must not be reused as a decoding target until all the frames referencing it have been decoded. The safest way to achieve this is to refrain from queueing a reference buffer until all the decoded frames referencing it have been dequeued. However, if the driver can guarantee that buffers queued to the CAPTURE queue are processed in queued order, then user-space can take advantage of this guarantee and queue a reference buffer when the following conditions are met:

1. All the requests for frames affected by the reference frame have been queued, and
2. A sufficient number of CAPTURE buffers to cover all the decoded referencing frames have been queued.

When queuing a decoding request, the driver will increase the reference count of all the resources associated with reference frames. This means that the client can e.g. close the DMABUF file descriptors of reference frame buffers if it won't need them afterwards.

## Seeking

In order to seek, the client just needs to submit requests using input buffers corresponding to the new stream position. It must however be aware that resolution may have changed and follow the dynamic resolution change sequence in that case. Also depending on the codec used, picture parameters (e.g. SPS/PPS for H.264) may have changed and the client is responsible for making sure that a valid state is sent to the decoder.

The client is then free to ignore any returned CAPTURE buffer that comes from the pre-seek position.

## Pausing

In order to pause, the client can just cease queuing buffers onto the OUTPUT queue. Without source bytestream data, there is no data to process and the codec will remain idle.

## Dynamic resolution change

If the client detects a resolution change in the stream, it will need to perform the initialization sequence again with the new resolution:

1. If the last submitted request resulted in a CAPTURE buffer being held by the use of the V4L2\_BUF\_FLAG\_M2M\_HOLD\_CAPTURE\_BUF flag, then the last frame is not available on the CAPTURE queue. In this case, a V4L2\_DEC\_CMD\_FLUSH command shall be sent. This will make the driver dequeue the held CAPTURE buffer.
2. Wait until all submitted requests have completed and dequeue the corresponding output buffers.
3. Call VIDIOC\_STREAMOFF() on both the OUTPUT and CAPTURE queues.
4. Free all CAPTURE buffers by calling VIDIOC\_REQBUFS() on the CAPTURE queue with a buffer count of zero.
5. Perform the initialization sequence again (minus the allocation of OUTPUT buffers), with the new resolution set on the OUTPUT queue. Note that due to resolution constraints, a different format may need to be picked on the CAPTURE queue.

## Drain

If the last submitted request resulted in a CAPTURE buffer being held by the use of the V4L2\_BUF\_FLAG\_M2M\_HOLD\_CAPTURE\_BUF flag, then the last frame is not available on the CAPTURE queue. In this case, a V4L2\_DEC\_CMD\_FLUSH command shall be sent. This will make the driver dequeue the held CAPTURE buffer.

After that, in order to drain the stream on a stateless decoder, the client just needs to wait until all the submitted requests are completed.

## Raw VBI Data Interface

VBI is an abbreviation of Vertical Blanking Interval, a gap in the sequence of lines of an analog video signal. During VBI no picture information is transmitted, allowing some time while the electron beam of a cathode ray tube TV returns to the top of the screen. Using an oscilloscope you will find here the vertical synchronization pulses and short data packages ASK modulated<sup>1</sup> onto the video signal. These are transmissions of services such as Teletext or Closed Caption.

Subject of this interface type is raw VBI data, as sampled off a video signal, or to be added to a signal for output. The data format is similar to uncompressed video images, a number of lines times a number of samples per line, we call this a VBI image.

Conventionally V4L2 VBI devices are accessed through character device special files named /dev/vbi and /dev/vbi0 to /dev/vbi31 with major number 81 and minor numbers 224 to 255. /dev/vbi is typically a symbolic link to the preferred VBI device. This convention applies to both input and output devices.

To address the problems of finding related video and VBI devices VBI capturing and output is also available as device function under /dev/video. To capture or output raw VBI data with these devices applications must call the VIDIOC\_S\_FMT ioctl. Accessed as /dev/vbi, raw VBI capturing or output is the default device function.

<sup>1</sup> ASK: Amplitude-Shift Keying. A high signal level represents a '1' bit, a low level a '0' bit.

## Querying Capabilities

Devices supporting the raw VBI capturing or output API set the V4L2\_CAP\_VBI\_CAPTURE or V4L2\_CAP\_VBI\_OUTPUT flags, respectively, in the capabilities field of struct `v4l2_capability` returned by the `ioctl VIDIOC_QUERYCAP` ioctl. At least one of the read/write or streaming I/O methods must be supported. VBI devices may or may not have a tuner or modulator.

## Supplemental Functions

VBI devices shall support *video input or output, tuner or modulator*, and *controls* ioctls as needed. The *video standard* ioctls provide information vital to program a VBI device, therefore must be supported.

### Raw VBI Format Negotiation

Raw VBI sampling abilities can vary, in particular the sampling frequency. To properly interpret the data V4L2 specifies an ioctl to query the sampling parameters. Moreover, to allow for some flexibility applications can also suggest different parameters.

As usual these parameters are *not* reset at `open()` time to permit Unix tool chains, programming a device and then reading from it as if it was a plain file. Well written V4L2 applications should always ensure they really get what they want, requesting reasonable parameters and then checking if the actual parameters are suitable.

To query the current raw VBI capture parameters applications set the type field of a struct `v4l2_format` to V4L2\_BUF\_TYPE\_VBI\_CAPTURE or V4L2\_BUF\_TYPE\_VBI\_OUTPUT, and call the `VIDIOC_G_FMT` ioctl with a pointer to this structure. Drivers fill the struct `v4l2_vbi_format` vbi member of the fmt union.

To request different parameters applications set the type field of a struct `v4l2_format` as above and initialize all fields of the struct `v4l2_vbi_format` vbi member of the fmt union, or better just modify the results of `VIDIOC_G_FMT`, and call the `VIDIOC_S_FMT` ioctl with a pointer to this structure. Drivers return an EINVAL error code only when the given parameters are ambiguous, otherwise they modify the parameters according to the hardware capabilities and return the actual parameters. When the driver allocates resources at this point, it may return an EBUSY error code to indicate the returned parameters are valid but the required resources are currently not available. That may happen for instance when the video and VBI areas to capture would overlap, or when the driver supports multiple opens and another process already requested VBI capturing or output. Anyway, applications must expect other resource allocation points which may return EBUSY, at the `ioctl VIDIOC_STREAMON`, `VIDIOC_STREAMOFF` ioctl and the first `read()`, `write()` and `select()` calls.

VBI devices must implement both the `VIDIOC_G_FMT` and `VIDIOC_S_FMT` ioctl, even if `VIDIOC_S_FMT` ignores all requests and always returns default parameters as `VIDIOC_G_FMT` does. `VIDIOC_TRY_FMT` is optional.

type `v4l2_vbi_format`

Table 133: struct `v4l2_vbi_format`

<code>_u32</code>	<code>sampling_rate</code>	Samples per second, i. e. unit 1 Hz.
		continues on next page

Table 133 – continued from previous page

<code>_u32</code>	<code>offset</code>	Horizontal offset of the VBI image, relative to the leading edge of the line synchronization pulse and counted in samples: The first sample in the VBI image will be located <code>offset / sampling_rate</code> seconds following the leading edge. See also <i>Figure 4.1. Line synchronization</i> .
<code>_u32</code>	<code>samples_per_line</code>	
<code>_u32</code>	<code>sample_format</code>	Defines the sample format as in <i>Image Formats</i> , a four-character-code. <sup>2</sup> Usually this is <code>V4L2_PIX_FMT_GREY</code> , i. e. each sample consists of 8 bits with lower values oriented towards the black level. Do not assume any other correlation of values with the signal level. For example, the MSB does not necessarily indicate if the signal is 'high' or 'low' because 128 may not be the mean value of the signal. Drivers shall not convert the sample format by software.
<code>_u32</code>	<code>start</code> <sup>Page 491, 2</sup>	This is the scanning system line number associated with the first line of the VBI image, of the first and the second field respectively. See <i>Figure 4.2. ITU-R 525 line numbering (M/NTSC and M/PAL)</i> and <i>Figure 4.3. ITU-R 625 line numbering</i> for valid values. The <code>V4L2_VBI_ITU_525_F1_START</code> , <code>V4L2_VBI_ITU_525_F2_START</code> , <code>V4L2_VBI_ITU_625_F1_START</code> and <code>V4L2_VBI_ITU_625_F2_START</code> defines give the start line numbers for each field for each 525 or 625 line format as a convenience. Don't forget that ITU line numbering starts at 1, not 0. VBI input drivers can return start values 0 if the hardware cannot reliable identify scanning lines, VBI acquisition may not require this information.
<code>_u32</code>	<code>count</code> <sup>2</sup>	The number of lines in the first and second field image, respectively.

Drivers should be as flexible as possible. For example, it may be possible to extend or move the VBI capture window down to the picture area, implementing a 'full field mode' to capture data service transmissions embedded in the picture.

An application can set the first or second count value to zero if no data is required from the respective field; `count[1]` if the scanning system is progressive, i. e. not interlaced. The corresponding start value shall be ignored by the application and driver. Anyway, drivers may not support single field capturing and return both count values non-zero.

Both count values set to zero, or line numbers are outside the bounds depicted<sup>4</sup>, or a field image covering lines of two fields, are invalid and shall not be returned by the driver.

To initialize the `start` and `count` fields, applications must first determine the current video standard selection. The `v4l2_std_id` or the `framelines` field of struct `v4l2_standard` can be evaluated for this purpose.

<code>_u32</code>	<code>flags</code>	See <i>Raw VBI Format Flags</i> below. Currently only drivers set flags, applications must set this field to zero.
<code>_u32</code>	<code>reserved</code> <sup>2</sup>	This array is reserved for future extensions. Drivers and applications must set it to zero.

<sup>2</sup> A few devices may be unable to sample VBI data at all but can extend the video capture window to the VBI region.

<sup>4</sup> The valid values ar shown at *Figure 4.2. ITU-R 525 line numbering (M/NTSC and M/PAL)* and *Figure 4.3. ITU-R 625 line numbering*.

Table 134: Raw VBI Format Flags

V4L2_VBI_UNSYNC	0x0001	This flag indicates hardware which does not properly distinguish between fields. Normally the VBI image stores the first field (lower scanning line numbers) first in memory. This may be a top or bottom field depending on the video standard. When this flag is set the first or second field may be stored first, however the fields are still in correct temporal order with the older field first in memory. <sup>3</sup>
V4L2_VBI_INTERLACED	0x0002	By default the two field images will be passed sequentially; all lines of the first field followed by all lines of the second field (compare <i>Field Order</i> V4L2_FIELD_SEQ_TB and V4L2_FIELD_SEQ_BT, whether the top or bottom field is first in memory depends on the video standard). When this flag is set, the two fields are interlaced (cf. V4L2_FIELD_INTERLACED). The first line of the first field followed by the first line of the second field, then the two second lines, and so on. Such a layout may be necessary when the hardware has been programmed to capture or output interlaced video images and is unable to separate the fields for VBI capturing at the same time. For simplicity setting this flag implies that both count values are equal and non-zero.

Remember the VBI image format depends on the selected video standard, therefore the application must choose a new standard or query the current standard first. Attempts to read or write data ahead of format negotiation, or after switching the video standard which may invalidate the negotiated VBI parameters, should be refused by the driver. A format change during active I/O is not permitted.

## Reading and writing VBI images

To assure synchronization with the field number and easier implementation, the smallest unit of data passed at a time is one frame, consisting of two fields of VBI images immediately following in memory.

The total size of a frame computes as follows:

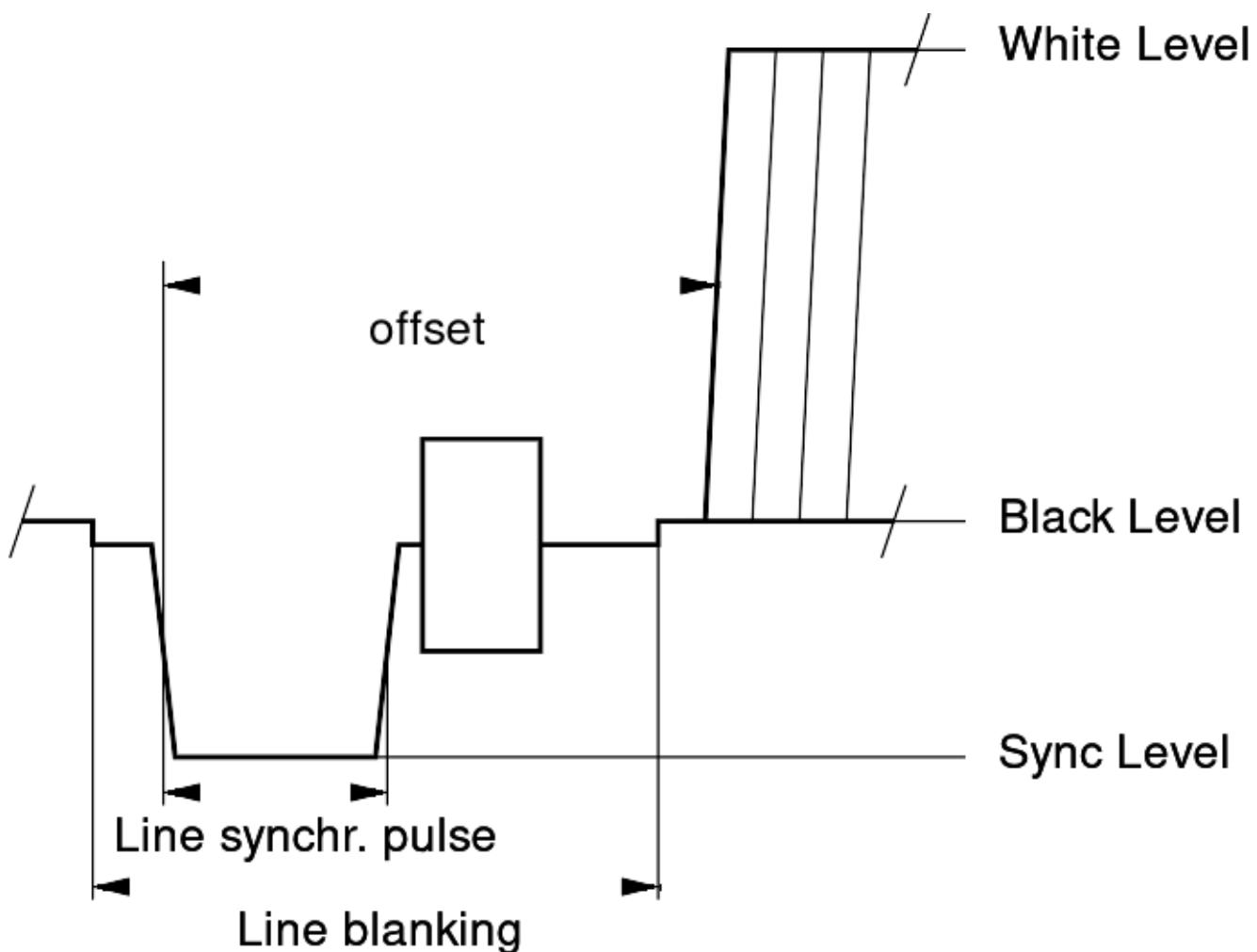
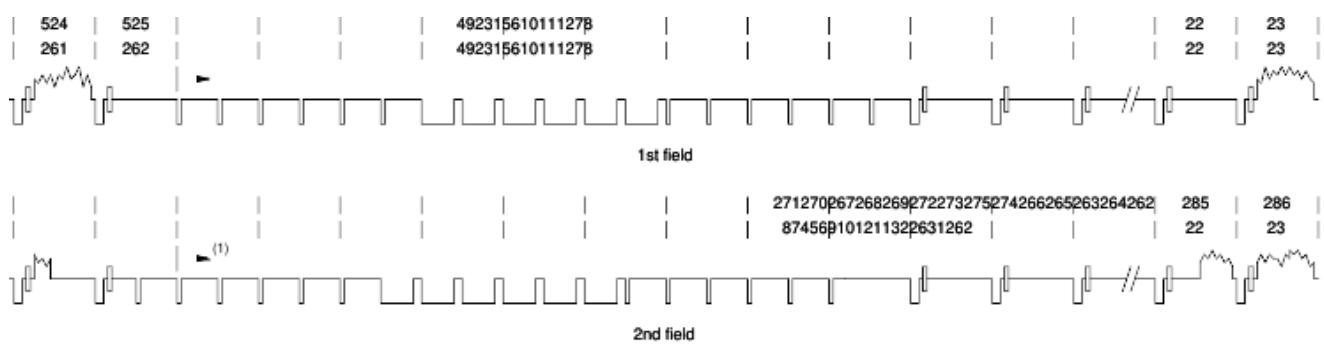
```
(count[0] + count[1]) * samples_per_line * sample size in bytes
```

The sample size is most likely always one byte, applications must check the `sample_format` field though, to function properly with other drivers.

A VBI device may support *read/write* and/or streaming (*memory mapping* or *user pointer*) I/O. The latter bears the possibility of synchronizing video and VBI data by using buffer timestamps.

Remember the `VIDIOC_STREAMON` ioctl and the first `read()`, `write()` and `select()` call can be resource allocation points returning an EBUSY error code if the required hardware resources are temporarily unavailable, for example the device is already in use by another process.

<sup>3</sup> Most VBI services transmit on both fields, but some have different semantics depending on the field number. These cannot be reliably decoded or encoded when `V4L2_VBI_UNSYNC` is set.

Fig. 10: **Figure 4.1. Line synchronization**Fig. 11: **Figure 4.2. ITU-R 525 line numbering (M/NTSC and M/PAL)**

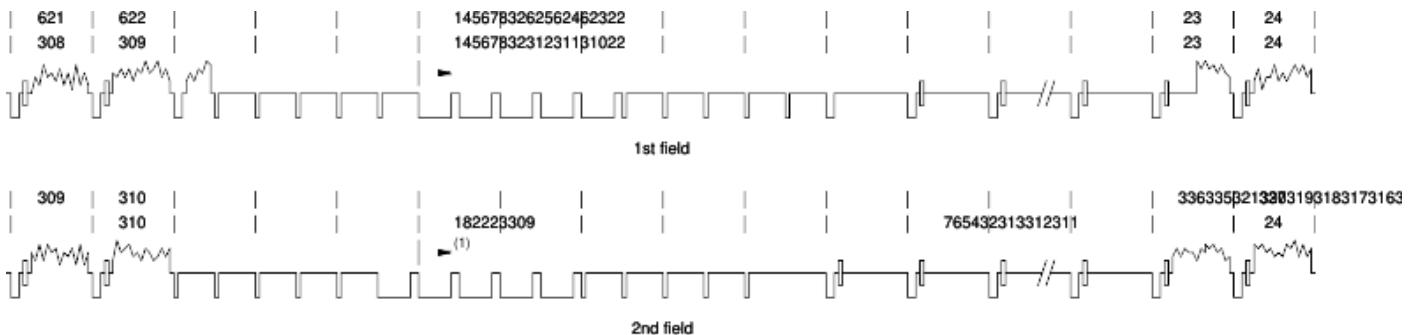


Fig. 12: **Figure 4.3. ITU-R 625 line numbering**

## Sliced VBI Data Interface

VBI stands for Vertical Blanking Interval, a gap in the sequence of lines of an analog video signal. During VBI no picture information is transmitted, allowing some time while the electron beam of a cathode ray tube TV returns to the top of the screen.

Sliced VBI devices use hardware to demodulate data transmitted in the VBI. V4L2 drivers shall *not* do this by software, see also the [raw VBI interface](#). The data is passed as short packets of fixed size, covering one scan line each. The number of packets per video frame is variable.

Sliced VBI capture and output devices are accessed through the same character special files as raw VBI devices. When a driver supports both interfaces, the default function of a `/dev/vbi` device is *raw* VBI capturing or output, and the sliced VBI function is only available after calling the [`VIDIOC\_S\_FMT`](#) ioctl as defined below. Likewise a `/dev/video` device may support the sliced VBI API, however the default function here is video capturing or output. Different file descriptors must be used to pass raw and sliced VBI data simultaneously, if this is supported by the driver.

## Querying Capabilities

Devices supporting the sliced VBI capturing or output API set the `V4L2_CAP_SLICED_VBI_CAPTURE` or `V4L2_CAP_SLICED_VBI_OUTPUT` flag respectively, in the `capabilities` field of struct `v4l2_capability` returned by the `ioctl VIDIOC_QUERYCAP` ioctl. At least one of the read/write or streaming [\*I/O methods\*](#) must be supported. Sliced VBI devices may have a tuner or modulator.

## Supplemental Functions

Sliced VBI devices shall support [\*video input or output\*](#) and [\*tuner or modulator\*](#) ioctls if they have these capabilities, and they may support [\*User Controls\*](#) ioctls. The [\*video standard\*](#) ioctls provide information vital to program a sliced VBI device, therefore must be supported.

## Sliced VBI Format Negotiation

To find out which data services are supported by the hardware applications can call the `VIDIOC_G_SLICED_VBI_CAP` ioctl. All drivers implementing the sliced VBI interface must support this ioctl. The results may differ from those of the `VIDIOC_S_FMT` ioctl when the number of VBI lines the hardware can capture or output per frame, or the number of services it can identify on a given line are limited. For example on PAL line 16 the hardware may be able to look for a VPS or Teletext signal, but not both at the same time.

To determine the currently selected services applications set the `type` field of struct `v4l2_format` to `V4L2_BUF_TYPE_SLICED_VBI_CAPTURE` or `V4L2_BUF_TYPE_SLICED_VBI_OUTPUT`, and the `VIDIOC_G_FMT` ioctl fills the `fmt.sliced` member, a struct `v4l2_sliced_vbi_format`.

Applications can request different parameters by initializing or modifying the `fmt.sliced` member and calling the `VIDIOC_S_FMT` ioctl with a pointer to the struct `v4l2_format` structure.

The sliced VBI API is more complicated than the raw VBI API because the hardware must be told which VBI service to expect on each scan line. Not all services may be supported by the hardware on all lines (this is especially true for VBI output where Teletext is often unsupported and other services can only be inserted in one specific line). In many cases, however, it is sufficient to just set the `service_set` field to the required services and let the driver fill the `service_lines` array according to hardware capabilities. Only if more precise control is needed should the programmer set the `service_lines` array explicitly.

The `VIDIOC_S_FMT` ioctl modifies the parameters according to hardware capabilities. When the driver allocates resources at this point, it may return an `EBUSY` error code if the required resources are temporarily unavailable. Other resource allocation points which may return `EBUSY` can be the ioctl `VIDIOC_STREAMON`, `VIDIOC_STREAMOFF` ioctl and the first `read()`, `write()` and `select()` call.

**type v4l2\_sliced\_vbi\_format**

**struct v4l2\_sliced\_vbi\_format**

<code>_u16 service_set</code>	If <code>service_set</code> is non-zero when passed with <code>VIDIOC_S_FMT</code> or <code>VIDIOC_TRY_FMT</code> , the <code>service_lines</code> array will be filled by the driver according to the services specified in this field. For example, if <code>service_set</code> is initialized with <code>V4L2_SLICED_TELETEXT_B   V4L2_SLICED_WSS_625</code> , a driver for the cx25840 video decoder sets lines 7-22 of both fields <sup>1</sup> to <code>V4L2_SLICED_TELETEXT_B</code> and line 23 of the first field to <code>V4L2_SLICED_WSS_625</code> . If <code>service_set</code> is set to zero, then the values of <code>service_lines</code> will be used instead. On return the driver sets this field to the union of all elements of the returned <code>service_lines</code> array. It may contain less services than requested, perhaps just one, if the hardware cannot handle more services simultaneously. It may be empty (zero) if none of the requested services are supported by the hardware.		
<code>_u16 service_lines[2][24]</code>	Applications initialize this array with sets of data services the driver shall look for or insert on the respective scan line. Subject to hardware capabilities drivers return the requested set, a subset, which may be just a single service, or an empty set. When the hardware cannot handle multiple services on the same line the driver shall choose one. No assumptions can be made on which service the driver chooses. Data services are defined in <a href="#">Sliced VBI services</a> . Array indices map to ITU-R line numbers <sup>2</sup> as follows:		
	Element	525 line systems	625 line systems
	<code>service_lines[0][1]</code>	1	1
	<code>service_lines[0][23]</code>	23	23
	<code>service_lines[1][1]</code>	264	314
	<code>service_lines[1][23]</code>	286	336

continues on next page

Table 135 – continued from previous page

		Drivers must set <code>service_lines[0][0]</code> and <code>service_lines[1][0]</code> to zero. The <code>V4L2_VBI_ITU_525_F1_START</code> , <code>V4L2_VBI_ITU_525_F2_START</code> , <code>V4L2_VBI_ITU_625_F1_START</code> and <code>V4L2_VBI_ITU_625_F2_START</code> defines give the start line numbers for each field for each 525 or 625 line format as a convenience. Don't forget that ITU line numbering starts at 1, not 0.
<code>_u32</code>	<code>io_size</code>	Maximum number of bytes passed by one <code>read()</code> or <code>write()</code> call, and the buffer size in bytes for the <code>ioctl VIDIOC_QBUF</code> , <code>VIDIOC_DQBUF</code> and <code>VIDIOC_DQBUF</code> ioctl. Drivers set this field to the size of struct <code>v4l2_sliced_vbi_data</code> times the number of non-zero elements in the returned <code>service_lines</code> array (that is the number of lines potentially carrying data).
<code>_u32</code>	<code>reserved[2]</code>	This array is reserved for future extensions. Applications and drivers must set it to zero.

## Sliced VBI services

Symbol	Value	Reference	Lines, usually	Payload
<code>V4L2_SLICED_TELETEXT_B</code> (Teletext System B)	0x0001	<a href="#">ETS 300 706, ITU BT.653</a>	PAL/SECAM line 7-22, 320-335 (second field 7-22)	Last 42 of the 45 byte Teletext packet, that is without clock run-in and framing code, lsb first transmitted.
<code>V4L2_SLICED_VPS</code>	0x0400	<a href="#">ETS 300 231</a>	PAL line 16	Byte number 3 to 15 according to Figure 9 of ETS 300 231, lsb first transmitted.
<code>V4L2_SLICED_CAPTION_525</code>	0x1000	<a href="#">CEA 608-E</a>	NTSC line 21, 284 (second field 21)	Two bytes in transmission order, including parity bit, lsb first transmitted.
<code>V4L2_SLICED_WSS_625</code>	0x4000	<a href="#">ITU BT.1119, EN 300 294</a>	PAL/SECAM line 23	See <a href="#">V4L2_SLICED_WSS_625 payload</a> below.
<code>V4L2_SLICED_VBI_525</code>	0x1000	Set of services applicable to 525 line systems.		
<code>V4L2_SLICED_VBI_625</code>	0x4401	Set of services applicable to 625 line systems.		

Drivers may return an `EINVAL` error code when applications attempt to read or write data without prior format negotiation, after switching the video standard (which may invalidate the negotiated VBI parameters) and after switching the video input (which may change the video standard as a side effect). The `VIDIOC_S_FMT` ioctl may return an `EBUSY` error code when applications attempt to change the format while i/o is in progress (between a `ioctl VIDIOC_STREAMON`, `VIDIOC_STREAMOFF` and `VIDIOC_STREAMOFF` call, and after the first `read()` or `write()` call).

## V4L2\_SLICED\_WSS\_625 payload

The payload for `V4L2_SLICED_WSS_625` is:

Byte	0								1							
Bit	msb				lsb				msb				lsb			
	7	6	5	4	3	2	1	0	x	x	13	12	11	10	9	8

<sup>1</sup> According to [ETS 300 706](#) lines 6-22 of the first field and lines 5-22 of the second field may carry Teletext data.

<sup>2</sup> See also [Figure 4.2. ITU-R 525 line numbering \(M/NTSC and M/PAL\)](#) and [Figure 4.3. ITU-R 625 line numbering](#).

## Reading and writing sliced VBI data

A single `read()` or `write()` call must pass all data belonging to one video frame. That is an array of struct `v4l2_sliced_vbi_data` structures with one or more elements and a total size not exceeding `io_size` bytes. Likewise in streaming I/O mode one buffer of `io_size` bytes must contain data of one video frame. The `id` of unused struct `v4l2_sliced_vbi_data` elements must be zero.

type `v4l2_sliced_vbi_data`

**struct v4l2\_sliced\_vbi\_data**

<code>_u32</code>	<code>id</code>	A flag from <i>Sliced VBI services</i> identifying the type of data in this packet. Only a single bit must be set. When the <code>id</code> of a captured packet is zero, the packet is empty and the contents of other fields are undefined. Applications shall ignore empty packets. When the <code>id</code> of a packet for output is zero the contents of the <code>data</code> field are undefined and the driver must no longer insert data on the requested field and line.
<code>_u32</code>	<code>field</code>	The video field number this data has been captured from, or shall be inserted at. 0 for the first field, 1 for the second field.
<code>_u32</code>	<code>line</code>	The field (as opposed to frame) line number this data has been captured from, or shall be inserted at. See <i>Figure 4.2. ITU-R 525 line numbering (M/NTSC and M/PAL)</i> and <i>Figure 4.3. ITU-R 625 line numbering</i> for valid values. Sliced VBI capture devices can set the line number of all packets to 0 if the hardware cannot reliably identify scan lines. The field number must always be valid.
<code>_u32</code>	<code>reserved</code>	This field is reserved for future extensions. Applications and drivers must set it to zero.
<code>_u8</code>	<code>data[48]</code>	The packet payload. See <i>Sliced VBI services</i> for the contents and number of bytes passed for each data type. The contents of padding bytes at the end of this array are undefined, drivers and applications shall ignore them.

Packets are always passed in ascending line number order, without duplicate line numbers. The `write()` function and the `ioctl VIDIOC_QBUF, VIDIOC_DQBUF` ioctl must return an `EINVAL` error code when applications violate this rule. They must also return an `EINVAL` error code when applications pass an incorrect field or line number, or a combination of `field`, `line` and `id` which has not been negotiated with the `VIDIOC_G_FMT` or `VIDIOC_S_FMT` ioctl. When the line numbers are unknown the driver must pass the packets in transmitted order. The driver can insert empty packets with `id` set to zero anywhere in the packet array.

To assure synchronization and to distinguish from frame dropping, when a captured frame does not carry any of the requested data services drivers must pass one or more empty packets. When an application fails to pass VBI data in time for output, the driver must output the last VPS and WSS packet again, and disable the output of Closed Caption and Teletext data, or output data which is ignored by Closed Caption and Teletext decoders.

A sliced VBI device may support `read/write` and/or streaming (`memory mapping` and/or `user pointer`) I/O. The latter bears the possibility of synchronizing video and VBI data by using buffer timestamps.

## Sliced VBI Data in MPEG Streams

If a device can produce an MPEG output stream, it may be capable of providing *negotiated sliced VBI services* as data embedded in the MPEG stream. Users or applications control this sliced VBI data insertion with the `V4L2_CID_MPEG_STREAM_VBI_FMT` control.

If the driver does not provide the `V4L2_CID_MPEG_STREAM_VBI_FMT` control, or only allows that control to be set to `V4L2_MPEG_STREAM_VBI_FMT_NONE`, then the device cannot embed sliced VBI data in the MPEG stream.

The `V4L2_CID_MPEG_STREAM_VBI_FMT` control does not implicitly set the device driver to capture nor cease capturing sliced VBI data. The control only indicates to embed sliced VBI data in the MPEG stream, if an application has negotiated sliced VBI service be captured.

It may also be the case that a device can embed sliced VBI data in only certain types of MPEG streams: for example in an MPEG-2 PS but not an MPEG-2 TS. In this situation, if sliced VBI data insertion is requested, the sliced VBI data will be embedded in MPEG stream types when supported, and silently omitted from MPEG stream types where sliced VBI data insertion is not supported by the device.

The following subsections specify the format of the embedded sliced VBI data.

### MPEG Stream Embedded, Sliced VBI Data Format: NONE

The `V4L2_MPEG_STREAM_VBI_FMT_NONE` embedded sliced VBI format shall be interpreted by drivers as a control to cease embedding sliced VBI data in MPEG streams. Neither the device nor driver shall insert "empty" embedded sliced VBI data packets in the MPEG stream when this format is set. No MPEG stream data structures are specified for this format.

### MPEG Stream Embedded, Sliced VBI Data Format: IVTV

The `V4L2_MPEG_STREAM_VBI_FMT_IVTV` embedded sliced VBI format, when supported, indicates to the driver to embed up to 36 lines of sliced VBI data per frame in an MPEG-2 *Private Stream 1 PES* packet encapsulated in an MPEG-2 *Program Pack* in the MPEG stream.

*Historical context:* This format specification originates from a custom, embedded, sliced VBI data format used by the `ivtv` driver. This format has already been informally specified in the kernel sources in the file `Documentation/userspace-api/media/drivers/cx2341x-uapi.rst`. The maximum size of the payload and other aspects of this format are driven by the CX23415 MPEG decoder's capabilities and limitations with respect to extracting, decoding, and displaying sliced VBI data embedded within an MPEG stream.

This format's use is *not* exclusive to the `ivtv` driver *nor* exclusive to CX2341x devices, as the sliced VBI data packet insertion into the MPEG stream is implemented in driver software. At least the `cx18` driver provides sliced VBI data insertion into an MPEG-2 PS in this format as well.

The following definitions specify the payload of the MPEG-2 *Private Stream 1 PES* packets that contain sliced VBI data when `V4L2_MPEG_STREAM_VBI_FMT_IVTV` is set. (The MPEG-2 *Private Stream 1 PES* packet header and encapsulating MPEG-2 *Program Pack* header are not detailed here. Please refer to the MPEG-2 specifications for details on those packet headers.)

The payload of the MPEG-2 *Private Stream 1 PES* packets that contain sliced VBI data is specified by struct `v4l2_mpeg_vbi_fmt_ivtv`. The payload is variable length, depending on the actual number of lines of sliced VBI data present in a video frame. The payload may be padded at the end with unspecified fill bytes to align the end of the payload to a 4-byte boundary. The payload shall never exceed 1552 bytes (2 fields with 18 lines/field with 43 bytes of data/line and a 4 byte magic number).

type `v4l2_mpeg_vbi_fmt_ivtv`

### `struct v4l2_mpeg_vbi_fmt_ivtv`

<code>_u8</code>	<code>magic[4]</code>	A "magic" constant from <i>Magic Constants for struct v4l2_mpeg_vbi_fmt_ivtv magic field</i> that indicates this is a valid sliced VBI data payload and also indicates which member of the anonymous union, <code>itv0</code> or <code>ITV0</code> , to use for the payload data.
union {	(anonymous)	
struct <code>v4l2_mpeg_vbi_itv0</code>	<code>itv0</code>	The primary form of the sliced VBI data payload that contains anywhere from 1 to 35 lines of sliced VBI data. Line masks are provided in this form of the payload indicating which VBI lines are provided.
struct <code>v4l2_mpeg_vbi_ITV0</code>	<code>ITV0</code>	An alternate form of the sliced VBI data payload used when 36 lines of sliced VBI data are present. No line masks are provided in this form of the payload; all valid line mask bits are implicitly set.
}		

### **Magic Constants for struct `v4l2_mpeg_vbi_fmt_ivtv` magic field**

Defined Symbol	Value	Description
<code>V4L2_MPEG_VBI_ITV0_MAGIC0</code>	"itv0"	Indicates the <code>itv0</code> member of the union in struct <code>v4l2_mpeg_vbi_fmt_ivtv</code> is valid.
<code>V4L2_MPEG_VBI_ITV0_MAGIC1</code>	"ITV0"	Indicates the <code>ITV0</code> member of the union in struct <code>v4l2_mpeg_vbi_fmt_ivtv</code> is valid and that 36 lines of sliced VBI data are present.

type `v4l2_mpeg_vbi_itv0`

type `v4l2_mpeg_vbi_ITV0`

**structs v4l2\_mpeg\_vbi\_itv0 and v4l2\_mpeg\_vbi\_ITV0**

<code>_le32</code>	<code>linemask[2]</code>	Bitmasks indicating the VBI service lines present. These linemask values are stored in little endian byte order in the MPEG stream. Some reference linemask bit positions with their corresponding VBI line number and video field are given below. $b_0$ indicates the least significant bit of a linemask value:  linemask[0] b0: line 6 first field linemask[0] b17: line 23 first field linemask[0] b18: line 6 second field linemask[0] b31: line 19 second field linemask[1] b0: line 20 second field linemask[1] b3: line 23 second field linemask[1] b4-b31: unused and set to 0
<code>struct v4l2_mpeg_vbi_itv0_line</code>	<code>line[35]</code>	This is a variable length array that holds from 1 to 35 lines of sliced VBI data. The sliced VBI data lines present correspond to the bits set in the linemask array, starting from $b_0$ of linemask[0] up through $b_{31}$ of linemask[0], and from $b_0$ of linemask[1] up through $b_3$ of linemask[1]. <code>line[0]</code> corresponds to the first bit found set in the linemask array, <code>line[1]</code> corresponds to the second bit found set in the linemask array, etc. If no linemask array bits are set, then <code>line[0]</code> may contain one line of unspecified data that should be ignored by applications.

**struct v4l2\_mpeg\_vbi\_ITV0**

<code>struct v4l2_mpeg_vbi_itv0_line</code>	<code>line[36]</code>	A fixed length array of 36 lines of sliced VBI data. <code>line[0]</code> through <code>line[17]</code> correspond to lines 6 through 23 of the first field. <code>line[18]</code> through <code>line[35]</code> corresponds to lines 6 through 23 of the second field.
---	-----------------------	---

**type v4l2\_mpeg\_vbi\_itv0\_line****struct v4l2\_mpeg\_vbi\_itv0\_line**

<code>_u8</code>	<code>id</code>	A line identifier value from <a href="#"><i>Line Identifiers for struct v4l2_mpeg_vbi_itv0_line id field</i></a> that indicates the type of sliced VBI data stored on this line.
<code>_u8</code>	<code>data[42]</code>	The sliced VBI data for the line.

## Line Identifiers for struct v4l2\_mpeg\_vbi\_itv0\_line id field

Defined Symbol	Value	Description
V4L2_MPEG_VBI_IVTV_TELETEXT_B	1	Refer to <a href="#">Sliced VBI services</a> for a description of the line payload.
V4L2_MPEG_VBI_IVTV_CAPTION_525	4	Refer to <a href="#">Sliced VBI services</a> for a description of the line payload.
V4L2_MPEG_VBI_IVTV_WSS_625	5	Refer to <a href="#">Sliced VBI services</a> for a description of the line payload.
V4L2_MPEG_VBI_IVTV_VPS	7	Refer to <a href="#">Sliced VBI services</a> for a description of the line payload.

## Radio Interface

This interface is intended for AM and FM (analog) radio receivers and transmitters.

Conventionally V4L2 radio devices are accessed through character device special files named /dev/radio and /dev/radio0 to /dev/radio63 with major number 81 and minor numbers 64 to 127.

## Querying Capabilities

Devices supporting the radio interface set the V4L2\_CAP\_RADIO and V4L2\_CAP\_TUNER or V4L2\_CAP\_MODULATOR flag in the capabilities field of struct v4l2\_capability returned by the ioctl [VIDIOC\\_QUERYCAP](#) ioctl. Other combinations of capability flags are reserved for future extensions.

## Supplemental Functions

Radio devices can support [controls](#), and must support the [tuner or modulator](#) ioctls.

They do not support the video input or output, audio input or output, video standard, cropping and scaling, compression and streaming parameter, or overlay ioctls. All other ioctls and I/O methods are reserved for future extensions.

## Programming

Radio devices may have a couple audio controls (as discussed in [User Controls](#)) such as a volume control, possibly custom controls. Further all radio devices have one tuner or modulator (these are discussed in [Tuners and Modulators](#)) with index number zero to select the radio frequency and to determine if a monaural or FM stereo program is received/emitted. Drivers switch automatically between AM and FM depending on the selected frequency. The [VIDIOC\\_G\\_TUNER](#) or [VIDIOC\\_G\\_MODULATOR](#) ioctl reports the supported frequency range.

## RDS Interface

The Radio Data System transmits supplementary information in binary format, for example the station name or travel information, on an inaudible audio subcarrier of a radio program. This interface is aimed at devices capable of receiving and/or transmitting RDS information.

For more information see the core RDS standard [IEC 62106](#) and the RBDS standard [NRSC-4-B](#).

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**Note:** Note that the RBDS standard as is used in the USA is almost identical to the RDS standard. Any RDS decoder/encoder can also handle RBDS. Only some of the fields have slightly different meanings. See the RBDS standard for more information.

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The RBDS standard also specifies support for MMBS (Modified Mobile Search). This is a proprietary format which seems to be discontinued. The RDS interface does not support this format. Should support for MMBS (or the so-called 'E blocks' in general) be needed, then please contact the linux-media mailing list: <https://linuxtv.org/lists.php>.

## Querying Capabilities

Devices supporting the RDS capturing API set the V4L2\_CAP\_RDS\_CAPTURE flag in the capabilities field of struct `v4l2_capability` returned by the `ioctl VIDIOC_QUERYCAP` ioctl. Any tuner that supports RDS will set the V4L2\_TUNER\_CAP\_RDS flag in the capability field of struct `v4l2_tuner`. If the driver only passes RDS blocks without interpreting the data the V4L2\_TUNER\_CAP\_RDS\_BLOCK\_IO flag has to be set, see [Reading RDS data](#). For future use the flag V4L2\_TUNER\_CAP\_RDS\_CONTROLS has also been defined. However, a driver for a radio tuner with this capability does not yet exist, so if you are planning to write such a driver you should discuss this on the linux-media mailing list: <https://linuxtv.org/lists.php>.

Whether an RDS signal is present can be detected by looking at the rxsubchans field of struct `v4l2_tuner`: the V4L2\_TUNER\_SUB\_RDS will be set if RDS data was detected.

Devices supporting the RDS output API set the V4L2\_CAP\_RDS\_OUTPUT flag in the capabilities field of struct `v4l2_capability` returned by the `ioctl VIDIOC_QUERYCAP` ioctl. Any modulator that supports RDS will set the V4L2\_TUNER\_CAP\_RDS flag in the capability field of struct `v4l2_modulator`. In order to enable the RDS transmission one must set the V4L2\_TUNER\_SUB\_RDS bit in the txsubchans field of struct `v4l2_modulator`. If the driver only passes RDS blocks without interpreting the data the V4L2\_TUNER\_CAP\_RDS\_BLOCK\_IO flag has to be set. If the tuner is capable of handling RDS entities like program identification codes and radio text, the flag V4L2\_TUNER\_CAP\_RDS\_CONTROLS should be set, see [Writing RDS data](#) and [FM Transmitter Control Reference](#).

## Reading RDS data

RDS data can be read from the radio device with the `read()` function. The data is packed in groups of three bytes.

## Writing RDS data

RDS data can be written to the radio device with the `write()` function. The data is packed in groups of three bytes, as follows:

### RDS datastructures

type `v4l2_rds_data`

Table 136: struct `v4l2_rds_data`

<code>__u8 lsb</code>	Least Significant Byte of RDS Block
<code>__u8 msb</code>	Most Significant Byte of RDS Block
<code>__u8 block</code>	Block description

Table 137: Block description

Bits 0-2	Block (aka offset) of the received data.
Bits 3-5	Deprecated. Currently identical to bits 0-2. Do not use these bits.
Bit 6	Corrected bit. Indicates that an error was corrected for this data block.
Bit 7	Error bit. Indicates that an uncorrectable error occurred during reception of this block.

Table 138: Block defines

<code>V4L2_RDS_BLOCK_MSK</code>		7	Mask for bits 0-2 to get the block ID.
<code>V4L2_RDS_BLOCK_A</code>		0	Block A.
<code>V4L2_RDS_BLOCK_B</code>		1	Block B.
<code>V4L2_RDS_BLOCK_C</code>		2	Block C.
<code>V4L2_RDS_BLOCK_D</code>		3	Block D.
<code>V4L2_RDS_BLOCK_C_ALT</code>		4	Block C'.
<code>V4L2_RDS_BLOCK_INVALID</code>	read-only	7	An invalid block.
<code>V4L2_RDS_BLOCK_CORRECTED</code>	read-only	0x40	A bit error was detected but corrected.
<code>V4L2_RDS_BLOCK_ERROR</code>	read-only	0x80	An uncorrectable error occurred.

### Software Defined Radio Interface (SDR)

SDR is an abbreviation of Software Defined Radio, the radio device which uses application software for modulation or demodulation. This interface is intended for controlling and data streaming of such devices.

SDR devices are accessed through character device special files named `/dev/swradio0` to `/dev/swradio255` with major number 81 and dynamically allocated minor numbers 0 to 255.

### Querying Capabilities

Devices supporting the SDR receiver interface set the `V4L2_CAP_SDR_CAPTURE` and `V4L2_CAP_TUNER` flag in the `capabilities` field of struct `v4l2_capability` returned by the [ioctl VIDIOC\\_QUERYCAP](#) ioctl. That flag means the device has an Analog to Digital Converter (ADC), which is a mandatory element for the SDR receiver.

Devices supporting the SDR transmitter interface set the `V4L2_CAP_SDR_OUTPUT` and `V4L2_CAP_MODULATOR` flag in the `capabilities` field of struct `v4l2_capability` returned by the [ioctl VIDIOC\\_QUERYCAP](#) ioctl. That flag means the device has an Digital to Analog Converter (DAC), which is a mandatory element for the SDR transmitter.

At least one of the read/write or streaming I/O methods must be supported.

### Supplemental Functions

SDR devices can support [controls](#), and must support the [Tuners and Modulators](#) ioctls. Tuner ioctls are used for setting the ADC/DAC sampling rate (sampling frequency) and the possible radio frequency (RF).

The `V4L2_TUNER_SDR` tuner type is used for setting SDR device ADC/DAC frequency, and the `V4L2_TUNER_RF` tuner type is used for setting radio frequency. The tuner index of the RF tuner (if any) must always follow the SDR tuner index. Normally the SDR tuner is #0 and the RF tuner is #1.

The [ioctl VIDIOC\\_S\\_HW\\_FREQ\\_SEEK](#) ioctl is not supported.

### Data Format Negotiation

The SDR device uses the [Data Formats](#) ioctls to select the capture and output format. Both the sampling resolution and the data streaming format are bound to that selectable format. In addition to the basic [Data Formats](#) ioctls, the [ioctl VIDIOC\\_ENUM\\_FMT](#) ioctl must be supported as well.

To use the [Data Formats](#) ioctls applications set the `type` field of a struct `v4l2_format` to `V4L2_BUF_TYPE_SDR_CAPTURE` or `V4L2_BUF_TYPE_SDR_OUTPUT` and use the struct `v4l2_sdr_format` `sdr` member of the `fmt` union as needed per the desired operation. Currently there are two fields, `pixelformat` and `buffersize`, of struct `v4l2_sdr_format` which are used. Content of the `pixelformat` is V4L2 FourCC code of the data format. The `buffersize` field is maximum buffer size in bytes required for data transfer, set by the driver in order to inform application.

type **v4l2\_sdr\_format**

Table 139: struct v4l2\_sdr\_format

<code>_u32</code>	<code>pixelformat</code>	The data format or type of compression, set by the application. This is a little endian <i>four character code</i> . V4L2 defines SDR formats in <a href="#">SDR Formats</a> .
<code>_u32</code>	<code>buffersize</code>	Maximum size in bytes required for data. Value is set by the driver.
<code>_u8</code>	<code>reserved[24]</code>	This array is reserved for future extensions. Drivers and applications must set it to zero.

An SDR device may support `read/write` and/or streaming (*memory mapping* or *user pointer*) I/O.

## Touch Devices

Touch devices are accessed through character device special files named `/dev/v4l-touch0` to `/dev/v4l-touch255` with major number 81 and dynamically allocated minor numbers 0 to 255.

### Overview

Sensors may be Optical, or Projected Capacitive touch (PCT).

Processing is required to analyse the raw data and produce input events. In some systems, this may be performed on the ASIC and the raw data is purely a side-channel for diagnostics or tuning. In other systems, the ASIC is a simple analogue front end device which delivers touch data at high rate, and any touch processing must be done on the host.

For capacitive touch sensing, the touchscreen is composed of an array of horizontal and vertical conductors (alternatively called rows/columns, X/Y lines, or tx/rx). Mutual Capacitance measured is at the nodes where the conductors cross. Alternatively, Self Capacitance measures the signal from each column and row independently.

A touch input may be determined by comparing the raw capacitance measurement to a no-touch reference (or "baseline") measurement:

$$\text{Delta} = \text{Raw} - \text{Reference}$$

The reference measurement takes account of variations in the capacitance across the touch sensor matrix, for example manufacturing irregularities, environmental or edge effects.

## Querying Capabilities

Devices supporting the touch interface set the V4L2\_CAP\_VIDEO\_CAPTURE flag and the V4L2\_CAP\_TOUCH flag in the capabilities field of `v4l2_capability` returned by the *ioctl VIDIOC\_QUERYCAP* ioctl.

At least one of the read/write or streaming I/O methods must be supported.

The formats supported by touch devices are documented in *Touch Formats*.

## Data Format Negotiation

A touch device may support any I/O method.

## Event Interface

The V4L2 event interface provides a means for a user to get immediately notified on certain conditions taking place on a device. This might include start of frame or loss of signal events, for example. Changes in the value or state of a V4L2 control can also be reported through events.

To receive events, the events the user is interested in first must be subscribed using the *ioctl VIDIOC\_SUBSCRIBE\_EVENT*, *VIDIOC\_UNSUBSCRIBE\_EVENT* ioctl. Once an event is subscribed, the events of subscribed types are dequeueable using the *ioctl VIDIOC\_DQEVENT* ioctl. Events may be unsubscribed using *VIDIOC\_UNSUBSCRIBE\_EVENT* ioctl. The special event type V4L2\_EVENT\_ALL may be used to unsubscribe all the events the driver supports.

The event subscriptions and event queues are specific to file handles. Subscribing an event on one file handle does not affect other file handles.

The information on dequeueable events is obtained by using select or poll system calls on video devices. The V4L2 events use POLLPRI events on poll system call and exceptions on select system call.

Starting with kernel 3.1 certain guarantees can be given with regards to events:

1. Each subscribed event has its own internal dedicated event queue. This means that flooding of one event type will not interfere with other event types.
2. If the internal event queue for a particular subscribed event becomes full, then the oldest event in that queue will be dropped.
3. Where applicable, certain event types can ensure that the payload of the oldest event that is about to be dropped will be merged with the payload of the next oldest event. Thus ensuring that no information is lost, but only an intermediate step leading up to that information. See the documentation for the event you want to subscribe to whether this is applicable for that event or not.

## Sub-device Interface

The complex nature of V4L2 devices, where hardware is often made of several integrated circuits that need to interact with each other in a controlled way, leads to complex V4L2 drivers. The drivers usually reflect the hardware model in software, and model the different hardware components as software blocks called sub-devices.

V4L2 sub-devices are usually kernel-only objects. If the V4L2 driver implements the media device API, they will automatically inherit from media entities. Applications will be able to enumerate the sub-devices and discover the hardware topology using the media entities, pads and links enumeration API.

In addition to make sub-devices discoverable, drivers can also choose to make them directly configurable by applications. When both the sub-device driver and the V4L2 device driver support this, sub-devices will feature a character device node on which ioctls can be called to

- query, read and write sub-devices controls
- subscribe and unsubscribe to events and retrieve them
- negotiate image formats on individual pads
- inspect and modify internal data routing between pads of the same entity

Sub-device character device nodes, conventionally named `/dev/v4l-subdev*`, use major number 81.

Drivers may opt to limit the sub-device character devices to only expose operations that do not modify the device state. In such a case the sub-devices are referred to as `read-only` in the rest of this documentation, and the related restrictions are documented in individual ioctls.

## Controls

Most V4L2 controls are implemented by sub-device hardware. Drivers usually merge all controls and expose them through video device nodes. Applications can control all sub-devices through a single interface.

Complex devices sometimes implement the same control in different pieces of hardware. This situation is common in embedded platforms, where both sensors and image processing hardware implement identical functions, such as contrast adjustment, white balance or faulty pixels correction. As the V4L2 controls API doesn't support several identical controls in a single device, all but one of the identical controls are hidden.

Applications can access those hidden controls through the sub-device node with the V4L2 control API described in [User Controls](#). The ioctls behave identically as when issued on V4L2 device nodes, with the exception that they deal only with controls implemented in the sub-device.

Depending on the driver, those controls might also be exposed through one (or several) V4L2 device nodes.

## Events

V4L2 sub-devices can notify applications of events as described in *Event Interface*. The API behaves identically as when used on V4L2 device nodes, with the exception that it only deals with events generated by the sub-device. Depending on the driver, those events might also be reported on one (or several) V4L2 device nodes.

## Pad-level Formats

**Warning:** Pad-level formats are only applicable to very complex devices that need to expose low-level format configuration to user space. Generic V4L2 applications do *not* need to use the API described in this section.

---

**Note:** For the purpose of this section, the term *format* means the combination of media bus data format, frame width and frame height.

---

Image formats are typically negotiated on video capture and output devices using the format and *selection* ioctls. The driver is responsible for configuring every block in the video pipeline according to the requested format at the pipeline input and/or output.

For complex devices, such as often found in embedded systems, identical image sizes at the output of a pipeline can be achieved using different hardware configurations. One such example is shown on *Image Format Negotiation on Pipelines*, where image scaling can be performed on both the video sensor and the host image processing hardware.

The sensor scaler is usually of less quality than the host scaler, but scaling on the sensor is required to achieve higher frame rates. Depending on the use case (quality vs. speed), the pipeline must be configured differently. Applications need to configure the formats at every point in the pipeline explicitly.

Drivers that implement the *media API* can expose pad-level image format configuration to applications. When they do, applications can use the `VIDIOC_SUBDEV_G_FMT` and `VIDIOC_SUBDEV_S_FMT` ioctls. to negotiate formats on a per-pad basis.

Applications are responsible for configuring coherent parameters on the whole pipeline and making sure that connected pads have compatible formats. The pipeline is checked for formats mismatch at `VIDIOC_STREAMON` time, and an EPIPE error code is then returned if the configuration is invalid.

Pad-level image format configuration support can be tested by calling the `ioctl VIDIOC_SUBDEV_G_FMT`, `VIDIOC_SUBDEV_S_FMT` ioctl on pad 0. If the driver returns an EINVAL error code pad-level format configuration is not supported by the sub-device.

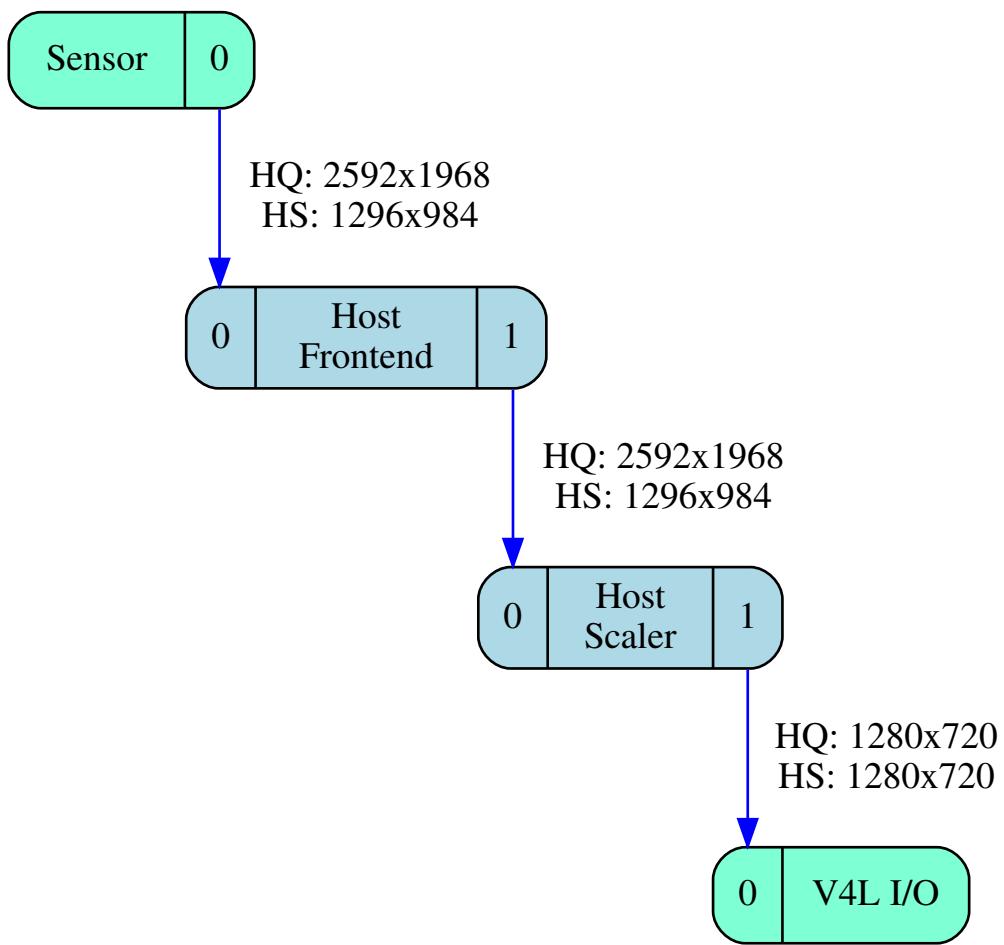


Fig. 13: Image Format Negotiation on Pipelines  
High quality and high speed pipeline configuration

## Format Negotiation

Acceptable formats on pads can (and usually do) depend on a number of external parameters, such as formats on other pads, active links, or even controls. Finding a combination of formats on all pads in a video pipeline, acceptable to both application and driver, can't rely on formats enumeration only. A format negotiation mechanism is required.

Central to the format negotiation mechanism are the get/set format operations. When called with the `which` argument set to `V4L2_SUBDEV_FORMAT_TRY`, the `VIDIOC_SUBDEV_G_FMT` and `VIDIOC_SUBDEV_S_FMT` ioctls operate on a set of formats parameters that are not connected to the hardware configuration. Modifying those 'try' formats leaves the device state untouched (this applies to both the software state stored in the driver and the hardware state stored in the device itself).

While not kept as part of the device state, try formats are stored in the sub-device file handles. A `VIDIOC_SUBDEV_G_FMT` call will return the last try format set *on the same sub-device file handle*. Several applications querying the same sub-device at the same time will thus not interact with each other.

To find out whether a particular format is supported by the device, applications use the `VIDIOC_SUBDEV_S_FMT` ioctl. Drivers verify and, if needed, change the requested format based on device requirements and return the possibly modified value. Applications can then choose to try a different format or accept the returned value and continue.

Formats returned by the driver during a negotiation iteration are guaranteed to be supported by the device. In particular, drivers guarantee that a returned format will not be further changed if passed to an `VIDIOC_SUBDEV_S_FMT` call as-is (as long as external parameters, such as formats on other pads or links' configuration are not changed).

Drivers automatically propagate formats inside sub-devices. When a try or active format is set on a pad, corresponding formats on other pads of the same sub-device can be modified by the driver. Drivers are free to modify formats as required by the device. However, they should comply with the following rules when possible:

- Formats should be propagated from sink pads to source pads. Modifying a format on a source pad should not modify the format on any sink pad.
- Sub-devices that scale frames using variable scaling factors should reset the scale factors to default values when sink pads formats are modified. If the 1:1 scaling ratio is supported, this means that source pads formats should be reset to the sink pads formats.

Formats are not propagated across links, as that would involve propagating them from one sub-device file handle to another. Applications must then take care to configure both ends of every link explicitly with compatible formats. Identical formats on the two ends of a link are guaranteed to be compatible. Drivers are free to accept different formats matching device requirements as being compatible.

[\*Sample Pipeline Configuration\*](#) shows a sample configuration sequence for the pipeline described in *Image Format Negotiation on Pipelines* (table columns list entity names and pad numbers).

Table 140: Sample Pipeline Configuration

	Sensor/0 format	Frontend/0 format	Frontend/1 format	Scaler/0 format	Scaler/0 compose selection rectangle	Scaler/1 format
Initial state	2048x1536 SGRBG8_1X8	(default)	(default)	(default)	(default)	(default)
Configure frontend sink format	2048x1536 SGRBG8_1X8	2048x1536 SGRBG8_1X8	2046x1534 SGRBG8_1X8	(default)	(default)	(default)
Configure scaler sink format	2048x1536 SGRBG8_1X8	2048x1536 SGRBG8_1X8	2046x1534 SGRBG8_1X8	2046x1534 SGRBG8_1X8	0,0/2046x1534	2046x1534 SGRBG8_1X8
Configure scaler sink compose selection	2048x1536 SGRBG8_1X8	2048x1536 SGRBG8_1X8	2046x1534 SGRBG8_1X8	2046x1534 SGRBG8_1X8	0,0/1280x960	1280x960 SGRBG8_1X8

1. Initial state. The sensor source pad format is set to its native 3MP size and V4L2\_MBUS\_FMT\_SGRBG8\_1X8 media bus code. Formats on the host frontend and scaler sink and source pads have the default values, as well as the compose rectangle on the scaler's sink pad.
2. The application configures the frontend sink pad format's size to 2048x1536 and its media bus code to V4L2\_MBUS\_FMT\_SGRBG\_1X8. The driver propagates the format to the frontend source pad.
3. The application configures the scaler sink pad format's size to 2046x1534 and the media bus code to V4L2\_MBUS\_FMT\_SGRBG\_1X8 to match the frontend source size and media bus code. The media bus code on the sink pad is set to V4L2\_MBUS\_FMT\_SGRBG\_1X8. The driver propagates the size to the compose selection rectangle on the scaler's sink pad, and the format to the scaler source pad.
4. The application configures the size of the compose selection rectangle of the scaler's sink pad 1280x960. The driver propagates the size to the scaler's source pad format.

When satisfied with the try results, applications can set the active formats by setting the `which` argument to `V4L2_SUBDEV_FORMAT_ACTIVE`. Active formats are changed exactly as try formats by drivers. To avoid modifying the hardware state during format negotiation, applications should negotiate try formats first and then modify the active settings using the try formats returned during the last negotiation iteration. This guarantees that the active format will be applied as-is by the driver without being modified.

## Selections: cropping, scaling and composition

Many sub-devices support cropping frames on their input or output pads (or possibly even on both). Cropping is used to select the area of interest in an image, typically on an image sensor or a video decoder. It can also be used as part of digital zoom implementations to select the area of the image that will be scaled up.

Crop settings are defined by a crop rectangle and represented in a struct `v4l2_rect` by the coordinates of the top left corner and the rectangle size. Both the coordinates and sizes are expressed in pixels.

As for pad formats, drivers store try and active rectangles for the selection targets *Common selection definitions*.

On sink pads, cropping is applied relative to the current pad format. The pad format represents the image size as received by the sub-device from the previous block in the pipeline, and the crop rectangle represents the sub-image that will be transmitted further inside the sub-device for processing.

The scaling operation changes the size of the image by scaling it to new dimensions. The scaling ratio isn't specified explicitly, but is implied from the original and scaled image sizes. Both sizes are represented by struct *v4l2\_rect*.

Scaling support is optional. When supported by a subdev, the crop rectangle on the subdev's sink pad is scaled to the size configured using the *VIDIOC\_SUBDEV\_S\_SELECTION* IOCTL using *V4L2\_SEL\_TGT\_COMPOSE* selection target on the same pad. If the subdev supports scaling but not composing, the top and left values are not used and must always be set to zero.

On source pads, cropping is similar to sink pads, with the exception that the source size from which the cropping is performed, is the COMPOSE rectangle on the sink pad. In both sink and source pads, the crop rectangle must be entirely contained inside the source image size for the crop operation.

The drivers should always use the closest possible rectangle the user requests on all selection targets, unless specifically told otherwise. *V4L2\_SEL\_FLAG\_GE* and *V4L2\_SEL\_FLAG\_LE* flags may be used to round the image size either up or down. *Selection flags*

## Types of selection targets

### Actual targets

Actual targets (without a postfix) reflect the actual hardware configuration at any point of time. There is a BOUNDS target corresponding to every actual target.

### BOUNDS targets

BOUNDS targets is the smallest rectangle that contains all valid actual rectangles. It may not be possible to set the actual rectangle as large as the BOUNDS rectangle, however. This may be because e.g. a sensor's pixel array is not rectangular but cross-shaped or round. The maximum size may also be smaller than the BOUNDS rectangle.

## Order of configuration and format propagation

Inside subdevs, the order of image processing steps will always be from the sink pad towards the source pad. This is also reflected in the order in which the configuration must be performed by the user: the changes made will be propagated to any subsequent stages. If this behaviour is not desired, the user must set *V4L2\_SEL\_FLAG\_KEEP\_CONFIG* flag. This flag causes no propagation of the changes are allowed in any circumstances. This may also cause the accessed rectangle to be adjusted by the driver, depending on the properties of the underlying hardware.

The coordinates to a step always refer to the actual size of the previous step. The exception to this rule is the sink compose rectangle, which refers to the sink compose bounds rectangle --- if it is supported by the hardware.

1. Sink pad format. The user configures the sink pad format. This format defines the parameters of the image the entity receives through the pad for further processing.
2. Sink pad actual crop selection. The sink pad crop defines the crop performed to the sink pad format.
3. Sink pad actual compose selection. The size of the sink pad compose rectangle defines the scaling ratio compared to the size of the sink pad crop rectangle. The location of the compose rectangle specifies the location of the actual sink compose rectangle in the sink compose bounds rectangle.
4. Source pad actual crop selection. Crop on the source pad defines crop performed to the image in the sink compose bounds rectangle.
5. Source pad format. The source pad format defines the output pixel format of the subdev, as well as the other parameters with the exception of the image width and height. Width and height are defined by the size of the source pad actual crop selection.

Accessing any of the above rectangles not supported by the subdev will return EINVAL. Any rectangle referring to a previous unsupported rectangle coordinates will instead refer to the previous supported rectangle. For example, if sink crop is not supported, the compose selection will refer to the sink pad format dimensions instead.

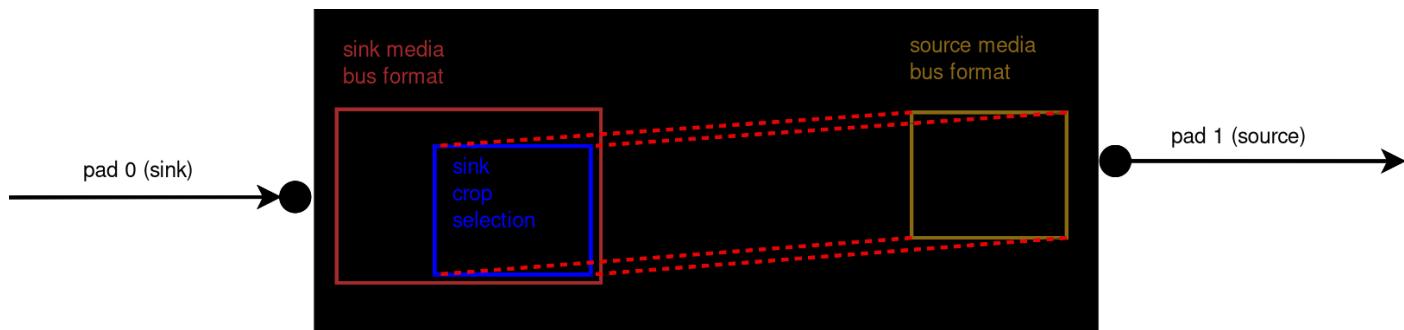


Fig. 14: **Figure 4.5. Image processing in subdevs: simple crop example**

In the above example, the subdev supports cropping on its sink pad. To configure it, the user sets the media bus format on the subdev's sink pad. Now the actual crop rectangle can be set on the sink pad --- the location and size of this rectangle reflect the location and size of a rectangle to be cropped from the sink format. The size of the sink crop rectangle will also be the size of the format of the subdev's source pad.

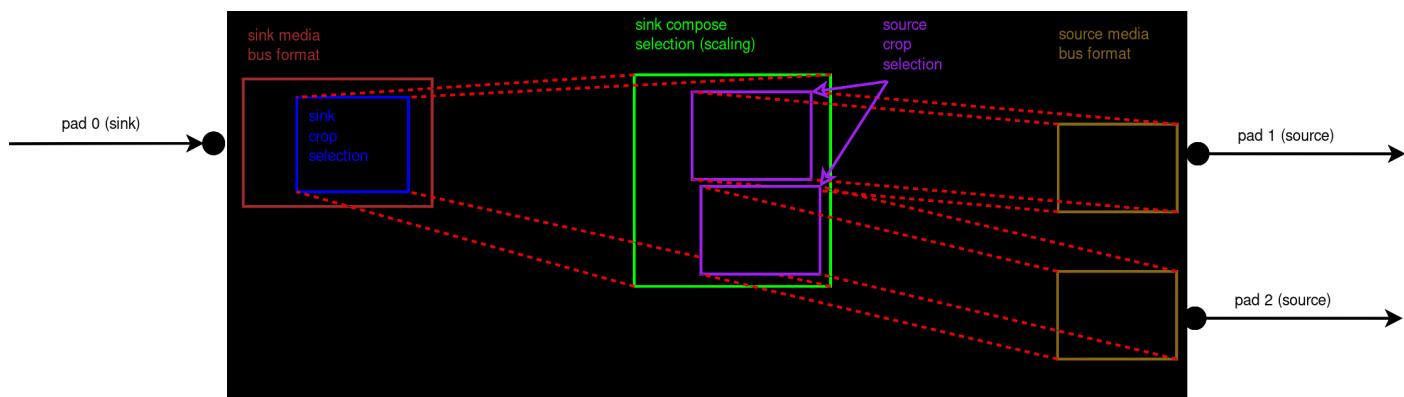


Fig. 15: **Figure 4.6. Image processing in subdevs: scaling with multiple sources**

In this example, the subdev is capable of first cropping, then scaling and finally cropping for two source pads individually from the resulting scaled image. The location of the scaled image in the cropped image is ignored in sink compose target. Both of the locations of the source crop rectangles refer to the sink scaling rectangle, independently cropping an area at location specified by the source crop rectangle from it.

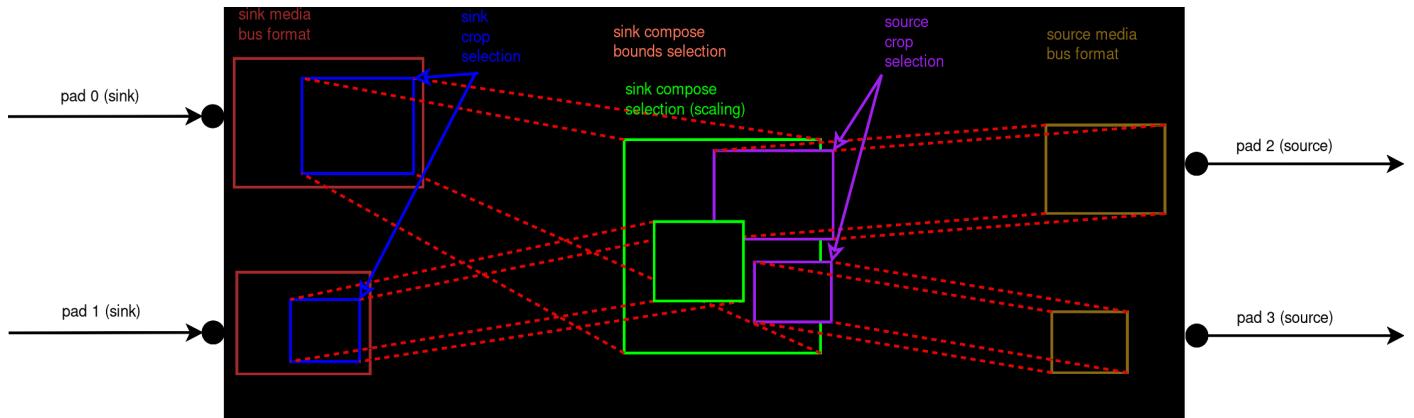


Fig. 16: **Figure 4.7. Image processing in subdevs: scaling and composition with multiple sinks and sources**

The subdev driver supports two sink pads and two source pads. The images from both of the sink pads are individually cropped, then scaled and further composed on the composition bounds rectangle. From that, two independent streams are cropped and sent out of the subdev from the source pads.

## Media Bus Formats

type `v4l2_mbus_framefmt`

Table 141: struct `v4l2_mbus_framefmt`

<code>_u32</code>	<code>width</code>	Image width in pixels.
<code>_u32</code>	<code>height</code>	Image height in pixels. If <code>field</code> is one of <code>V4L2_FIELD_TOP</code> , <code>V4L2_FIELD_BOTTOM</code> or <code>V4L2_FIELD_ALTERNATE</code> then height refers to the number of lines in the field, otherwise it refers to the number of lines in the frame (which is twice the field height for interlaced formats).
<code>_u32</code>	<code>code</code>	Format code, from enum <code>v4l2_mbus_pixelcode</code> .
<code>_u32</code>	<code>field</code>	Field order, from enum <code>v4l2_field</code> . See <i>Field Order</i> for details.

continues on next page

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<code>_u32</code>	<code>colorspace</code>	Image colorspace, from enum <code>v4l2_colorspace</code> . Must be set by the driver for subdevices. If the application sets the flag <code>V4L2_MBUS_FRAMEFMT_SET_CSC</code> then the application can set this field on the source pad to request a specific colorspace for the media bus data. If the driver cannot handle the requested conversion, it will return another supported colorspace. The driver indicates that colorspace conversion is supported by setting the flag <code>V4L2_SUBDEV_MBUS_CODE_CSC_COLORSPACE</code> in the corresponding struct <code>v4l2_subdev_mbus_code_enum</code> during enumeration. See <a href="#">Subdev Media Bus Code Enumerate Flags</a> .
<code>union {</code>	<code>(anonymous)</code>	
<code>_u16</code>	<code>ycbcr_enc</code>	Y'CbCr encoding, from enum <code>v4l2_ycbcr_encoding</code> . This information supplements the <code>colorspace</code> and must be set by the driver for subdevices, see <a href="#">Colorspaces</a> . If the application sets the flag <code>V4L2_MBUS_FRAMEFMT_SET_CSC</code> then the application can set this field on a source pad to request a specific Y'CbCr encoding for the media bus data. If the driver cannot handle the requested conversion, it will return another supported encoding. This field is ignored for HSV media bus formats. The driver indicates that <code>ycbcr_enc</code> conversion is supported by setting the flag <code>V4L2_SUBDEV_MBUS_CODE_CSC_YCBCR_ENC</code> in the corresponding struct <code>v4l2_subdev_mbus_code_enum</code> during enumeration. See <a href="#">Subdev Media Bus Code Enumerate Flags</a> .
<code>_u16</code>	<code>hsv_enc</code>	HSV encoding, from enum <code>v4l2_hsv_encoding</code> . This information supplements the <code>colorspace</code> and must be set by the driver for subdevices, see <a href="#">Colorspaces</a> . If the application sets the flag <code>V4L2_MBUS_FRAMEFMT_SET_CSC</code> then the application can set this field on a source pad to request a specific HSV encoding for the media bus data. If the driver cannot handle the requested conversion, it will return another supported encoding. This field is ignored for Y'CbCr media bus formats. The driver indicates that <code>hsv_enc</code> conversion is supported by setting the flag <code>V4L2_SUBDEV_MBUS_CODE_CSC_HSV_ENC</code> in the corresponding struct <code>v4l2_subdev_mbus_code_enum</code> during enumeration. See <a href="#">Subdev Media Bus Code Enumerate Flags</a>
<code>}</code>		

continues on next page

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<code>_u16</code>	<code>quantization</code>	Quantization range, from enum <code>v4l2_quantization</code> . This information supplements the colorspace and must be set by the driver for subdevices, see <a href="#">Colorspaces</a> . If the application sets the flag <code>V4L2_MBUS_FRAMEFMT_SET_CSC</code> then the application can set this field on a source pad to request a specific quantization for the media bus data. If the driver cannot handle the requested conversion, it will return another supported quantization. The driver indicates that quantization conversion is supported by setting the flag <code>V4L2_SUBDEV_MBUS_CODE_CSC_QUANTIZATION</code> in the corresponding struct <code>v4l2_subdev_mbus_code_enum</code> during enumeration. See <a href="#">Subdev Media Bus Code Enumerate Flags</a> .
<code>_u16</code>	<code>xfer_func</code>	Transfer function, from enum <code>v4l2_xfer_func</code> . This information supplements the colorspace and must be set by the driver for subdevices, see <a href="#">Colorspaces</a> . If the application sets the flag <code>V4L2_MBUS_FRAMEFMT_SET_CSC</code> then the application can set this field on a source pad to request a specific transfer function for the media bus data. If the driver cannot handle the requested conversion, it will return another supported transfer function. The driver indicates that the transfer function conversion is supported by setting the flag <code>V4L2_SUBDEV_MBUS_CODE_CSC_XFER_FUNC</code> in the corresponding struct <code>v4l2_subdev_mbus_code_enum</code> during enumeration. See <a href="#">Subdev Media Bus Code Enumerate Flags</a> .
<code>_u16</code>	<code>flags</code>	flags See: <a href="#">:ref:v4l2-mbus-framefmt-flags</a>
<code>_u16</code>	<code>reserved[10]</code>	Reserved for future extensions. Applications and drivers must set the array to zero.

Table 142: v4l2\_mbus\_framefmt Flags

V4L2_MBUS_FRAMEFMT_SET_CSC	0x0001	<p>Set by the application. It is only used for source pads and is ignored for sink pads. If set, then request the subdevice to do colorspace conversion from the received colorspace to the requested colorspace values. If the colorimetry field (colorspace, xfer_func, ycbcr_enc, hsv_enc or quantization) is set to * _DEFAULT, then that colorimetry setting will remain unchanged from what was received. So in order to change the quantization, only the quantization field shall be set to non default value (V4L2_QUANTIZATION_FULL_RANGE or V4L2_QUANTIZATION_LIM_RANGE) and all other colorimetry fields shall be set to * _DEFAULT.</p> <p>To check which conversions are supported by the hardware for the current media bus frame format, see <a href="#">Subdev Media Bus Code Enumerate Flags</a>.</p>
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## Media Bus Pixel Codes

The media bus pixel codes describe image formats as flowing over physical buses (both between separate physical components and inside SoC devices). This should not be confused with the V4L2 pixel formats that describe, using four character codes, image formats as stored in memory.

While there is a relationship between image formats on buses and image formats in memory (a raw Bayer image won't be magically converted to JPEG just by storing it to memory), there is no one-to-one correspondence between them.

The media bus pixel codes document parallel formats. Should the pixel data be transported over a serial bus, the media bus pixel code that describes a parallel format that transfers a sample on a single clock cycle is used. For instance, both MEDIA\_BUS\_FMT\_BGR888\_1X24 and MEDIA\_BUS\_FMT\_BGR888\_3X8 are used on parallel busses for transferring an 8 bits per sample BGR data, whereas on serial busses the data in this format is only referred to using MEDIA\_BUS\_FMT\_BGR888\_1X24. This is because there is effectively only a single way to transport that format on the serial busses.

## Packed RGB Formats

Those formats transfer pixel data as red, green and blue components. The format code is made of the following information.

- The red, green and blue components order code, as encoded in a pixel sample. Possible values are RGB and BGR.
- The number of bits per component, for each component. The values can be different for all components. Common values are 555 and 565.

- The number of bus samples per pixel. Pixels that are wider than the bus width must be transferred in multiple samples. Common values are 1 and 2.
- The bus width.
- For formats where the total number of bits per pixel is smaller than the number of bus samples per pixel times the bus width, a padding value stating if the bytes are padded in their most high order bits (PADHI) or low order bits (PADLO). A "C" prefix is used for component-wise padding in the most high order bits (CPADHI) or low order bits (CPADLO) of each separate component.
- For formats where the number of bus samples per pixel is larger than 1, an endianness value stating if the pixel is transferred MSB first (BE) or LSB first (LE).

For instance, a format where pixels are encoded as 5-bits red, 5-bits green and 5-bit blue values padded on the high bit, transferred as 2 8-bit samples per pixel with the most significant bits (padding, red and half of the green value) transferred first will be named `MEDIA_BUS_FMT_RGB555_2X8_PADHI_BE`.

The following tables list existing packed RGB formats.

Table 143: RGB formats

Identifier	Code	Data organization
		Bit 31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0
<code>MEDIA_BUS_FMT_RGB444_1X12</code>	0x1016	r <sub>3</sub> r <sub>2</sub> r <sub>1</sub> r <sub>0</sub> g <sub>3</sub> g <sub>2</sub> g <sub>1</sub> g <sub>0</sub> b <sub>3</sub> b <sub>2</sub> b <sub>1</sub> b <sub>0</sub>
<code>MEDIA_BUS_FMT_RGB444_2X8_PADHI_BE</code>	0x1001	0 0 0 0 r <sub>3</sub> r <sub>2</sub> r <sub>1</sub> r <sub>0</sub> g <sub>3</sub> g <sub>2</sub> g <sub>1</sub> g <sub>0</sub> b <sub>3</sub> b <sub>2</sub> b <sub>1</sub> b <sub>0</sub>
<code>MEDIA_BUS_FMT_RGB444_2X8_PADHI_LE</code>	0x1002	g <sub>3</sub> g <sub>2</sub> g <sub>1</sub> g <sub>0</sub> b <sub>3</sub> b <sub>2</sub> b <sub>1</sub> b <sub>0</sub> 0 0 0 0 r <sub>3</sub> r <sub>2</sub> r <sub>1</sub> r <sub>0</sub>
<code>MEDIA_BUS_FMT_RGB555_2X8_PADHI_BE</code>	0x1003	0 r <sub>4</sub> r <sub>3</sub> r <sub>2</sub> r <sub>1</sub> r <sub>0</sub> g <sub>4</sub> g <sub>3</sub> g <sub>2</sub> g <sub>1</sub> g <sub>0</sub> b <sub>4</sub> b <sub>3</sub> b <sub>2</sub> b <sub>1</sub> b <sub>0</sub>
<code>MEDIA_BUS_FMT_RGB555_2X8_PADHI_LE</code>	0x1004	g <sub>2</sub> g <sub>1</sub> g <sub>0</sub> b <sub>4</sub> b <sub>3</sub> b <sub>2</sub> b <sub>1</sub> b <sub>0</sub> 0 r <sub>4</sub> r <sub>3</sub> r <sub>2</sub> r <sub>1</sub> r <sub>0</sub> g <sub>4</sub> g <sub>3</sub>
<code>MEDIA_BUS_FMT_RGB565_1X16</code>	0x1017	r <sub>4</sub> r <sub>3</sub> r <sub>2</sub> r <sub>1</sub> r <sub>0</sub> g <sub>5</sub> g <sub>4</sub> g <sub>3</sub> g <sub>2</sub> g <sub>1</sub> g <sub>0</sub> b <sub>4</sub> b <sub>3</sub> b <sub>2</sub> b <sub>1</sub> b <sub>0</sub>
<code>MEDIA_BUS_FMT_BGR565_2X8_BE</code>	0x1005	b <sub>4</sub> b <sub>3</sub> b <sub>2</sub> b <sub>1</sub> b <sub>0</sub> g <sub>5</sub> g <sub>4</sub> g <sub>3</sub> g <sub>2</sub> g <sub>1</sub> g <sub>0</sub> r <sub>4</sub> r <sub>3</sub> r <sub>2</sub> r <sub>1</sub> r <sub>0</sub>
<code>MEDIA_BUS_FMT_BGR565_2X8_LE</code>	0x1006	g <sub>2</sub> g <sub>1</sub> g <sub>0</sub> r <sub>4</sub> r <sub>3</sub> r <sub>2</sub> r <sub>1</sub> r <sub>0</sub> b <sub>4</sub> b <sub>3</sub> b <sub>2</sub> b <sub>1</sub> b <sub>0</sub>
<code>MEDIA_BUS_FMT_RGB565_2X8_BE</code>	0x1007	r <sub>4</sub> r <sub>3</sub> r <sub>2</sub> r <sub>1</sub> r <sub>0</sub> g <sub>5</sub> g <sub>4</sub> g <sub>3</sub> g <sub>2</sub> g <sub>1</sub> g <sub>0</sub> b <sub>4</sub> b <sub>3</sub> b <sub>2</sub> b <sub>1</sub> b <sub>0</sub>
<code>MEDIA_BUS_FMT_RGB565_2X8_LE</code>	0x1008	g <sub>2</sub> g <sub>1</sub> g <sub>0</sub> b <sub>4</sub> b <sub>3</sub> b <sub>2</sub> b <sub>1</sub> b <sub>0</sub> r <sub>4</sub> r <sub>3</sub> r <sub>2</sub> r <sub>1</sub> r <sub>0</sub> g <sub>5</sub> g <sub>4</sub> g <sub>3</sub>
<code>MEDIA_BUS_FMT_RGB666_1X18</code>	0x1009	r <sub>5</sub> r <sub>4</sub> r <sub>3</sub> r <sub>2</sub> r <sub>1</sub> r <sub>0</sub> g <sub>5</sub> g <sub>4</sub> g <sub>3</sub> g <sub>2</sub> g <sub>1</sub> g <sub>0</sub> b <sub>5</sub> b <sub>4</sub> b <sub>3</sub> b <sub>2</sub> b <sub>1</sub> b <sub>0</sub>
<code>MEDIA_BUS_FMT_RGB666_2X9_BE</code>	0x1025	r <sub>5</sub> r <sub>4</sub> r <sub>3</sub> r <sub>2</sub> r <sub>1</sub> r <sub>0</sub> g <sub>5</sub> g <sub>4</sub> g <sub>3</sub> g <sub>2</sub> g <sub>1</sub> g <sub>0</sub> b <sub>5</sub> b <sub>4</sub> b <sub>3</sub> b <sub>2</sub> b <sub>1</sub> b <sub>0</sub>
<code>MEDIA_BUS_FMT_BGR666_1X18</code>	0x1023	b <sub>5</sub> b <sub>4</sub> b <sub>3</sub> b <sub>2</sub> b <sub>1</sub> b <sub>0</sub> g <sub>5</sub> g <sub>4</sub> g <sub>3</sub> g <sub>2</sub> g <sub>1</sub> g <sub>0</sub> r <sub>5</sub> r <sub>4</sub> r <sub>3</sub> r <sub>2</sub> r <sub>1</sub> r <sub>0</sub>
<code>MEDIA_BUS_FMT_RGB888_1X24</code>	0x100e	r <sub>7</sub> r <sub>6</sub> r <sub>5</sub> r <sub>4</sub> r <sub>3</sub> r <sub>2</sub> r <sub>1</sub> r <sub>0</sub> b <sub>7</sub> b <sub>6</sub> b <sub>5</sub> b <sub>4</sub> b <sub>3</sub> b <sub>2</sub> b <sub>1</sub> b <sub>0</sub> g <sub>7</sub> g <sub>6</sub> g <sub>5</sub> g <sub>4</sub> g <sub>3</sub> g <sub>2</sub> g <sub>1</sub> g <sub>0</sub>
<code>MEDIA_BUS_FMT_RGB666_1X24_CPADHI</code>	0x1015	0 0 r <sub>5</sub> r <sub>4</sub> r <sub>3</sub> r <sub>2</sub> r <sub>1</sub> r <sub>0</sub> 0 0 g <sub>5</sub> g <sub>4</sub> g <sub>3</sub> g <sub>2</sub> g <sub>1</sub> g <sub>0</sub> 0 0 b <sub>5</sub> b <sub>4</sub> b <sub>3</sub> b <sub>2</sub> b <sub>1</sub> b <sub>0</sub>
<code>MEDIA_BUS_FMT_BGR666_1X24_CPADHI</code>	0x1024	0 0 b <sub>5</sub> b <sub>4</sub> b <sub>3</sub> b <sub>2</sub> b <sub>1</sub> b <sub>0</sub> 0 0 g <sub>5</sub> g <sub>4</sub> g <sub>3</sub> g <sub>2</sub> g <sub>1</sub> g <sub>0</sub> 0 0 r <sub>5</sub> r <sub>4</sub> r <sub>3</sub> r <sub>2</sub> r <sub>1</sub> r <sub>0</sub>
<code>MEDIA_BUS_FMT_RGB565_1X24_CPADHI</code>	0x1022	0 0 0 r <sub>4</sub> r <sub>3</sub> r <sub>2</sub> r <sub>1</sub> r <sub>0</sub> 0 0 g <sub>5</sub> g <sub>4</sub> g <sub>3</sub> g <sub>2</sub> g <sub>1</sub> g <sub>0</sub> 0 0 b <sub>4</sub> b <sub>3</sub> b <sub>2</sub> b <sub>1</sub> b <sub>0</sub>
<code>MEDIA_BUS_FMT_BGR888_1X24</code>	0x1013	b <sub>7</sub> b <sub>6</sub> b <sub>5</sub> b <sub>4</sub> b <sub>3</sub> b <sub>2</sub> b <sub>1</sub> b <sub>0</sub> g <sub>7</sub> g <sub>6</sub> g <sub>5</sub> g <sub>4</sub> g <sub>3</sub> g <sub>2</sub> g <sub>1</sub> g <sub>0</sub> r <sub>7</sub> r <sub>6</sub> r <sub>5</sub> r <sub>4</sub> r <sub>3</sub> r <sub>2</sub> r <sub>1</sub> r <sub>0</sub>
<code>MEDIA_BUS_FMT_BGR888_3X8</code>	0x101b	b <sub>7</sub> b <sub>6</sub> b <sub>5</sub> b <sub>4</sub> b <sub>3</sub> b <sub>2</sub> b <sub>1</sub> b <sub>0</sub> g <sub>7</sub> g <sub>6</sub> g <sub>5</sub> g <sub>4</sub> g <sub>3</sub> g <sub>2</sub> g <sub>1</sub> g <sub>0</sub> r <sub>7</sub> r <sub>6</sub> r <sub>5</sub> r <sub>4</sub> r <sub>3</sub> r <sub>2</sub> r <sub>1</sub> r <sub>0</sub>
<code>MEDIA_BUS_FMT_GBR888_1X24</code>	0x1014	g <sub>7</sub> g <sub>6</sub> g <sub>5</sub> g <sub>4</sub> g <sub>3</sub> g <sub>2</sub> g <sub>1</sub> g <sub>0</sub> b <sub>7</sub> b <sub>6</sub> b <sub>5</sub> b <sub>4</sub> b <sub>3</sub> b <sub>2</sub> b <sub>1</sub> b <sub>0</sub> r <sub>7</sub> r <sub>6</sub> r <sub>5</sub> r <sub>4</sub> r <sub>3</sub> r <sub>2</sub> r <sub>1</sub> r <sub>0</sub>
<code>MEDIA_BUS_FMT_RGB888_1X24</code>	0x100a	r <sub>7</sub> r <sub>6</sub> r <sub>5</sub> r <sub>4</sub> r <sub>3</sub> r <sub>2</sub> r <sub>1</sub> r <sub>0</sub> g <sub>7</sub> g <sub>6</sub> g <sub>5</sub> g <sub>4</sub> g <sub>3</sub> g <sub>2</sub> g <sub>1</sub> g <sub>0</sub> b <sub>7</sub> b <sub>6</sub> b <sub>5</sub> b <sub>4</sub> b <sub>3</sub> b <sub>2</sub> b <sub>1</sub> b <sub>0</sub>
<code>MEDIA_BUS_FMT_RGB888_2X12_BE</code>	0x100b	g <sub>7</sub> g <sub>6</sub> g <sub>5</sub> g <sub>4</sub> g <sub>3</sub> g <sub>2</sub> g <sub>1</sub> g <sub>0</sub> b <sub>7</sub> b <sub>6</sub> b <sub>5</sub> b <sub>4</sub> b <sub>3</sub> b <sub>2</sub> b <sub>1</sub> b <sub>0</sub> r <sub>7</sub> r <sub>6</sub> r <sub>5</sub> r <sub>4</sub> r <sub>3</sub> r <sub>2</sub> r <sub>1</sub> r <sub>0</sub>
<code>MEDIA_BUS_FMT_RGB888_2X12_LE</code>	0x100c	g <sub>3</sub> g <sub>2</sub> g <sub>1</sub> g <sub>0</sub> b <sub>7</sub> b <sub>6</sub> b <sub>5</sub> b <sub>4</sub> b <sub>3</sub> b <sub>2</sub> b <sub>1</sub> b <sub>0</sub> g <sub>7</sub> g <sub>6</sub> g <sub>5</sub> g <sub>4</sub> g <sub>3</sub> g <sub>2</sub> g <sub>1</sub> g <sub>0</sub>

continues on next page

Table 143 - continued from previous page

Identifier	Code	Data organization																																						
		Bit	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0						
MEDIA_BUS_FMT_RGB888_3X8	0x101c																																							
MEDIA_BUS_FMT_RGB666_1X30-CPADLO	0x101e				r <sub>5</sub>	r <sub>4</sub>	r <sub>3</sub>	r <sub>2</sub>	r <sub>1</sub>	r <sub>0</sub>	0	0	0	0	g <sub>5</sub>	g <sub>4</sub>	g <sub>3</sub>	g <sub>2</sub>	g <sub>1</sub>	g <sub>0</sub>	0	0	0	0	b <sub>5</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>	b <sub>0</sub>	0	0	0	0	0	0				
MEDIA_BUS_FMT_RGB888_1X30-CPADLO	0x101f				r <sub>7</sub>	r <sub>6</sub>	r <sub>5</sub>	r <sub>4</sub>	r <sub>3</sub>	r <sub>2</sub>	r <sub>1</sub>	r <sub>0</sub>	0	0	g <sub>7</sub>	g <sub>6</sub>	g <sub>5</sub>	g <sub>4</sub>	g <sub>3</sub>	g <sub>2</sub>	g <sub>1</sub>	g <sub>0</sub>	0	0	b <sub>7</sub>	b <sub>6</sub>	b <sub>5</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>	b <sub>0</sub>	0	0	0	0	0	0		
MEDIA_BUS_FMT_ARGB888_1X32	0x100d	a <sub>7</sub>	a <sub>6</sub>	a <sub>5</sub>	a <sub>4</sub>	a <sub>3</sub>	a <sub>2</sub>	a <sub>1</sub>	a <sub>0</sub>	r <sub>7</sub>	r <sub>6</sub>	r <sub>5</sub>	r <sub>4</sub>	r <sub>3</sub>	r <sub>2</sub>	r <sub>1</sub>	r <sub>0</sub>	g <sub>7</sub>	g <sub>6</sub>	g <sub>5</sub>	g <sub>4</sub>	g <sub>3</sub>	g <sub>2</sub>	g <sub>1</sub>	g <sub>0</sub>	b <sub>7</sub>	b <sub>6</sub>	b <sub>5</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>	b <sub>0</sub>	0	0	0	0	0	0	
MEDIA_BUS_FMT_RGB888_1X32_PADHI	0x100f	0	0	0	0	0	0	0	0	0	r <sub>7</sub>	r <sub>6</sub>	r <sub>5</sub>	r <sub>4</sub>	r <sub>3</sub>	r <sub>2</sub>	r <sub>1</sub>	r <sub>0</sub>	g <sub>7</sub>	g <sub>6</sub>	g <sub>5</sub>	g <sub>4</sub>	g <sub>3</sub>	g <sub>2</sub>	g <sub>1</sub>	g <sub>0</sub>	b <sub>7</sub>	b <sub>6</sub>	b <sub>5</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>	b <sub>0</sub>	0	0	0	0	0	0
MEDIA_BUS_FMT_RGB101010_1X30	0x1018				r <sub>9</sub>	r <sub>8</sub>	r <sub>7</sub>	r <sub>6</sub>	r <sub>5</sub>	r <sub>4</sub>	r <sub>3</sub>	r <sub>2</sub>	r <sub>1</sub>	r <sub>0</sub>	g <sub>9</sub>	g <sub>8</sub>	g <sub>7</sub>	g <sub>6</sub>	g <sub>5</sub>	g <sub>4</sub>	g <sub>3</sub>	g <sub>2</sub>	g <sub>1</sub>	g <sub>0</sub>	b <sub>9</sub>	b <sub>8</sub>	b <sub>7</sub>	b <sub>6</sub>	b <sub>5</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>	b <sub>0</sub>	0	0	0	0	0	0

The following table list existing packed 36bit wide RGB formats.

Table 144: 36bit RGB formats

Identifier	Code	Data organization																																									
		Bit	35	34	33	32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0					
MEDIA_BUS_FMT_RGB666_1X36 CPADLO20	0x101020	r <sub>5</sub>	r <sub>4</sub>	r <sub>3</sub>	r <sub>2</sub>	r <sub>1</sub>	r <sub>0</sub>	0	0	0	0	0	0	0	g <sub>5</sub>	g <sub>4</sub>	g <sub>3</sub>	g <sub>2</sub>	g <sub>1</sub>	g <sub>0</sub>	0	0	0	0	b <sub>5</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>	b <sub>0</sub>	0	0	0	0	0	0							
MEDIA_BUS_FMT_RGB888_1X36 CPADLO21	0x101021	r <sub>7</sub>	r <sub>6</sub>	r <sub>5</sub>	r <sub>4</sub>	r <sub>3</sub>	r <sub>2</sub>	r <sub>1</sub>	r <sub>0</sub>	0	0	0	0	0	g <sub>7</sub>	g <sub>6</sub>	g <sub>5</sub>	g <sub>4</sub>	g <sub>3</sub>	g <sub>2</sub>	g <sub>1</sub>	g <sub>0</sub>	0	0	0	0	b <sub>7</sub>	b <sub>6</sub>	b <sub>5</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>	b <sub>0</sub>	0	0	0	0	0	0			
MEDIA_BUS_FMT_RGB121212_1X36	0x1019	r <sub>11</sub>	r <sub>10</sub>	r <sub>9</sub>	r <sub>8</sub>	r <sub>7</sub>	r <sub>6</sub>	r <sub>5</sub>	r <sub>4</sub>	r <sub>3</sub>	r <sub>2</sub>	r <sub>1</sub>	r <sub>0</sub>	g <sub>11</sub>	g <sub>10</sub>	g <sub>9</sub>	g <sub>8</sub>	g <sub>7</sub>	g <sub>6</sub>	g <sub>5</sub>	g <sub>4</sub>	g <sub>3</sub>	g <sub>2</sub>	g <sub>1</sub>	g <sub>0</sub>	b <sub>11</sub>	b <sub>10</sub>	b <sub>9</sub>	b <sub>8</sub>	b <sub>7</sub>	b <sub>6</sub>	b <sub>5</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>	b <sub>0</sub>	0	0	0	0	0	0
MEDIA_BUS_FMT_RGB161616_1X48	0x101a																																										

On LVDS buses, usually each sample is transferred serialized in seven time slots per pixel clock, on three (18-bit) or four (24-bit) differential data pairs at the same time. The remaining bits are used for control signals as defined by SPWG/PSWG/VESA or JEIDA standards. The 24-bit RGB format serialized in seven time slots on four lanes using JEIDA defined bit mapping will be named `MEDIA_BUS_FMT_RGB888_1X7X4_JEIDA`, for example.

Table 146: LVDS RGB formats

Identifier	Code	Timeslot	Lane	Data organization			
				3	2	1	0
MEDIA_BUS_FMT_RGB666_1X7X3_SPWG	0x1010	0		d	b <sub>1</sub>	g <sub>0</sub>	
				d	b <sub>0</sub>	r <sub>5</sub>	
				d	g <sub>5</sub>	r <sub>4</sub>	
				b <sub>5</sub>	g <sub>4</sub>	r <sub>3</sub>	
				b <sub>4</sub>	g <sub>3</sub>	r <sub>2</sub>	
				b <sub>3</sub>	g <sub>2</sub>	r <sub>1</sub>	
				b <sub>2</sub>	g <sub>1</sub>	r <sub>0</sub>	
MEDIA_BUS_FMT_RGB888_1X7X4_SPWG	0x1011	0		d	d	b <sub>1</sub>	g <sub>0</sub>
				b <sub>7</sub>	d	b <sub>0</sub>	r <sub>5</sub>
				b <sub>6</sub>	d	g <sub>5</sub>	r <sub>4</sub>
				g <sub>7</sub>	b <sub>5</sub>	g <sub>4</sub>	r <sub>3</sub>
				g <sub>6</sub>	b <sub>4</sub>	g <sub>3</sub>	r <sub>2</sub>
				r <sub>7</sub>	b <sub>3</sub>	g <sub>2</sub>	r <sub>1</sub>
				r <sub>6</sub>	b <sub>2</sub>	g <sub>1</sub>	r <sub>0</sub>
MEDIA_BUS_FMT_RGB888_1X7X4_JEIDA	0x1012	0		d	d	b <sub>3</sub>	g <sub>2</sub>
				b <sub>1</sub>	d	b <sub>2</sub>	r <sub>7</sub>
				b <sub>0</sub>	d	g <sub>7</sub>	r <sub>6</sub>
				g <sub>1</sub>	b <sub>7</sub>	g <sub>6</sub>	r <sub>5</sub>
				g <sub>0</sub>	b <sub>6</sub>	g <sub>5</sub>	r <sub>4</sub>
				r <sub>1</sub>	b <sub>5</sub>	g <sub>4</sub>	r <sub>3</sub>
				r <sub>0</sub>	b <sub>4</sub>	g <sub>3</sub>	r <sub>2</sub>

## Bayer Formats

Those formats transfer pixel data as red, green and blue components. The format code is made of the following information.

- The red, green and blue components order code, as encoded in a pixel sample. The possible values are shown in *Figure 4.8 Bayer Patterns*.
- The number of bits per pixel component. All components are transferred on the same number of bits. Common values are 8, 10 and 12.
- The compression (optional). If the pixel components are ALAW- or DPCM-compressed, a mention of the compression scheme and the number of bits per compressed pixel component.
- The number of bus samples per pixel. Pixels that are wider than the bus width must be transferred in multiple samples. Common values are 1 and 2.
- The bus width.
- For formats where the total number of bits per pixel is smaller than the number of bus samples per pixel times the bus width, a padding value stating if the bytes are padded in their most high order bits (PADHI) or low order bits (PADLO).
- For formats where the number of bus samples per pixel is larger than 1, an endianness value stating if the pixel is transferred MSB first (BE) or LSB first (LE).

For instance, a format with uncompressed 10-bit Bayer components arranged in a red, green,

green, blue pattern transferred as 2 8-bit samples per pixel with the least significant bits transferred first will be named MEDIA\_BUS\_FMT\_SRGGB10\_2X8\_PADHI\_LE.

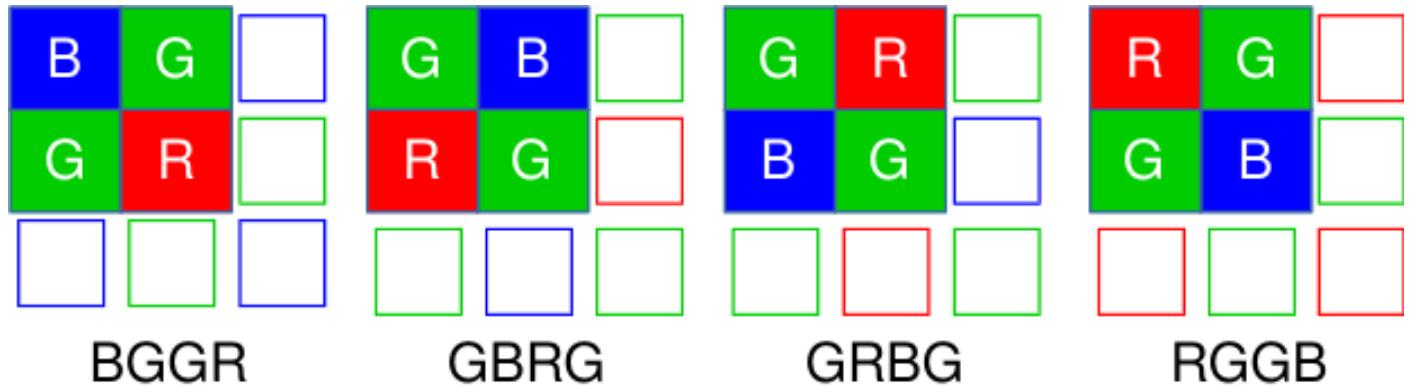


Fig. 17: **Figure 4.8** Bayer Patterns

The following table lists existing packed Bayer formats. The data organization is given as an example for the first pixel only.

Table 147: Bayer Formats

Identifier	Code	Data organization																	
		Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0	
MEDIA_BUS_FMT_SBGGR8_1X8	0x3001										b <sub>7</sub>	b <sub>6</sub>	b <sub>5</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>	b <sub>0</sub>	
MEDIA_BUS_FMT_SGBRG8_1X8	0x3013										g <sub>7</sub>	g <sub>6</sub>	g <sub>5</sub>	g <sub>4</sub>	g <sub>3</sub>	g <sub>2</sub>	g <sub>1</sub>	g <sub>0</sub>	
MEDIA_BUS_FMT_SGRBG8_1X8	0x3002										g <sub>7</sub>	g <sub>6</sub>	g <sub>5</sub>	g <sub>4</sub>	g <sub>3</sub>	g <sub>2</sub>	g <sub>1</sub>	g <sub>0</sub>	
MEDIA_BUS_FMT_SRGGB8_1X8	0x3014										r <sub>7</sub>	r <sub>6</sub>	r <sub>5</sub>	r <sub>4</sub>	r <sub>3</sub>	r <sub>2</sub>	r <sub>1</sub>	r <sub>0</sub>	
MEDIA_BUS_FMT_SBGGR10_ALAW8_1X8	0x3015										b <sub>7</sub>	b <sub>6</sub>	b <sub>5</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>	b <sub>0</sub>	
MEDIA_BUS_FMT_SGBRG10_ALAW8_1X8	0x3016										g <sub>7</sub>	g <sub>6</sub>	g <sub>5</sub>	g <sub>4</sub>	g <sub>3</sub>	g <sub>2</sub>	g <sub>1</sub>	g <sub>0</sub>	
MEDIA_BUS_FMT_SGRBG10_ALAW8_1X8	0x3017										g <sub>7</sub>	g <sub>6</sub>	g <sub>5</sub>	g <sub>4</sub>	g <sub>3</sub>	g <sub>2</sub>	g <sub>1</sub>	g <sub>0</sub>	
MEDIA_BUS_FMT_SRGGB10_ALAW8_1X8	0x3018										r <sub>7</sub>	r <sub>6</sub>	r <sub>5</sub>	r <sub>4</sub>	r <sub>3</sub>	r <sub>2</sub>	r <sub>1</sub>	r <sub>0</sub>	
MEDIA_BUS_FMT_SBGGR10_DPCM8_1X8	0x300b										b <sub>7</sub>	b <sub>6</sub>	b <sub>5</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>	b <sub>0</sub>	
MEDIA_BUS_FMT_SGBRG10_DPCM8_1X8	0x300c										g <sub>7</sub>	g <sub>6</sub>	g <sub>5</sub>	g <sub>4</sub>	g <sub>3</sub>	g <sub>2</sub>	g <sub>1</sub>	g <sub>0</sub>	
MEDIA_BUS_FMT_SGRBG10_DPCM8_1X8	0x3009										g <sub>7</sub>	g <sub>6</sub>	g <sub>5</sub>	g <sub>4</sub>	g <sub>3</sub>	g <sub>2</sub>	g <sub>1</sub>	g <sub>0</sub>	
MEDIA_BUS_FMT_SRGGB10_DPCM8_1X8	0x300d										r <sub>7</sub>	r <sub>6</sub>	r <sub>5</sub>	r <sub>4</sub>	r <sub>3</sub>	r <sub>2</sub>	r <sub>1</sub>	r <sub>0</sub>	
MEDIA_BUS_FMT_SBGGR10_2X8_PADHI_BE	0x3003										0	0	0	0	0	0	b <sub>9</sub>	b <sub>8</sub>	
MEDIA_BUS_FMT_SBGGR10_2X8_PADHI_LE	0x3004										b <sub>7</sub>	b <sub>6</sub>	b <sub>5</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	b <sub>1</sub>	b <sub>0</sub>	
MEDIA_BUS_FMT_SBGGR10_2X8_PADLO_BE	0x3005										0	0	0	0	0	0	b <sub>9</sub>	b <sub>8</sub>	
MEDIA_BUS_FMT_SBGGR10_2X8_PADLO_LE	0x3006										b <sub>9</sub>	b <sub>8</sub>	b <sub>7</sub>	b <sub>6</sub>	b <sub>5</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>2</sub>	
MEDIA_BUS_FMT_SBGGR10_1X10	0x3007										b <sub>9</sub>	b <sub>8</sub>	b <sub>7</sub>	b <sub>6</sub>	b <sub>5</sub>	b <sub>4</sub>	b <sub>3</sub>	b <sub>1</sub>	b <sub>0</sub>
MEDIA_BUS_FMT_SGBRG10_1X10	0x300e										g <sub>9</sub>	g <sub>8</sub>	g <sub>7</sub>	g <sub>6</sub>	g <sub>5</sub>	g <sub>4</sub>	g <sub>3</sub>	g <sub>1</sub>	g <sub>0</sub>
MEDIA_BUS_FMT_SGRBG10_1X10	0x300a										g <sub>9</sub>	g <sub>8</sub>	g <sub>7</sub>	g <sub>6</sub>	g <sub>5</sub>	g <sub>4</sub>	g <sub>3</sub>	g <sub>2</sub>	g <sub>0</sub>
MEDIA_BUS_FMT_SRGGB10_1X10	0x300f										r <sub>9</sub>	r <sub>8</sub>	r <sub>7</sub>	r <sub>6</sub>	r <sub>5</sub>	r <sub>4</sub>	r <sub>3</sub>	r <sub>1</sub>	r <sub>0</sub>
MEDIA_BUS_FMT_SBGGR12_1X12	0x3008										b <sub>1</sub>	b <sub>10</sub>	b <sub>9</sub>	b <sub>8</sub>	b <sub>7</sub>	b <sub>6</sub>	b <sub>5</sub>	b <sub>4</sub>	b <sub>3</sub>
MEDIA_BUS_FMT_SGBRG12_1X12	0x3010										g <sub>11</sub>	g <sub>10</sub>	g <sub>9</sub>	g <sub>8</sub>	g <sub>7</sub>	g <sub>6</sub>	g <sub>5</sub>	g <sub>4</sub>	g <sub>3</sub>
MEDIA_BUS_FMT_SGRBG12_1X12	0x3011										g <sub>11</sub>	g <sub>10</sub>	g <sub>9</sub>	g <sub>8</sub>	g <sub>7</sub>	g <sub>6</sub>	g <sub>5</sub>	g <sub>4</sub>	g <sub>3</sub>
MEDIA_BUS_FMT_SRGGB12_1X12	0x3012										r <sub>11</sub>	r <sub>10</sub>	r <sub>9</sub>	r <sub>8</sub>	r <sub>7</sub>	r <sub>6</sub>	r <sub>5</sub>	r <sub>4</sub>	r <sub>3</sub>
MEDIA_BUS_FMT_SBGGR14_1X14	0x3019										b <sub>13</sub>	b <sub>12</sub>	b <sub>11</sub>	b <sub>10</sub>	b <sub>9</sub>	b <sub>8</sub>	b <sub>7</sub>	b <sub>6</sub>	b <sub>5</sub>
MEDIA_BUS_FMT_SGBRG14_1X14	0x301a										g <sub>13</sub>	g <sub>12</sub>	g <sub>11</sub>	g <sub>10</sub>	g <sub>9</sub>	g <sub>8</sub>	g <sub>7</sub>	g <sub>6</sub>	g <sub>5</sub>

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Table 147 - continued from previous page

Identifier	Code	Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MEDIA_BUS_FMT_SGRBG14_1X14	0x301b				g13	g12	g11	g10	g9	g8	g7	g6	g5	g4	g3	g2	g1	g0
MEDIA_BUS_FMT_SRGGGB14_1X14	0x301c		r13	r12	r11	r10	r9	r8	r7	r6	r5	r4	r3	r2	r1	r0		
MEDIA_BUS_FMT_SBGRG16_1X16	0x301d	b15	b14	b13	b12	b11	b10	b9	b8	b7	b6	b5	b4	b3	b2	b1	b0	
MEDIA_BUS_FMT_SGBRG16_1X16	0x301e	g15	g14	g13	g12	g11	g10	g9	g8	g7	g6	g5	g4	g3	g2	g1	g0	
MEDIA_BUS_FMT_SGRBG16_1X16	0x301f	g15	g14	g13	g12	g11	g10	g9	g8	g7	g6	g5	g4	g3	g2	g1	g0	
MEDIA_BUS_FMT_SRGGGB16_1X16	0x3020	r15	r14	r13	r12	r11	r10	r9	r8	r7	r6	r5	r4	r3	r2	r1	r0	

## Packed YUV Formats

Those data formats transfer pixel data as (possibly downsampled) Y, U and V components. Some formats include dummy bits in some of their samples and are collectively referred to as "YDYC" (Y-Dummy-Y-Chroma) formats. One cannot rely on the values of these dummy bits as those are undefined.

The format code is made of the following information.

- The Y, U and V components order code, as transferred on the bus. Possible values are YUYV, UYVY, YVYU and VYUY for formats with no dummy bit, and YDYUYDYV, YDYVYDYU, YUYDYVYD and YVYDYUYD for YDYC formats.
- The number of bits per pixel component. All components are transferred on the same number of bits. Common values are 8, 10 and 12.
- The number of bus samples per pixel. Pixels that are wider than the bus width must be transferred in multiple samples. Common values are 0.5 (encoded as 0\_5; in this case two pixels are transferred per bus sample), 1, 1.5 (encoded as 1\_5) and 2.
- The bus width. When the bus width is larger than the number of bits per pixel component, several components are packed in a single bus sample. The components are ordered as specified by the order code, with components on the left of the code transferred in the high order bits. Common values are 8 and 16.

For instance, a format where pixels are encoded as 8-bit YUV values downsampled to 4:2:2 and transferred as 2 8-bit bus samples per pixel in the U, Y, V, Y order will be named `MEDIA_BUS_FMT_UYVY8_2X8`.

*YUV Formats* lists existing packed YUV formats and describes the organization of each pixel data in each sample. When a format pattern is split across multiple samples each of the samples in the pattern is described.

The role of each bit transferred over the bus is identified by one of the following codes.

- $y_x$  for luma component bit number x
- $u_x$  for blue chroma component bit number x
- $v_x$  for red chroma component bit number x
- $a_x$  for alpha component bit number x
- for non-available bits (for positions higher than the bus width)
- d for dummy bits

Table 148: YUV Formats

Identifier	Code	Bit 31	30	29	28	27	26	25	24	23	22	21	10	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0								
MEDIA_BUS_FMT_Y8_1X8	0x2001																								y7	y6	y5	y4	y3	y2	y1	y0									
MEDIA_BUS_FMT_UV8_1X8	0x2015																								u7	u6	u5	u4	u3	u2	u1	u0									
MEDIA_BUS_FMT_UYVY8_1_5X8	0x2002																								u7	u6	u5	u4	u3	u2	u1	u0									
																									y7	y6	y5	y4	y3	y2	y1	y0									
																									y7	y6	y5	y4	y3	y2	y1	y0									
																									y7	y6	y5	y4	y3	y2	y1	y0									
																									y7	y6	y5	y4	y3	y2	y1	y0									
MEDIA_BUS_FMT_VYUY8_1_5X8	0x2003																								v7	v6	v5	v4	v3	v2	v1	v0									
																									y7	y6	y5	y4	y3	y2	y1	y0									
																									y7	y6	y5	y4	y3	y2	y1	y0									
																									u7	u6	u5	u4	u3	u2	u1	u0									
																									y7	y6	y5	y4	y3	y2	y1	y0									
MEDIA_BUS_FMT_YUYV8_1_5X8	0x2004																								y7	y6	y5	y4	y3	y2	y1	y0									
																									y7	y6	y5	y4	y3	y2	y1	y0									
																									v7	v6	v5	v4	v3	v2	v1	v0									
																									y7	y6	y5	y4	y3	y2	y1	y0									
																									v7	v6	v5	v4	v3	v2	v1	v0									
MEDIA_BUS_FMT_VYVU8_1_5X8	0x2005																								y7	y6	y5	y4	y3	y2	y1	y0									
																									y7	y6	y5	y4	y3	y2	y1	y0									
																									v7	v6	v5	v4	v3	v2	v1	v0									
																									y7	y6	y5	y4	y3	y2	y1	y0									
MEDIA_BUS_FMT_UYVY8_2X8	0x2006																								u7	u6	u5	u4	u3	u2	u1	u0									
																									y7	y6	y5	y4	y3	y2	y1	y0									
																									v7	v6	v5	v4	v3	v2	v1	v0									
																									y7	y6	y5	y4	y3	y2	y1	y0									
MEDIA_BUS_FMT_VYUY8_2X8	0x2007																								v7	v6	v5	v4	v3	v2	v1	v0									
																									y7	y6	y5	y4	y3	y2	y1	y0									
																									u7	u6	u5	u4	u3	u2	u1	u0									
																									y7	y6	y5	y4	y3	y2	y1	y0									
MEDIA_BUS_FMT_YUYV8_2X8	0x2008																								v7	v6	v5	v4	v3	v2	v1	v0									
																									y7	y6	y5	y4	y3	y2	y1	y0									
																									v7	v6	v5	v4	v3	v2	v1	v0									
																									y7	y6	y5	y4	y3	y2	y1	y0									
MEDIA_BUS_FMT_YVYU8_2X8	0x2009																								y7	y6	y5	y4	y3	y2	y1	y0									
																									v7	v6	v5	v4	v3	v2	v1	v0									
																									y7	y6	y5	y4	y3	y2	y1	y0									
																									u7	u6	u5	u4	u3	u2	u1	u0									
MEDIA_BUS_FMT_Y10_1X10	0x200a																								y9	y8	y7	y6	y5	y4	y3	y2	y1	y0							
MEDIA_BUS_FMT_Y10_2X8_PADHI_LE	0x202c																								y7	y6	y5	y4	y3	y2	y1	y0									
																									0	0	0	0	0	0	0	y9	y8	y7	y6	y5	y4	y3	y2	y1	y0
MEDIA_BUS_FMT_UYVY10_2X10	0x2018																								u9	u8	u7	u6	u5	u4	u3	u2	u1	u0							
																									y9	y8	y7	y6	y5	y4	y3	y2	y1	y0							
																									v9	v8	v7	v6	v5	v4	v3	v2	v1	v0							
																									y9	y8	y7	y6	y5	y4	y3	y2	y1	y0							
																									u9	u8	u7	u6	u5	u4	u3	u2	u1	u0							
MEDIA_BUS_FMT_VYUY10_2X10	0x2019																								y9	y8	y7	y6	y5	y4	y3	y2	y1	y0							
																									v9	v8	v7	v6	v5	v4	v3	v2	v1	v0							
																									y9	y8	y7	y6	y5	y4	y3	y2	y1	y0							
																									v9	v8	v7	v6	v5	v4	v3	v2	v1	v0							
MEDIA_BUS_FMT_YVYU10_2X10	0x200c																								y9	y8	y7	y6	y5	y4	y3	y2	y1	y0							
																									v9	v8	v7	v6	v5	v4	v3	v2	v1	v0							
																									y9	y8	y7	y6	y5	y4	y3	y2	y1	y0							
																									u9	u8	u7	u6	u5	u4	u3	u2	u1	u0							
MEDIA_BUS_FMT_Y12_1X12	0x2013																								y11	y10	y9	y8	y7	y6	y5	y4	y3	y2	y1	y0					
MEDIA_BUS_FMT_UYVY12_2X12	0x201c																								u11	u10	u9	u8	u7	u6	u5	u4	u3	u2	u1	u0					
																									y11	y10	y9	y8	y7	y6	y5	y4	y3	y2	y1	y0					
																									V11	V10	V9	V8	V7	V6	V5	V4	V3	V2	V1	V0					
																									y11	y10	y9	y8	y7	y6	y5	y4	y3	y2	y1	y0					
MEDIA_BUS_FMT_VYUY12_2X12	0x201d																								V11	V10	V9	V8	V7	V6	V5	V4	V3	V2	V1	V0					
																									y11	y10	y9	y8	y7	y6	y5	y4	y3	y2	y1	y0					
																									u11	u10	u9	u8	u7	u6	u5	u4	u3	u2	u1	u0					
																									y11	y10	y9	y8	y7	y6	y5	y4	y3	y2	y1	y0					

continues on next page

Table 148 - continued from previous page

Identifier	Code	Data organization
	Bit 31 30 29 28 27 26 25 24 23 22 21 10 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	
MEDIA_BUS_FMT_YUYV12_2X12	0x201e	y <sub>11</sub> y <sub>10</sub> y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> u <sub>11</sub> u <sub>10</sub> u <sub>9</sub> u <sub>8</sub> u <sub>7</sub> u <sub>6</sub> u <sub>5</sub> u <sub>4</sub> u <sub>3</sub> u <sub>2</sub> u <sub>1</sub> u <sub>0</sub> y <sub>11</sub> y <sub>10</sub> y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> v <sub>11</sub> v <sub>10</sub> v <sub>9</sub> v <sub>8</sub> v <sub>7</sub> v <sub>6</sub> v <sub>5</sub> v <sub>4</sub> v <sub>3</sub> v <sub>2</sub> v <sub>1</sub> v <sub>0</sub>
MEDIA_BUS_FMT_YVYU12_2X12	0x201f	y <sub>11</sub> y <sub>10</sub> y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> v <sub>11</sub> v <sub>10</sub> v <sub>9</sub> v <sub>8</sub> v <sub>7</sub> v <sub>6</sub> v <sub>5</sub> v <sub>4</sub> v <sub>3</sub> v <sub>2</sub> v <sub>1</sub> v <sub>0</sub> y <sub>11</sub> y <sub>10</sub> y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> u <sub>11</sub> u <sub>10</sub> u <sub>9</sub> u <sub>8</sub> u <sub>7</sub> u <sub>6</sub> u <sub>5</sub> u <sub>4</sub> u <sub>3</sub> u <sub>2</sub> u <sub>1</sub> u <sub>0</sub>
MEDIA_BUS_FMT_Y14_1X14	0x202d	y <sub>13</sub> y <sub>12</sub> y <sub>11</sub> y <sub>10</sub> y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub>
MEDIA_BUS_FMT_Y16_1X16	0x202e	y <sub>15</sub> y <sub>14</sub> y <sub>13</sub> y <sub>12</sub> y <sub>11</sub> y <sub>10</sub> y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub>
MEDIA_BUS_FMT_UYVY8_1X16	0x200f	u <sub>7</sub> u <sub>6</sub> u <sub>5</sub> u <sub>4</sub> u <sub>3</sub> u <sub>2</sub> u <sub>1</sub> u <sub>0</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> v <sub>7</sub> v <sub>6</sub> v <sub>5</sub> v <sub>4</sub> v <sub>3</sub> v <sub>2</sub> v <sub>1</sub> v <sub>0</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub>
MEDIA_BUS_FMT_VYUY8_1X16	0x2010	v <sub>7</sub> v <sub>6</sub> v <sub>5</sub> v <sub>4</sub> v <sub>3</sub> v <sub>2</sub> v <sub>1</sub> v <sub>0</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> u <sub>7</sub> u <sub>6</sub> u <sub>5</sub> u <sub>4</sub> u <sub>3</sub> u <sub>2</sub> u <sub>1</sub> u <sub>0</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub>
MEDIA_BUS_FMT_YUYV8_1X16	0x2011	y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> u <sub>7</sub> u <sub>6</sub> u <sub>5</sub> u <sub>4</sub> u <sub>3</sub> u <sub>2</sub> u <sub>1</sub> u <sub>0</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> v <sub>7</sub> v <sub>6</sub> v <sub>5</sub> v <sub>4</sub> v <sub>3</sub> v <sub>2</sub> v <sub>1</sub> v <sub>0</sub>
MEDIA_BUS_FMT_YVYU8_1X16	0x2012	y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> v <sub>7</sub> v <sub>6</sub> v <sub>5</sub> v <sub>4</sub> v <sub>3</sub> v <sub>2</sub> v <sub>1</sub> v <sub>0</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> u <sub>7</sub> u <sub>6</sub> u <sub>5</sub> u <sub>4</sub> u <sub>3</sub> u <sub>2</sub> u <sub>1</sub> u <sub>0</sub>
MEDIA_BUS_FMT_YDYUYDYV8_1X16	0x2014	y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> d d d d d d d d y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> u <sub>7</sub> u <sub>6</sub> u <sub>5</sub> u <sub>4</sub> u <sub>3</sub> u <sub>2</sub> u <sub>1</sub> u <sub>0</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> v <sub>7</sub> v <sub>6</sub> v <sub>5</sub> v <sub>4</sub> v <sub>3</sub> v <sub>2</sub> v <sub>1</sub> v <sub>0</sub>
MEDIA_BUS_FMT_UYVY10_1X20	0x201a	u <sub>9</sub> u <sub>8</sub> u <sub>7</sub> u <sub>6</sub> u <sub>5</sub> u <sub>4</sub> u <sub>3</sub> u <sub>2</sub> u <sub>1</sub> u <sub>0</sub> y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> v <sub>9</sub> v <sub>8</sub> v <sub>7</sub> v <sub>6</sub> v <sub>5</sub> v <sub>4</sub> v <sub>3</sub> v <sub>2</sub> v <sub>1</sub> v <sub>0</sub> y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub>
MEDIA_BUS_FMT_VYUY10_1X20	0x201b	v <sub>9</sub> v <sub>8</sub> v <sub>7</sub> v <sub>6</sub> v <sub>5</sub> v <sub>4</sub> v <sub>3</sub> v <sub>2</sub> v <sub>1</sub> v <sub>0</sub> y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> u <sub>9</sub> u <sub>8</sub> u <sub>7</sub> u <sub>6</sub> u <sub>5</sub> u <sub>4</sub> u <sub>3</sub> u <sub>2</sub> u <sub>1</sub> u <sub>0</sub> y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub>
MEDIA_BUS_FMT_YUYV10_1X20	0x200d	y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> u <sub>9</sub> u <sub>8</sub> u <sub>7</sub> u <sub>6</sub> u <sub>5</sub> u <sub>4</sub> u <sub>3</sub> u <sub>2</sub> u <sub>1</sub> u <sub>0</sub> y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> v <sub>9</sub> v <sub>8</sub> v <sub>7</sub> v <sub>6</sub> v <sub>5</sub> v <sub>4</sub> v <sub>3</sub> v <sub>2</sub> v <sub>1</sub> v <sub>0</sub>
MEDIA_BUS_FMT_YVYU10_1X20	0x200e	y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> v <sub>9</sub> v <sub>8</sub> v <sub>7</sub> v <sub>6</sub> v <sub>5</sub> v <sub>4</sub> v <sub>3</sub> v <sub>2</sub> v <sub>1</sub> v <sub>0</sub> y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> u <sub>9</sub> u <sub>8</sub> u <sub>7</sub> u <sub>6</sub> u <sub>5</sub> u <sub>4</sub> u <sub>3</sub> u <sub>2</sub> u <sub>1</sub> u <sub>0</sub>
MEDIA_BUS_FMT_VUY8_1X24	0x201a	v <sub>7</sub> v <sub>6</sub> v <sub>5</sub> v <sub>4</sub> v <sub>3</sub> v <sub>2</sub> v <sub>1</sub> v <sub>0</sub> u <sub>7</sub> u <sub>6</sub> u <sub>5</sub> u <sub>4</sub> u <sub>3</sub> u <sub>2</sub> u <sub>1</sub> u <sub>0</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub>
MEDIA_BUS_FMT_YUV8_1X24	0x2025	y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> u <sub>7</sub> u <sub>6</sub> u <sub>5</sub> u <sub>4</sub> u <sub>3</sub> u <sub>2</sub> u <sub>1</sub> u <sub>0</sub> v <sub>7</sub> v <sub>6</sub> v <sub>5</sub> v <sub>4</sub> v <sub>3</sub> v <sub>2</sub> v <sub>1</sub> v <sub>0</sub>
MEDIA_BUS_FMT_UYYYYY8_0_5X24	0x2026	u <sub>7</sub> u <sub>6</sub> u <sub>5</sub> u <sub>4</sub> u <sub>3</sub> u <sub>2</sub> u <sub>1</sub> u <sub>0</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub>
MEDIA_BUS_FMT_UYVY12_1X24	0x2020	v <sub>7</sub> v <sub>6</sub> v <sub>5</sub> v <sub>4</sub> v <sub>3</sub> v <sub>2</sub> v <sub>1</sub> v <sub>0</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> u <sub>11</sub> u <sub>10</sub> u <sub>9</sub> u <sub>8</sub> u <sub>7</sub> u <sub>6</sub> u <sub>5</sub> u <sub>4</sub> u <sub>3</sub> u <sub>2</sub> u <sub>1</sub> u <sub>0</sub> y <sub>11</sub> y <sub>10</sub> y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub>
MEDIA_BUS_FMT_VYUY12_1X24	0x2021	v <sub>11</sub> v <sub>10</sub> v <sub>9</sub> v <sub>8</sub> v <sub>7</sub> v <sub>6</sub> v <sub>5</sub> v <sub>4</sub> v <sub>3</sub> v <sub>2</sub> v <sub>1</sub> v <sub>0</sub> y <sub>11</sub> y <sub>10</sub> y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> u <sub>11</sub> u <sub>10</sub> u <sub>9</sub> u <sub>8</sub> u <sub>7</sub> u <sub>6</sub> u <sub>5</sub> u <sub>4</sub> u <sub>3</sub> u <sub>2</sub> u <sub>1</sub> u <sub>0</sub> y <sub>11</sub> y <sub>10</sub> y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub>
MEDIA_BUS_FMT_YUYV12_1X24	0x2022	y <sub>11</sub> y <sub>10</sub> y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> u <sub>11</sub> u <sub>10</sub> u <sub>9</sub> u <sub>8</sub> u <sub>7</sub> u <sub>6</sub> u <sub>5</sub> u <sub>4</sub> u <sub>3</sub> u <sub>2</sub> u <sub>1</sub> u <sub>0</sub> y <sub>11</sub> y <sub>10</sub> y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> v <sub>11</sub> v <sub>10</sub> v <sub>9</sub> v <sub>8</sub> v <sub>7</sub> v <sub>6</sub> v <sub>5</sub> v <sub>4</sub> v <sub>3</sub> v <sub>2</sub> v <sub>1</sub> v <sub>0</sub>
MEDIA_BUS_FMT_YVYU12_1X24	0x2023	y <sub>11</sub> y <sub>10</sub> y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> y <sub>11</sub> y <sub>10</sub> y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> y <sub>11</sub> y <sub>10</sub> y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> v <sub>11</sub> v <sub>10</sub> v <sub>9</sub> v <sub>8</sub> v <sub>7</sub> v <sub>6</sub> v <sub>5</sub> v <sub>4</sub> v <sub>3</sub> v <sub>2</sub> v <sub>1</sub> v <sub>0</sub>
MEDIA_BUS_FMT_YUV10_1X30	0x2016	y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> u <sub>9</sub> u <sub>8</sub> u <sub>7</sub> u <sub>6</sub> u <sub>5</sub> u <sub>4</sub> u <sub>3</sub> u <sub>2</sub> u <sub>1</sub> u <sub>0</sub> v <sub>8</sub> v <sub>7</sub> v <sub>6</sub> v <sub>5</sub> v <sub>4</sub> v <sub>3</sub> v <sub>2</sub> v <sub>1</sub> v <sub>0</sub>
MEDIA_BUS_FMT_UYYYYY10_0_5X30	0x2027	u <sub>9</sub> u <sub>8</sub> u <sub>7</sub> u <sub>6</sub> u <sub>5</sub> u <sub>4</sub> u <sub>3</sub> u <sub>2</sub> u <sub>1</sub> u <sub>0</sub> y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> v <sub>9</sub> v <sub>8</sub> v <sub>7</sub> v <sub>6</sub> v <sub>5</sub> v <sub>4</sub> v <sub>3</sub> v <sub>2</sub> v <sub>1</sub> v <sub>0</sub> y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub>
MEDIA_BUS_FMT_AYUV8_1X32	0x2017	a <sub>7</sub> a <sub>6</sub> a <sub>5</sub> a <sub>4</sub> a <sub>3</sub> a <sub>2</sub> a <sub>1</sub> a <sub>0</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> u <sub>7</sub> u <sub>6</sub> u <sub>5</sub> u <sub>4</sub> u <sub>3</sub> u <sub>2</sub> u <sub>1</sub> u <sub>0</sub> v <sub>7</sub> v <sub>6</sub> v <sub>5</sub> v <sub>4</sub> v <sub>3</sub> v <sub>2</sub> v <sub>1</sub> v <sub>0</sub>

The following table list existing packed 36bit wide YUV formats.

Table 149: 36bit YUV Formats

Identifier	Code	Data organization
	Bit 35 34 33 32 31 30 29 28 27 26 25 24 23 22 21 20 19 18 17 16 15 14 13 12 11 10 9 8 7 6 5 4 3 2 1 0	
MEDIA_BUS_FMT_UYYYYY12_0_5X36	0x2028	u <sub>11</sub> u <sub>10</sub> u <sub>9</sub> u <sub>8</sub> u <sub>7</sub> u <sub>6</sub> u <sub>5</sub> u <sub>4</sub> u <sub>3</sub> u <sub>2</sub> u <sub>1</sub> u <sub>0</sub> y <sub>11</sub> y <sub>10</sub> y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> v <sub>11</sub> v <sub>10</sub> v <sub>9</sub> v <sub>8</sub> v <sub>7</sub> v <sub>6</sub> v <sub>5</sub> v <sub>4</sub> v <sub>3</sub> v <sub>2</sub> v <sub>1</sub> v <sub>0</sub> y <sub>11</sub> y <sub>10</sub> y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub>
MEDIA_BUS_FMT_YUV12_1X36	0x2029	y <sub>11</sub> y <sub>10</sub> y <sub>9</sub> y <sub>8</sub> y <sub>7</sub> y <sub>6</sub> y <sub>5</sub> y <sub>4</sub> y <sub>3</sub> y <sub>2</sub> y <sub>1</sub> y <sub>0</sub> u <sub>11</sub> u <sub>10</sub> u <sub>9</sub> u <sub>8</sub> u <sub>7</sub> u <sub>6</sub> u <sub>5</sub> u <sub>4</sub> u <sub>3</sub> u <sub>2</sub> u <sub>1</sub> u <sub>0</sub> v <sub>11</sub> v <sub>10</sub> v <sub>9</sub> v <sub>8</sub> v <sub>7</sub> v <sub>6</sub> v <sub>5</sub> v <sub>4</sub> v <sub>3</sub> v <sub>2</sub> v <sub>1</sub> v <sub>0</sub>

The following table list existing packed 48bit wide YUV formats.

Table 150: 48bit YUV Formats

Identifier	Code	Bit	Data organization																															
			31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MEDIA_BUS_FMT_YUV16_1X48	0x202a		u <sub>15</sub>	u <sub>14</sub>	u <sub>13</sub>	u <sub>12</sub>	u <sub>11</sub>	u <sub>10</sub>	u <sub>9</sub>	u <sub>8</sub>	u <sub>7</sub>	u <sub>6</sub>	u <sub>5</sub>	u <sub>4</sub>	u <sub>3</sub>	u <sub>2</sub>	u <sub>1</sub>	u <sub>0</sub>	y <sub>15</sub>	y <sub>14</sub>	y <sub>13</sub>	y <sub>12</sub>	y <sub>11</sub>	y <sub>10</sub>	y <sub>8</sub>	y <sub>8</sub>	y <sub>7</sub>	y <sub>6</sub>	y <sub>5</sub>	y <sub>4</sub>	y <sub>3</sub>	y <sub>2</sub>	y <sub>1</sub>	y <sub>0</sub>
MEDIA_BUS_FMT_UYYYYY16_0_5X48	0x202b		y <sub>15</sub>	y <sub>14</sub>	y <sub>13</sub>	y <sub>12</sub>	y <sub>11</sub>	y <sub>10</sub>	y <sub>9</sub>	y <sub>8</sub>	y <sub>7</sub>	y <sub>6</sub>	y <sub>5</sub>	y <sub>4</sub>	y <sub>3</sub>	y <sub>2</sub>	y <sub>1</sub>	y <sub>0</sub>	y <sub>15</sub>	y <sub>14</sub>	y <sub>13</sub>	y <sub>12</sub>	y <sub>11</sub>	y <sub>10</sub>	y <sub>8</sub>	y <sub>8</sub>	y <sub>7</sub>	y <sub>6</sub>	y <sub>5</sub>	y <sub>4</sub>	y <sub>3</sub>	y <sub>2</sub>	y <sub>1</sub>	y <sub>0</sub>
			y <sub>15</sub>	y <sub>14</sub>	y <sub>13</sub>	y <sub>12</sub>	y <sub>11</sub>	y <sub>10</sub>	y <sub>9</sub>	y <sub>8</sub>	y <sub>7</sub>	y <sub>6</sub>	y <sub>5</sub>	y <sub>4</sub>	y <sub>3</sub>	y <sub>2</sub>	y <sub>1</sub>	y <sub>0</sub>	y <sub>15</sub>	y <sub>14</sub>	y <sub>13</sub>	y <sub>12</sub>	y <sub>11</sub>	y <sub>10</sub>	y <sub>8</sub>	y <sub>8</sub>	y <sub>7</sub>	y <sub>6</sub>	y <sub>5</sub>	y <sub>4</sub>	y <sub>3</sub>	y <sub>2</sub>	y <sub>1</sub>	y <sub>0</sub>

## HSV/HSL Formats

Those formats transfer pixel data as RGB values in a cylindrical-coordinate system using Hue-Saturation-Value or Hue-Saturation-Lightness components. The format code is made of the following information.

- The hue, saturation, value or lightness and optional alpha components order code, as encoded in a pixel sample. The only currently supported value is AHSV.
- The number of bits per component, for each component. The values can be different for all components. The only currently supported value is 8888.
- The number of bus samples per pixel. Pixels that are wider than the bus width must be transferred in multiple samples. The only currently supported value is 1.
- The bus width.
- For formats where the total number of bits per pixel is smaller than the number of bus samples per pixel times the bus width, a padding value stating if the bytes are padded in their most high order bits (PADHI) or low order bits (PADLO).
- For formats where the number of bus samples per pixel is larger than 1, an endianness value stating if the pixel is transferred MSB first (BE) or LSB first (LE).

The following table lists existing HSV/HSL formats.

Table 151: HSV/HSL formats

Identifier	Code	Bit	Data organization																															
			31	30	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
MEDIA_BUS_FMT_AHSV8888_1X32	0x6001		a <sub>7</sub>	a <sub>6</sub>	a <sub>5</sub>	a <sub>4</sub>	a <sub>3</sub>	a <sub>2</sub>	a <sub>1</sub>	a <sub>0</sub>	h <sub>7</sub>	h <sub>6</sub>	h <sub>5</sub>	h <sub>4</sub>	h <sub>3</sub>	h <sub>2</sub>	h <sub>1</sub>	h <sub>0</sub>	s <sub>7</sub>	s <sub>6</sub>	s <sub>5</sub>	s <sub>4</sub>	s <sub>3</sub>	s <sub>2</sub>	s <sub>1</sub>	s <sub>0</sub>	v <sub>7</sub>	v <sub>6</sub>	v <sub>5</sub>	v <sub>4</sub>	v <sub>3</sub>	v <sub>2</sub>	v <sub>1</sub>	v <sub>0</sub>

## JPEG Compressed Formats

Those data formats consist of an ordered sequence of 8-bit bytes obtained from JPEG compression process. Additionally to the \_JPEG postfix the format code is made of the following information.

- The number of bus samples per entropy encoded byte.
- The bus width.

For instance, for a JPEG baseline process and an 8-bit bus width the format will be named MEDIA\_BUS\_FMT\_JPEG\_1X8.

The following table lists existing JPEG compressed formats.

Table 152: JPEG Formats

Identifier	Code	Remarks
MEDIA_BUS_FMT_JPEG_1X8	0x4001	Besides of its usage for the parallel bus this format is recommended for transmission of JPEG data over MIPI CSI bus using the User Defined 8-bit Data types.

## Vendor and Device Specific Formats

This section lists complex data formats that are either vendor or device specific.

The following table lists the existing vendor and device specific formats.

Table 153: Vendor and device specific formats

Identifier	Code	Comments
MEDIA_BUS_FMT_S5C_UYVY_JPEG_1X8	0x5001	Interleaved raw UYVY and JPEG image format with embedded meta-data used by Samsung S3C73MX camera sensors.

## Metadata Formats

This section lists all metadata formats.

The following table lists the existing metadata formats.

Table 154: Metadata formats

Identifier	Code	Comments
MEDIA_BUS_FMT_METADATA_FIXED	0x7001	This format should be used when the same driver handles both sides of the link and the bus format is a fixed metadata format that is not configurable from userspace. Width and height will be set to 0 for this format.

## Streams, multiplexed media pads and internal routing

Simple V4L2 sub-devices do not support multiple, unrelated video streams, and only a single stream can pass through a media link and a media pad. Thus each pad contains a format and selection configuration for that single stream. A subdev can do stream processing and split a stream into two or compose two streams into one, but the inputs and outputs for the subdev are still a single stream per pad.

Some hardware, e.g. MIPI CSI-2, support multiplexed streams, that is, multiple data streams are transmitted on the same bus, which is represented by a media link connecting a transmitter

source pad with a sink pad on the receiver. For example, a camera sensor can produce two distinct streams, a pixel stream and a metadata stream, which are transmitted on the multiplexed data bus, represented by a media link which connects the single sensor's source pad with the receiver sink pad. The stream-aware receiver will de-multiplex the streams received on its sink pad and allows to route them individually to one of its source pads.

Subdevice drivers that support multiplexed streams are compatible with non-multiplexed sub-dev drivers, but, of course, require a routing configuration where the link between those two types of drivers contains only a single stream.

## Understanding streams

A stream is a stream of content (e.g. pixel data or metadata) flowing through the media pipeline from a source (e.g. a sensor) towards the final sink (e.g. a receiver and demultiplexer in a SoC). Each media link carries all the enabled streams from one end of the link to the other, and sub-devices have routing tables which describe how the incoming streams from sink pads are routed to the source pads.

A stream ID is a media pad-local identifier for a stream. Stream IDs of the same stream must be equal on both ends of a link. In other words, a particular stream ID must exist on both sides of a media link, but another stream ID can be used for the same stream at the other side of the sub-device.

A stream at a specific point in the media pipeline is identified by the sub-device and a (pad, stream) pair. For sub-devices that do not support multiplexed streams the 'stream' field is always 0.

## Interaction between routes, streams, formats and selections

The addition of streams to the V4L2 sub-device interface moves the sub-device formats and selections from pads to (pad, stream) pairs. Besides the usual pad, also the stream ID needs to be provided for setting formats and selections. The order of configuring formats and selections along a stream is the same as without streams (see [Order of configuration and format propagation](#)).

Instead of the sub-device wide merging of streams from all sink pads towards all source pads, data flows for each route are separate from each other. Any number of routes from streams on sink pads towards streams on source pads is allowed, to the extent supported by drivers. For every stream on a source pad, however, only a single route is allowed.

Any configurations of a stream within a pad, such as format or selections, are independent of similar configurations on other streams. This is subject to change in the future.

## Configuring streams

The configuration of the streams is done individually for each sub-device and the validity of the streams between sub-devices is validated when the pipeline is started.

There are three steps in configuring the streams:

1. Set up links. Connect the pads between sub-devices using the [Media Controller API](#)
2. Streams. Streams are declared and their routing is configured by setting the routing table for the sub-device using [`VIDIOC\_SUBDEV\_S\_ROUTING`](#) ioctl. Note that setting the routing table will reset formats and selections in the sub-device to default values.
3. Configure formats and selections. Formats and selections of each stream are configured separately as documented for plain sub-devices in [\*Order of configuration and format propagation\*](#). The stream ID is set to the same stream ID associated with either sink or source pads of routes configured using the [`VIDIOC\_SUBDEV\_S\_ROUTING`](#) ioctl.

## Multiplexed streams setup example

A simple example of a multiplexed stream setup might be as follows:

- Two identical sensors (Sensor A and Sensor B). Each sensor has a single source pad (pad 0) which carries a pixel data stream.
- Multiplexer bridge (Bridge). The bridge has two sink pads, connected to the sensors (pads 0, 1), and one source pad (pad 2), which outputs two streams.
- Receiver in the SoC (Receiver). The receiver has a single sink pad (pad 0), connected to the bridge, and two source pads (pads 1-2), going to the DMA engine. The receiver demultiplexes the incoming streams to the source pads.
- DMA Engines in the SoC (DMA Engine), one for each stream. Each DMA engine is connected to a single source pad in the receiver.

The sensors, the bridge and the receiver are modeled as V4L2 sub-devices, exposed to userspace via /dev/v4l-subdevX device nodes. The DMA engines are modeled as V4L2 devices, exposed to userspace via /dev/videoX nodes.

To configure this pipeline, the userspace must take the following steps:

1. Set up media links between entities: connect the sensors to the bridge, bridge to the receiver, and the receiver to the DMA engines. This step does not differ from normal non-multiplexed media controller setup.
2. Configure routing

Table 155: Bridge routing table

Sink Pad/Stream	Source Pad/Stream	Routing Flags	Comments
0/0	2/0	V4L2_SUBDEV_ROUTE_FL	AC3xM1 Data stream from Sensor A
1/0	2/1	V4L2_SUBDEV_ROUTE_FL	AC3xM1 Data stream from Sensor B

Table 156: Receiver routing table

Sink Pad/Stream	Source Pad/Stream	Routing Flags	Comments
0/0	1/0	V4L2_SUBDEV_ROUTE_FL	ACTIVE Data stream from Sensor A
0/1	2/0	V4L2_SUBDEV_ROUTE_FL	ACTIVE Data stream from Sensor B

### 3. Configure formats and selections

After configuring routing, the next step is configuring the formats and selections for the streams. This is similar to performing this step without streams, with just one exception: the `stream` field needs to be assigned to the value of the stream ID.

A common way to accomplish this is to start from the sensors and propagate the configurations along the stream towards the receiver, using `VIDIOC_SUBDEV_S_FMT` ioctls to configure each stream endpoint in each sub-device.

## Metadata Interface

Metadata refers to any non-image data that supplements video frames with additional information. This may include statistics computed over the image, frame capture parameters supplied by the image source or device specific parameters for specifying how the device processes images. This interface is intended for transfer of metadata between the userspace and the hardware and control of that operation.

The metadata interface is implemented on video device nodes. The device can be dedicated to metadata or can support both video and metadata as specified in its reported capabilities.

## Querying Capabilities

Device nodes supporting the metadata capture interface set the `V4L2_CAP_META_CAPTURE` flag in the `device_caps` field of the `v4l2_capability` structure returned by the `VIDIOC_QUERYCAP()` ioctl. That flag means the device can capture metadata to memory. Similarly, device nodes supporting metadata output interface set the `V4L2_CAP_META_OUTPUT` flag in the `device_caps` field of `v4l2_capability` structure. That flag means the device can read metadata from memory.

At least one of the read/write or streaming I/O methods must be supported.

## Data Format Negotiation

The metadata device uses the `Data Formats` ioctls to select the capture format. The metadata buffer content format is bound to that selected format. In addition to the basic `Data Formats` ioctls, the `VIDIOC_ENUM_FMT()` ioctl must be supported as well.

To use the `Data Formats` ioctls applications set the `type` field of the `v4l2_format` structure to `V4L2_BUF_TYPE_META_CAPTURE` or to `V4L2_BUF_TYPE_META_OUTPUT` and use the `v4l2_meta_format` meta member of the `fmt` union as needed per the desired operation. Both drivers and applications must set the remainder of the `v4l2_format` structure to 0.

type **v4l2\_meta\_format**

Table 157: struct v4l2\_meta\_format

<code>_u32</code>	<code>dataformat</code>	The data format, set by the application. This is a little endian <i>four character code</i> . V4L2 defines metadata formats in <a href="#">Metadata Formats</a> .
<code>_u32</code>	<code>buffersize</code>	Maximum buffer size in bytes required for data. The value is set by the driver.

## 13.2.5 Libv4l Userspace Library

### Introduction

libv4l is a collection of libraries which adds a thin abstraction layer on top of video4linux2 devices. The purpose of this (thin) layer is to make it easy for application writers to support a wide variety of devices without having to write separate code for different devices in the same class.

An example of using libv4l is provided by [v4l2grab](#).

libv4l consists of 3 different libraries:

### libv4lconvert

libv4lconvert is a library that converts several different pixelformats found in V4L2 drivers into a few common RGB and YUY formats.

It currently accepts the following V4L2 driver formats:

`V4L2_PIX_FMT_NV12_16L16`,  
`V4L2_PIX_FMT_MR97310A`,  
`V4L2_PIX_FMT_PAC207`,  
`V4L2_PIX_FMT_SBGGR8`,  
`V4L2_PIX_FMT_SN9C10X`,  
`V4L2_PIX_FMT_SPCA505`,  
`V4L2_PIX_FMT_SQ905C`,  
`V4L2_PIX_FMT_YUV420`,  
`V4L2_PIX_FMT_YVYU`.

`V4L2_PIX_FMT_JPEG`,  
`V4L2_PIX_FMT_OV511`,  
`V4L2_PIX_FMT_PJPG`,  
`V4L2_PIX_FMT_SGBRG8`,  
`V4L2_PIX_FMT_SN9C20X_I420`,  
`V4L2_PIX_FMT_SPCA508`,  
`V4L2_PIX_FMT_SRGGB8`,  
`V4L2_PIX_FMT_YUYV`,

`V4L2_PIX_FMT_BGR24`,  
`V4L2_PIX_FMT_MJPEG`,  
`V4L2_PIX_FMT_OV518`,  
`V4L2_PIX_FMT_RGB24`,  
`V4L2_PIX_FMT_SGRBG8`,  
`V4L2_PIX_FMT_SPCA501`,  
`V4L2_PIX_FMT_SPCA561`,  
`V4L2_PIX_FMT_UYVY`,  
`V4L2_PIX_FMT_YVU420`, and

Later on libv4lconvert was expanded to also be able to do various video processing functions to improve webcam video quality. The video processing is split in to 2 parts: libv4lconvert/control and libv4lconvert/processing.

The control part is used to offer video controls which can be used to control the video processing functions made available by libv4lconvert/processing. These controls are stored application wide (until reboot) by using a persistent shared memory object.

libv4lconvert/processing offers the actual video processing functionality.

## libv4l1

This library offers functions that can be used to quickly make v4l1 applications work with v4l2 devices. These functions work exactly like the normal open/close/etc, except that libv4l1 does full emulation of the v4l1 api on top of v4l2 drivers, in case of v4l1 drivers it will just pass calls through.

Since those functions are emulations of the old V4L1 API, it shouldn't be used for new applications.

## libv4l2

This library should be used for all modern V4L2 applications.

It provides handles to call V4L2 open/ioctl/close/poll methods. Instead of just providing the raw output of the device, it enhances the calls in the sense that it will use libv4lconvert to provide more video formats and to enhance the image quality.

In most cases, libv4l2 just passes the calls directly through to the v4l2 driver, intercepting the calls to `VIDIOC_TRY_FMT`, `VIDIOC_G_FMT`, `VIDIOC_S_FMT`, `VIDIOC_ENUM_FRAMESIZES` and `VIDIOC_ENUM_FRAMEINTERVALS` in order to emulate the formats `V4L2_PIX_FMT_BGR24`, `V4L2_PIX_FMT_RGB24`, `V4L2_PIX_FMT_YUV420`, and `V4L2_PIX_FMT_YVU420`, if they aren't available in the driver. `VIDIOC_ENUM_FMT` keeps enumerating the hardware supported formats, plus the emulated formats offered by libv4l at the end.

## Libv4l device control functions

The common file operation methods are provided by libv4l.

Those functions operate just like the gcc function `dup()` and V4L2 functions `open()`, `close()`, `ioctl()`, `read()`, `mmap()` and `munmap()`:

`int v4l2_open(const char *file, int oflag, ...)`

operates like the `open()` function.

`int v4l2_close(int fd)`

operates like the `close()` function.

`int v4l2_dup(int fd)`

operates like the libc `dup()` function, duplicating a file handler.

`int v4l2_ioctl(int fd, unsigned long int request, ...)`

operates like the `ioctl()` function.

`int v4l2_read(int fd, void *buffer, size_t n)`

operates like the `read()` function.

`void *v4l2_mmap(void *start, size_t length, int prot, int flags, int fd, int64_t offset);`

operates like the `mmap()` function.

```
int v4l2_munmap(void *_start, size_t length);
```

operates like the [munmap\(\)](#) function.

Those functions provide additional control:

```
int v4l2_fd_open(int fd, int v4l2_flags)
```

opens an already opened fd for further use through v4l2lib and possibly modify libv4l2's default behavior through the `v4l2_flags` argument. Currently, `v4l2_flags` can be `V4L2_DISABLE_CONVERSION`, to disable format conversion.

```
int v4l2_set_control(int fd, int cid, int value)
```

This function takes a value of 0 - 65535, and then scales that range to the actual range of the given v4l control id, and then if the cid exists and is not locked sets the cid to the scaled value.

```
int v4l2_get_control(int fd, int cid)
```

This function returns a value of 0 - 65535, scaled to from the actual range of the given v4l control id. when the cid does not exist, could not be accessed for some reason, or some error occurred 0 is returned.

### **v4l1compat.so wrapper library**

This library intercepts calls to `open()`, `close()`, `ioctl()`, `mmap()` and `munmap()` operations and redirects them to the libv4l counterparts, by using `LD_PRELOAD=/usr/lib/v4l1compat.so`. It also emulates V4L1 calls via V4L2 API.

It allows usage of binary legacy applications that still don't use libv4l.

### **13.2.6 Changes**

The following chapters document the evolution of the V4L2 API, errata or extensions. They are also intended to help application and driver writers to port or update their code.

### **Differences between V4L and V4L2**

The Video For Linux API was first introduced in Linux 2.1 to unify and replace various TV and radio device related interfaces, developed independently by driver writers in prior years. Starting with Linux 2.5 the much improved V4L2 API replaces the V4L API. The support for the old V4L calls were removed from Kernel, but the library [Libv4l Userspace Library](#) supports the conversion of a V4L API system call into a V4L2 one.

### **Opening and Closing Devices**

For compatibility reasons the character device file names recommended for V4L2 video capture, overlay, radio and raw vbi capture devices did not change from those used by V4L. They are listed in [Interfaces](#) and below in [V4L Device Types, Names and Numbers](#).

The teletext devices (minor range 192-223) have been removed in V4L2 and no longer exist. There is no hardware available anymore for handling pure teletext. Instead raw or sliced VBI is used.

The V4L videodev module automatically assigns minor numbers to drivers in load order, depending on the registered device type. We recommend that V4L2 drivers by default register devices with the same numbers, but the system administrator can assign arbitrary minor numbers using driver module options. The major device number remains 81.

Table 158: V4L Device Types, Names and Numbers

Device Type	File Name	Minor Numbers
Video capture and overlay	/dev/video and /dev/bttv0 <sup>1</sup> , /dev/video0 to /dev/video63	0-63
Radio receiver	/dev/radio <sup>2</sup> , /dev/radio0 to /dev/radio63	64-127
Raw VBI capture	/dev/vbi, /dev/vbi0 to /dev/vbi31	224-255

V4L prohibits (or used to prohibit) multiple opens of a device file. V4L2 drivers *may* support multiple opens, see [Opening and Closing Devices](#) for details and consequences.

V4L drivers respond to V4L2 ioctls with an EINVAL error code.

## Querying Capabilities

The V4L VIDIOC\_G\_CCAP ioctl is equivalent to V4L2's [ioctl VIDIOC\\_QUERYCAP](#).

The name field in struct `video_capability` became `card` in struct `v4l2_capability`, type was replaced by capabilities. Note V4L2 does not distinguish between device types like this, better think of basic video input, video output and radio devices supporting a set of related functions like video capturing, video overlay and VBI capturing. See [Opening and Closing Devices](#) for an introduction.

struct <code>video_capability</code> type	struct <code>v4l2_capability</code> capabilities flags	Purpose
VID_TYPE_CAPTURE	V4L2_CAP_VIDEO_CAPTURE	The <code>video capture</code> interface is supported.
VID_TYPE_TUNER	V4L2_CAP_TUNER	The device has a <code>tuner or modulator</code> .
VID_TYPE_TELETEXT	V4L2_CAP_VBI_CAPTURE	The <code>raw VBI capture</code> interface is supported.
VID_TYPE_OVERLAY	V4L2_CAP_VIDEO_OVERLAY	The <code>video overlay</code> interface is supported.
VID_TYPE_CHROMAKEY	V4L2_FBUF_CAP_CHROMAKEY in field <code>capability</code> of struct <code>v4l2_framebuffer</code>	Whether chromakey overlay is supported. For more information on overlay see <a href="#">Video Overlay Interface</a> .
VID_TYPE_CLIPPING	V4L2_FBUF_CAP_LIST_CLIPPING and V4L2_FBUF_CAP_BITMAP_CLIPPING in field <code>capability</code> of struct <code>v4l2_framebuffer</code>	Whether clipping the overlaid image is supported, see <a href="#">Video Overlay Interface</a> .
VID_TYPE_FRAMERAM	V4L2_FBUF_CAP_EXTERNOVERLAY not set in field <code>capability</code> of struct <code>v4l2_framebuffer</code>	Whether overlay overwrites frame buffer memory, see <a href="#">Video Overlay Interface</a> .

continues on next page

<sup>1</sup> According to Documentation/admin-guide/devices.rst these should be symbolic links to /dev/video0. Note the original bttv interface is not compatible with V4L or V4L2.

<sup>2</sup> According to Documentation/admin-guide/devices.rst a symbolic link to /dev/radio0.

Table 159 – continued from previous page

<code>struct video_capability type</code>	<code>struct v4l2_capability capabilities flags</code>	Purpose
<code>VID_TYPE_SCALES</code>	-	This flag indicates if the hardware can scale images. The V4L2 API implies the scale factor by setting the cropping dimensions and image size with the <code>VIDIOC_S_CROP</code> and <code>VIDIOC_S_FMT</code> ioctl, respectively. The driver returns the closest sizes possible. For more information on cropping and scaling see <a href="#">Image Cropping, Insertion and Scaling -- the CROP API</a> .
<code>VID_TYPE_MONOCHROME</code>	-	Applications can enumerate the supported image formats with the <code>ioctl VIDIOC_ENUM_FMT</code> ioctl to determine if the device supports grey scale capturing only. For more information on image formats see <a href="#">Image Formats</a> .
<code>VID_TYPE_SUBCAPTURE</code>	-	Applications can call the <code>VIDIOC_G_CROP</code> ioctl to determine if the device supports capturing a subsection of the full picture ("cropping" in V4L2). If not, the ioctl returns the EINVAL error code. For more information on cropping and scaling see <a href="#">Image Cropping, Insertion and Scaling -- the CROP API</a> .
<code>VID_TYPE_MPEG_DECODER</code>	-	Applications can enumerate the supported image formats with the <code>ioctl VIDIOC_ENUM_FMT</code> ioctl to determine if the device supports MPEG streams.
<code>VID_TYPE_MPEG_ENCODER</code>	-	See above.
<code>VID_TYPE_MJPEG_DECODER</code>	-	See above.
<code>VID_TYPE_MJPEG_ENCODER</code>	-	See above.

The `audios` field was replaced by `capabilities` flag `V4L2_CAP_AUDIO`, indicating *if* the device has any audio inputs or outputs. To determine their number applications can enumerate audio inputs with the `VIDIOC_G_AUDIO` ioctl. The audio ioctls are described in [Audio Inputs and Outputs](#).

The `maxwidth`, `maxheight`, `minwidth` and `minheight` fields were removed. Calling the `VIDIOC_S_FMT` or `VIDIOC_TRY_FMT` ioctl with the desired dimensions returns the closest size possible, taking into account the current video standard, cropping and scaling limitations.

## Video Sources

V4L provides the VIDIOCGCHAN and VIDIOCSCHAN ioctl using struct `video_channel` to enumerate the video inputs of a V4L device. The equivalent V4L2 ioctls are `ioctl VIDIOC_ENUMINPUT`, `VIDIOC_G_INPUT` and `VIDIOC_S_INPUT` using struct `v4l2_input` as discussed in [Video Inputs and Outputs](#).

The channel field counting inputs was renamed to `index`, the video input types were renamed as follows:

struct <code>video_channel</code> type	struct <code>v4l2_input</code> type
<code>VIDEO_TYPE_TV</code>	<code>V4L2_INPUT_TYPE_TUNER</code>
<code>VIDEO_TYPE_CAMERA</code>	<code>V4L2_INPUT_TYPE_CAMERA</code>

Unlike the `tuners` field expressing the number of tuners of this input, V4L2 assumes each video input is connected to at most one tuner. However a tuner can have more than one input, i. e. RF connectors, and a device can have multiple tuners. The index number of the tuner associated with the input, if any, is stored in field `tuner` of struct `v4l2_input`. Enumeration of tuners is discussed in [Tuners and Modulators](#).

The redundant `VIDEO_VC_TUNER` flag was dropped. Video inputs associated with a tuner are of type `V4L2_INPUT_TYPE_TUNER`. The `VIDEO_VC_AUDIO` flag was replaced by the `audioset` field. V4L2 considers devices with up to 32 audio inputs. Each set bit in the `audioset` field represents one audio input this video input combines with. For information about audio inputs and how to switch between them see [Audio Inputs and Outputs](#).

The `norm` field describing the supported video standards was replaced by `std`. The V4L specification mentions a flag `VIDEO_VC_NORM` indicating whether the standard can be changed. This flag was a later addition together with the `norm` field and has been removed in the meantime. V4L2 has a similar, albeit more comprehensive approach to video standards, see [Video Standards](#) for more information.

## Tuning

The V4L VIDIOCGTUNER and VIDIOCSTUNER ioctl and struct `video_tuner` can be used to enumerate the tuners of a V4L TV or radio device. The equivalent V4L2 ioctls are `VIDIOC_G_TUNER` and `VIDIOC_S_TUNER` using struct `v4l2_tuner`. Tuners are covered in [Tuners and Modulators](#).

The `tuner` field counting tuners was renamed to `index`. The fields `name`, `rangelow` and `rangehigh` remained unchanged.

The `VIDEO_TUNER_PAL`, `VIDEO_TUNER_NTSC` and `VIDEO_TUNER_SECAM` flags indicating the supported video standards were dropped. This information is now contained in the associated struct `v4l2_input`. No replacement exists for the `VIDEO_TUNER_NORM` flag indicating whether the video standard can be switched. The `mode` field to select a different video standard was replaced by a whole new set of ioctls and structures described in [Video Standards](#). Due to its ubiquity it should be mentioned the BTTV driver supports several standards in addition to the regular `VIDEO_MODE_PAL` (0), `VIDEO_MODE_NTSC`, `VIDEO_MODE_SECAM` and `VIDEO_MODE_AUTO` (3). Namely N/PAL Argentina, M/PAL, N/PAL, and NTSC Japan with numbers 3-6 (sic).

The `VIDEO_TUNER_STEREO_ON` flag indicating stereo reception became `V4L2_TUNER_SUB_STEREO` in field `rxsubchans`. This field also permits the detection of monaural and bilingual audio,

see the definition of struct `v4l2_tuner` for details. Presently no replacement exists for the `VIDEO_TUNER_RDS_ON` and `VIDEO_TUNER_MBS_ON` flags.

The `VIDEO_TUNER_LOW` flag was renamed to `V4L2_TUNER_CAP_LOW` in the struct `v4l2_tuner` capability field.

The `VIDIOCGFREQ` and `VIDIOCSFREQ` ioctl to change the tuner frequency were renamed to `VIDIOC_G_FREQUENCY` and `VIDIOC_S_FREQUENCY`. They take a pointer to a struct `v4l2_frequency` instead of an unsigned long integer.

## Image Properties

V4L2 has no equivalent of the `VIDIOCGPICT` and `VIDIOCSPICT` ioctl and struct `video_picture`. The following fields were replaced by V4L2 controls accessible with the *ioctls* `VIDIOC_QUERYCTRL`, `VIDIOC_QUERY_EXT_CTRL` and `VIDIOC_QUERYMENU`, `VIDIOC_G_CTRL` and `VIDIOC_S_CTRL` ioctls:

<code>struct video_picture</code>	V4L2 Control ID
<code>brightness</code>	<code>V4L2_CID_BRIGHTNESS</code>
<code>hue</code>	<code>V4L2_CID_HUE</code>
<code>colour</code>	<code>V4L2_CID_SATURATION</code>
<code>contrast</code>	<code>V4L2_CID_CONTRAST</code>
<code>whiteness</code>	<code>V4L2_CID_WHITENESS</code>

The V4L picture controls are assumed to range from 0 to 65535 with no particular reset value. The V4L2 API permits arbitrary limits and defaults which can be queried with the *ioctls* `VIDIOC_QUERYCTRL`, `VIDIOC_QUERY_EXT_CTRL` and `VIDIOC_QUERYMENU` ioctl. For general information about controls see *User Controls*.

The depth (average number of bits per pixel) of a video image is implied by the selected image format. V4L2 does not explicitly provide such information assuming applications recognizing the format are aware of the image depth and others need not know. The palette field moved into the struct `v4l2_pix_format`:

struct video_picture_palette	struct v4l2_pix_format pixfmt
VIDEO_PALETTE_GREY	V4L2_PIX_FMT_GREY
VIDEO_PALETTE_HI240	V4L2_PIX_FMT_HI240 <sup>3</sup>
VIDEO_PALETTE_RGB565	V4L2_PIX_FMT_RGB565
VIDEO_PALETTE_RGB555	V4L2_PIX_FMT_RGB555
VIDEO_PALETTE_RGB24	V4L2_PIX_FMT_BGR24
VIDEO_PALETTE_RGB32	V4L2_PIX_FMT_BGR32 <sup>4</sup>
VIDEO_PALETTE_YUV422	V4L2_PIX_FMT_YUYV
VIDEO_PALETTE_YUYV <sup>5</sup>	V4L2_PIX_FMT_YUYV
VIDEO_PALETTE_UYVY	V4L2_PIX_FMT_UYVY
VIDEO_PALETTE_YUV420	None
VIDEO_PALETTE_YUV411	V4L2_PIX_FMT_Y41P <sup>6</sup>
VIDEO_PALETTE_RAW	None <sup>7</sup>
VIDEO_PALETTE_YUV422P	V4L2_PIX_FMT_YUV422P
VIDEO_PALETTE_YUV411P	V4L2_PIX_FMT_YUV411P <sup>8</sup>
VIDEO_PALETTE_YUV420P	V4L2_PIX_FMT_YVU420
VIDEO_PALETTE_YUV410P	V4L2_PIX_FMT_YVU410

V4L2 image formats are defined in [Image Formats](#). The image format can be selected with the [VIDIOC\\_S\\_FMT](#) ioctl.

## Audio

The VIDIOCGAUDIO and VIDIOCSAUDIO ioctl and struct `video_audio` are used to enumerate the audio inputs of a V4L device. The equivalent V4L2 ioctls are [VIDIOC\\_G\\_AUDIO](#) and [VIDIOC\\_S\\_AUDIO](#) using struct `v4l2_audio` as discussed in [Audio Inputs and Outputs](#).

The `audio` "channel number" field counting audio inputs was renamed to `index`.

On VIDIOCSAUDIO the mode field selects *one* of the VIDEO\_SOUND\_MONO, VIDEO\_SOUND\_STEREO, VIDEO\_SOUND\_LANG1 or VIDEO\_SOUND\_LANG2 audio demodulation modes. When the current audio standard is BTSC VIDEO\_SOUND\_LANG2 refers to SAP and VIDEO\_SOUND\_LANG1 is meaningless. Also undocumented in the V4L specification, there is no way to query the selected mode. On VIDIOCGAUDIO the driver returns the *actually received* audio programmes in this field. In the V4L2 API this information is stored in the struct `v4l2_tuner` rxsubchans and audmode fields, respectively. See [Tuners and Modulators](#) for more information on tuners. Related to audio modes struct `v4l2_audio` also reports if this is a mono or stereo input, regardless if the source is a tuner.

The following fields where replaced by V4L2 controls accessible with the `ioctls VIDIOC_QUERYCTRL, VIDIOC_QUERY_EXT_CTRL and VIDIOC_QUERYMENU, VIDIOC_G_CTRL`

<sup>3</sup> This is a custom format used by the BTTV driver, not one of the V4L2 standard formats.

<sup>4</sup> Presumably all V4L RGB formats are little-endian, although some drivers might interpret them according to machine endianness. V4L2 defines little-endian, big-endian and red/blue swapped variants. For details see [RGB Formats](#).

<sup>5</sup> VIDEO\_PALETTE\_YUV422 and VIDEO\_PALETTE\_YUYV are the same formats. Some V4L drivers respond to one, some to the other.

<sup>6</sup> Not to be confused with V4L2\_PIX\_FMT\_YUV411P, which is a planar format.

<sup>7</sup> V4L explains this as: "RAW capture (BT848)"

<sup>8</sup> Not to be confused with V4L2\_PIX\_FMT\_Y41P, which is a packed format.

and `VIDIOC_S_CTRL` ioctls:

<code>struct video_audio</code>	V4L2 Control ID
<code>volume</code>	<code>V4L2_CID_AUDIO_VOLUME</code>
<code>bass</code>	<code>V4L2_CID_AUDIO_BASS</code>
<code>treble</code>	<code>V4L2_CID_AUDIO_TREBLE</code>
<code>balance</code>	<code>V4L2_CID_AUDIO_BALANCE</code>

To determine which of these controls are supported by a driver V4L provides the flags `VIDEO_AUDIO_VOLUME`, `VIDEO_AUDIO_BASS`, `VIDEO_AUDIO_TREBLE` and `VIDEO_AUDIO_BALANCE`. In the V4L2 API the `ioctls VIDIOC_QUERYCTRL`, `VIDIOC_QUERY_EXT_CTRL` and `VIDIOC_QUERYMENU` ioctl reports if the respective control is supported. Accordingly the `VIDEO_AUDIO_MUTABLE` and `VIDEO_AUDIO_MUTE` flags where replaced by the boolean `V4L2_CID_AUDIO_MUTE` control.

All V4L2 controls have a `step` attribute replacing the `struct video_audio step` field. The V4L audio controls are assumed to range from 0 to 65535 with no particular reset value. The V4L2 API permits arbitrary limits and defaults which can be queried with the `ioctls VIDIOC_QUERYCTRL`, `VIDIOC_QUERY_EXT_CTRL` and `VIDIOC_QUERYMENU` ioctl. For general information about controls see [User Controls](#).

## Frame Buffer Overlay

The V4L2 ioctls equivalent to `VIDIOCGFBUF` and `VIDIOCSFBUF` are `VIDIOC_G_FBUF` and `VIDIOC_S_FBUF`. The base field of `struct video_buffer` remained unchanged, except V4L2 defines a flag to indicate non-destructive overlays instead of a `NULL` pointer. All other fields moved into the `struct v4l2_pix_format` `fmt` substructure of `struct v4l2_framebuffer`. The `depth` field was replaced by `pixelformat`. See [RGB Formats](#) for a list of RGB formats and their respective color depths.

Instead of the special ioctls `VIDIOCGWIN` and `VIDIOCSWIN` V4L2 uses the general-purpose data format negotiation ioctls `VIDIOC_G_FMT` and `VIDIOC_S_FMT`. They take a pointer to a `struct v4l2_format` as argument. Here the `win` member of the `fmt` union is used, a `struct v4l2_window`.

The `x`, `y`, `width` and `height` fields of `struct video_window` moved into `struct v4l2_rect` substructure `w` of `struct v4l2_window`. The `chromakey`, `clips`, and `clipcount` fields remained unchanged. `Struct video_clip` was renamed to `struct v4l2_clip`, also containing a `struct v4l2_rect`, but the semantics are still the same.

The `VIDEO_WINDOW_INTERLACE` flag was dropped. Instead applications must set the `field` field to `V4L2_FIELD_ANY` or `V4L2_FIELD_INTERLACED`. The `VIDEO_WINDOW_CHROMAKEY` flag moved into `struct v4l2_framebuffer`, under the new name `V4L2_FBUF_FLAG_CHROMAKEY`.

In V4L, storing a bitmap pointer in `clips` and setting `clipcount` to `VIDEO_CLIP_BITMAP` (-1) requests bitmap clipping, using a fixed size bitmap of  $1024 \times 625$  bits. `Struct v4l2_window` has a separate bitmap pointer field for this purpose and the bitmap size is determined by `w.width` and `w.height`.

The `VIDIOCCAPTURE` ioctl to enable or disable overlay was renamed to `ioctl VIDIOC_OVERLAY`.

## Cropping

To capture only a subsection of the full picture V4L defines the VIDIOCGCAPTURE and VIDIOCSCAPTURE ioctls using struct `video_capture`. The equivalent V4L2 ioctls are `VIDIOC_G_CROP` and `VIDIOC_S_CROP` using struct `v4l2_crop`, and the related ioctl `VIDIOC_CROPCAP`. This is a rather complex matter, see *Image Cropping, Insertion and Scaling -- the CROP API* for details.

The `x`, `y`, `width` and `height` fields moved into struct `v4l2_rect` substructure `c` of struct `v4l2_crop`. The decimation field was dropped. In the V4L2 API the scaling factor is implied by the size of the cropping rectangle and the size of the captured or overlaid image.

The `VIDEO_CAPTURE_ODD` and `VIDEO_CAPTURE_EVEN` flags to capture only the odd or even field, respectively, were replaced by `V4L2_FIELD_TOP` and `V4L2_FIELD_BOTTOM` in the field named `field` of struct `v4l2_pix_format` and struct `v4l2_window`. These structures are used to select a capture or overlay format with the `VIDIOC_S_FMT` ioctl.

## Reading Images, Memory Mapping

### Capturing using the read method

There is no essential difference between reading images from a V4L or V4L2 device using the `read()` function, however V4L2 drivers are not required to support this I/O method. Applications can determine if the function is available with the ioctl `VIDIOC_QUERYCAP` ioctl. All V4L2 devices exchanging data with applications must support the `select()` and `poll()` functions.

To select an image format and size, V4L provides the VIDIOCSPICT and VIDIOCSWIN ioctls. V4L2 uses the general-purpose data format negotiation ioctls `VIDIOC_G_FMT` and `VIDIOC_S_FMT`. They take a pointer to a struct `v4l2_format` as argument, here the struct `v4l2_pix_format` named `pix` of its `fmt` union is used.

For more information about the V4L2 read interface see [Read/Write](#).

### Capturing using memory mapping

Applications can read from V4L devices by mapping buffers in device memory, or more often just buffers allocated in DMA-able system memory, into their address space. This avoids the data copying overhead of the read method. V4L2 supports memory mapping as well, with a few differences.

V4L	V4L2
	The image format must be selected before buffers are allocated, with the <a href="#">VIDIOC_S_FMT</a> ioctl. When no format is selected the driver may use the last, possibly by another application requested format.
Applications cannot change the number of buffers. The it is built into the driver, unless it has a module option to change the number when the driver module is loaded.	The <a href="#">ioctl VIDIOC_REQBUFS</a> ioctl allocates the desired number of buffers, this is a required step in the initialization sequence.
Drivers map all buffers as one contiguous range of memory. The VIDIOCMBUF ioctl is available to query the number of buffers, the offset of each buffer from the start of the virtual file, and the overall amount of memory used, which can be used as arguments for the <a href="#">mmap()</a> function.	Buffers are individually mapped. The offset and size of each buffer can be determined with the <a href="#">ioctl VIDIOC_QUERYBUF</a> ioctl.
The VIDIOCMCAPTURE ioctl prepares a buffer for capturing. It also determines the image format for this buffer. The ioctl returns immediately, eventually with an EAGAIN error code if no video signal had been detected. When the driver supports more than one buffer applications can call the ioctl multiple times and thus have multiple outstanding capture requests. The VIDIOCSYNC ioctl suspends execution until a particular buffer has been filled.	Drivers maintain an incoming and outgoing queue. <a href="#">ioctl VIDIOC_QBUF</a> , <a href="#">VIDIOC_DQBUF</a> enqueues any empty buffer into the incoming queue. Filled buffers are dequeued from the outgoing queue with the <a href="#">VIDIOC_DQBUF</a> ioctl. To wait until filled buffers become available this function, <a href="#">select()</a> or <a href="#">poll()</a> can be used. The <a href="#">ioctl VIDIOC_STREAMON</a> , <a href="#">VIDIOC_STREAMOFF</a> ioctl must be called once after enqueueing one or more buffers to start capturing. Its counterpart <a href="#">VIDIOC_STREAMOFF</a> stops capturing and dequeues all buffers from both queues. Applications can query the signal status, if known, with the <a href="#">ioctl VIDIOC_ENUMINPUT</a> ioctl.

For a more in-depth discussion of memory mapping and examples, see [Streaming I/O \(Memory Mapping\)](#).

## Reading Raw VBI Data

Originally the V4L API did not specify a raw VBI capture interface, only the device file /dev/vbi was reserved for this purpose. The only driver supporting this interface was the BTTV driver, de-facto defining the V4L VBI interface. Reading from the device yields a raw VBI image with the following parameters:

<code>struct v4l2_vbi_format</code>	V4L, BTTV driver
sampling_rate	28636363 Hz NTSC (or any other 525-line standard); 35468950 Hz PAL and SECAM (625-line standards)
offset	?
samples_per_line	2048
sample_format	V4L2_PIX_FMT_GREY. The last four bytes (a machine endianness integer) contain a frame counter.
start[]	10, 273 NTSC; 22, 335 PAL and SECAM
count[]	16, 16 <sup>9</sup>
flags	0

Undocumented in the V4L specification, in Linux 2.3 the VIDIOCGVBIFMT and VIDIOCSVBFMT ioctls using struct `vbi_format` were added to determine the VBI image parameters. These ioctls are only partially compatible with the V4L2 VBI interface specified in [Raw VBI Data Interface](#).

An `offset` field does not exist, `sample_format` is supposed to be `VIDEO_PALETTE_RAW`, equivalent to `V4L2_PIX_FMT_GREY`. The remaining fields are probably equivalent to struct `v4l2_vbi_format`.

Apparently only the Zoran (ZR 36120) driver implements these ioctls. The semantics differ from those specified for V4L2 in two ways. The parameters are reset on `open()` and VIDIOCSVBFMT always returns an `EINVAL` error code if the parameters are invalid.

## Miscellaneous

V4L2 has no equivalent of the VIDIOCGUNIT ioctl. Applications can find the VBI device associated with a video capture device (or vice versa) by reopening the device and requesting VBI data. For details see [Opening and Closing Devices](#).

No replacement exists for VIDIOCKEY, and the V4L functions for microcode programming. A new interface for MPEG compression and playback devices is documented in [Extended Controls API](#).

## Changes of the V4L2 API

Soon after the V4L API was added to the kernel it was criticised as too inflexible. In August 1998 Bill Dirks proposed a number of improvements and began to work on documentation, example drivers and applications. With the help of other volunteers this eventually became the V4L2 API, not just an extension but a replacement for the V4L API. However it took another four years and two stable kernel releases until the new API was finally accepted for inclusion into the kernel in its present form.

---

<sup>9</sup> Old driver versions used different values, eventually the custom `BTTV_VBISIZE` ioctl was added to query the correct values.

## Early Versions

1998-08-20: First version.

1998-08-27: The `select()` function was introduced.

1998-09-10: New video standard interface.

1998-09-18: The `VIDIOC_NONCAP` ioctl was replaced by the otherwise meaningless `O_TRUNC` `open()` flag, and the aliases `O_NONCAP` and `O_NOIO` were defined. Applications can set this flag if they intend to access controls only, as opposed to capture applications which need exclusive access. The `VIDEO_STD_XXX` identifiers are now ordinals instead of flags, and the `video_std_construct()` helper function takes `id` and `transmission` arguments.

1998-09-28: Revamped video standard. Made video controls individually enumerable.

1998-10-02: The `id` field was removed from struct `video_standard` and the color subcarrier fields were renamed. The `ioctl VIDIOC_QUERYSTD, VIDIOC_SUBDEV_QUERYSTD` ioctl was renamed to `ioctl VIDIOC_ENUMSTD, VIDIOC_SUBDEV_ENUMSTD, VIDIOC_G_INPUT` to `ioctl VIDIOC_ENUMINPUT`. A first draft of the Codec API was released.

1998-11-08: Many minor changes. Most symbols have been renamed. Some material changes to struct `v4l2_capability`.

1998-11-12: The read/write direction of some ioctls was misdefined.

1998-11-14: `V4L2_PIX_FMT_RGB24` changed to `V4L2_PIX_FMT_BGR24`, and `V4L2_PIX_FMT_RGB32` changed to `V4L2_PIX_FMT_BGR32`. Audio controls are now accessible with the `VIDIOC_G_CTRL` and `VIDIOC_S_CTRL` ioctls under names starting with `V4L2_CID_AUDIO`. The `V4L2_MAJOR` define was removed from `videodev.h` since it was only used once in the `videodev` kernel module. The `YUV422` and `YUV411` planar image formats were added.

1998-11-28: A few ioctl symbols changed. Interfaces for codecs and video output devices were added.

1999-01-14: A raw VBI capture interface was added.

1999-01-19: The `VIDIOC_NEXTPBUF` ioctl was removed.

## V4L2 Version 0.16 1999-01-31

1999-01-27: There is now one QBUF ioctl, `VIDIOC_QWBUF` and `VIDIOC_QRBUF` are gone. `VIDIOC_QBUF` takes a `v4l2_buffer` as a parameter. Added digital zoom (cropping) controls.

## V4L2 Version 0.18 1999-03-16

Added a v4l to V4L2 ioctl compatibility layer to `videodev.c`. Driver writers, this changes how you implement your ioctl handler. See the Driver Writer's Guide. Added some more control id codes.

**V4L2 Version 0.19 1999-06-05**

1999-03-18: Fill in the category and catname fields of v4l2\_queryctrl objects before passing them to the driver. Required a minor change to the VIDIOC\_QUERYCTRL handlers in the sample drivers.

1999-03-31: Better compatibility for v4l memory capture ioctls. Requires changes to drivers to fully support new compatibility features, see Driver Writer's Guide and v4l2cap.c. Added new control IDs: V4L2\_CID\_HFLIP, \_VFLIP. Changed V4L2\_PIX\_FMT\_YUV422P to \_YUV422P, and \_YUV411P to \_YUV411P.

1999-04-04: Added a few more control IDs.

1999-04-07: Added the button control type.

1999-05-02: Fixed a typo in videodev.h, and added the V4L2\_CTRL\_FLAG\_GRAYED (later V4L2\_CTRL\_FLAG\_GRABBED) flag.

1999-05-20: Definition of VIDIOC\_G\_CTRL was wrong causing a malfunction of this ioctl.

1999-06-05: Changed the value of V4L2\_CID\_WHITENESS.

**V4L2 Version 0.20 (1999-09-10)**

Version 0.20 introduced a number of changes which were *not backward compatible* with 0.19 and earlier versions. Purpose of these changes was to simplify the API, while making it more extensible and following common Linux driver API conventions.

1. Some typos in V4L2\_FMT\_FLAG symbols were fixed. `struct v4l2_clip` was changed for compatibility with v4l. (1999-08-30)
2. V4L2\_TUNER\_SUB\_LANG1 was added. (1999-09-05)
3. All ioctl() commands that used an integer argument now take a pointer to an integer. Where it makes sense, ioctls will return the actual new value in the integer pointed to by the argument, a common convention in the V4L2 API. The affected ioctls are: VIDIOC\_PREVIEW, VIDIOC\_STREAMON, VIDIOC\_STREAMOFF, VIDIOC\_S\_FREQ, VIDIOC\_S\_INPUT, VIDIOC\_S\_OUTPUT, VIDIOC\_S\_EFFECT. For example

```
err = ioctl (fd, VIDIOC_XXX, V4L2_XXX);
```

becomes

```
int a = V4L2_XXX; err = ioctl(fd, VIDIOC_XXX, &a);
```

4. All the different get- and set-format commands were swept into one `VIDIOC_G_FMT` and `VIDIOC_S_FMT` ioctl taking a union and a type field selecting the union member as parameter. Purpose is to simplify the API by eliminating several ioctls and to allow new and driver private data streams without adding new ioctls.

This change obsoletes the following ioctls: VIDIOC\_S\_INFMT, VIDIOC\_G\_INFMT, VIDIOC\_S\_OUTFMT, VIDIOC\_G\_OUTFMT, VIDIOC\_S\_VBIFMT and VIDIOC\_G\_VBIFMT. The image format struct `v4l2_format` was renamed to `struct v4l2_pix_format`, while `struct v4l2_format` is now the enveloping structure for all format negotiations.

5. Similar to the changes above, the VIDIOC\_G\_PARM and VIDIOC\_S\_PARM ioctls were merged with VIDIOC\_G\_OUTPARM and VIDIOC\_S\_OUTPARM. A type field in the new struct v4l2\_streamparm selects the respective union member.

This change obsoletes the VIDIOC\_G\_OUTPARM and VIDIOC\_S\_OUTPARM ioctls.

6. Control enumeration was simplified, and two new control flags were introduced and one dropped. The catname field was replaced by a group field.

Drivers can now flag unsupported and temporarily unavailable controls with V4L2\_CTRL\_FLAG\_DISABLED and V4L2\_CTRL\_FLAG\_GRABBED respectively. The group name indicates a possibly narrower classification than the category. In other words, there may be multiple groups within a category. Controls within a group would typically be drawn within a group box. Controls in different categories might have a greater separation, or may even appear in separate windows.

7. The struct v4l2\_buffer timestamp was changed to a 64 bit integer, containing the sampling or output time of the frame in nanoseconds. Additionally timestamps will be in absolute system time, not starting from zero at the beginning of a stream. The data type name for timestamps is stamp\_t, defined as a signed 64-bit integer. Output devices should not send a buffer out until the time in the timestamp field has arrived. I would like to follow SGI's lead, and adopt a multimedia timestamping system like their UST (Unadjusted System Time). See [http://web.archive.org/web/\\*/http://reality.sgi.com/cpirazzi\\_engr/lg/time/intro.html](http://web.archive.org/web/*/http://reality.sgi.com/cpirazzi_engr/lg/time/intro.html). UST uses timestamps that are 64-bit signed integers (not struct timeval's) and given in nanosecond units. The UST clock starts at zero when the system is booted and runs continuously and uniformly. It takes a little over 292 years for UST to overflow. There is no way to set the UST clock. The regular Linux time-of-day clock can be changed periodically, which would cause errors if it were being used for timestamping a multimedia stream. A real UST style clock will require some support in the kernel that is not there yet. But in anticipation, I will change the timestamp field to a 64-bit integer, and I will change the v4l2\_masterclock\_gettime() function (used only by drivers) to return a 64-bit integer.
8. A sequence field was added to struct v4l2\_buffer. The sequence field counts captured frames, it is ignored by output devices. When a capture driver drops a frame, the sequence number of that frame is skipped.

### V4L2 Version 0.20 incremental changes

1999-12-23: In struct v4l2\_vbi\_format the reserved1 field became offset. Previously drivers were required to clear the reserved1 field.

2000-01-13: The V4L2\_FMT\_FLAG\_NOT\_INTERLACED flag was added.

2000-07-31: The linux/poll.h header is now included by videodev.h for compatibility with the original videodev.h file.

2000-11-20: V4L2\_TYPE\_VBI\_OUTPUT and V4L2\_PIX\_FMT\_Y41P were added.

2000-11-25: V4L2\_TYPE\_VBI\_INPUT was added.

2000-12-04: A couple typos in symbol names were fixed.

2001-01-18: To avoid namespace conflicts the fourcc macro defined in the videodev.h header file was renamed to v4l2\_fourcc.

2001-01-25: A possible driver-level compatibility problem between the `videodev.h` file in Linux 2.4.0 and the `videodev.h` file included in the `videodevX` patch was fixed. Users of an earlier version of `videodevX` on Linux 2.4.0 should recompile their V4L and V4L2 drivers.

2001-01-26: A possible kernel-level incompatibility between the `videodev.h` file in the `videodevX` patch and the `videodev.h` file in Linux 2.2.x with devfs patches applied was fixed.

2001-03-02: Certain V4L ioctls which pass data in both direction although they are defined with read-only parameter, did not work correctly through the backward compatibility layer. [Solution?]

2001-04-13: Big endian 16-bit RGB formats were added.

2001-09-17: New YUV formats and the `VIDIOC_G_FREQUENCY` and `VIDIOC_S_FREQUENCY` ioctls were added. (The old `VIDIOC_G_FREQ` and `VIDIOC_S_FREQ` ioctls did not take multiple tuners into account.)

2000-09-18: `V4L2_BUF_TYPE_VBI` was added. This may *break compatibility* as the `VIDIOC_G_FMT` and `VIDIOC_S_FMT` ioctls may fail now if the struct `v4l2_fmt` type field does not contain `V4L2_BUF_TYPE_VBI`. In the documentation of the struct `v4l2_vbi_format`, the offset field the ambiguous phrase "rising edge" was changed to "leading edge".

## V4L2 Version 0.20 2000-11-23

A number of changes were made to the raw VBI interface.

1. Figures clarifying the line numbering scheme were added to the V4L2 API specification. The `start[0]` and `start[1]` fields no longer count line numbers beginning at zero. Rationale: a) The previous definition was unclear. b) The `start[]` values are ordinal numbers. c) There is no point in inventing a new line numbering scheme. We now use line number as defined by ITU-R, period. Compatibility: Add one to the start values. Applications depending on the previous semantics may not function correctly.
2. The restriction "`count[0] > 0` and `count[1] > 0`" has been relaxed to "`(count[0] + count[1]) > 0`". Rationale: Drivers may allocate resources at scan line granularity and some data services are transmitted only on the first field. The comment that both `count` values will usually be equal is misleading and pointless and has been removed. This change *breaks compatibility* with earlier versions: Drivers may return `EINVAL`, applications may not function correctly.
3. Drivers are again permitted to return negative (unknown) start values as proposed earlier. Why this feature was dropped is unclear. This change may *break compatibility* with applications depending on the start values being positive. The use of `EBUSY` and `EINVAL` error codes with the `VIDIOC_S_FMT` ioctl was clarified. The `EBUSY` error code was finally documented, and the `reserved2` field which was previously mentioned only in the `videodev.h` header file.
4. New buffer types `V4L2_TYPE_VBI_INPUT` and `V4L2_TYPE_VBI_OUTPUT` were added. The former is an alias for the old `V4L2_TYPE_VBI`, the latter was missing in the `videodev.h` file.

## V4L2 Version 0.20 2002-07-25

Added sliced VBI interface proposal.

## V4L2 in Linux 2.5.46, 2002-10

Around October-November 2002, prior to an announced feature freeze of Linux 2.5, the API was revised, drawing from experience with V4L2 0.20. This unnamed version was finally merged into Linux 2.5.46.

1. As specified in [Related Devices](#), drivers must make related device functions available under all minor device numbers.
2. The [`open\(\)`](#) function requires access mode `O_RDWR` regardless of the device type. All V4L2 drivers exchanging data with applications must support the `O_NONBLOCK` flag. The `O_NOIO` flag, a V4L2 symbol which aliased the meaningless `O_TRUNC` to indicate accesses without data exchange (panel applications) was dropped. Drivers must stay in "panel mode" until the application attempts to initiate a data exchange, see [Opening and Closing Devices](#).
3. The struct `v4l2_capability` changed dramatically. Note that also the size of the structure changed, which is encoded in the ioctl request code, thus older V4L2 devices will respond with an `EINVAL` error code to the new [`ioctl VIDIOC\_QUERYCAP`](#) ioctl.

There are new fields to identify the driver, a new RDS device function `V4L2_CAP_RDS_CAPTURE`, the `V4L2_CAP_AUDIO` flag indicates if the device has any audio connectors, another I/O capability `V4L2_CAP_ASYNCIO` can be flagged. In response to these changes the type field became a bit set and was merged into the flags field. `V4L2_FLAG_TUNER` was renamed to `V4L2_CAP_TUNER`, `V4L2_CAP_VIDEO_OVERLAY` replaced `V4L2_FLAG_PREVIEW` and `V4L2_CAP_VBI_CAPTURE` and `V4L2_CAP_VBI_OUTPUT` replaced `V4L2_FLAG_DATA_SERVICE`. `V4L2_FLAG_READ` and `V4L2_FLAG_WRITE` were merged into `V4L2_CAP_READWRITE`.

The redundant fields inputs, outputs and audios were removed. These properties can be determined as described in [Video Inputs and Outputs](#) and [Audio Inputs and Outputs](#).

The somewhat volatile and therefore barely useful fields `maxwidth`, `maxheight`, `minwidth`, `minheight`, `maxframerate` were removed. This information is available as described in [Data Formats](#) and [Video Standards](#).

`V4L2_FLAG_SELECT` was removed. We believe the select() function is important enough to require support of it in all V4L2 drivers exchanging data with applications. The redundant `V4L2_FLAG_MONOCHROME` flag was removed, this information is available as described in [Data Formats](#).

4. In struct `v4l2_input` the `assoc_audio` field and the `capability` field and its only flag `V4L2_INPUT_CAP_AUDIO` was replaced by the new `audioset` field. Instead of linking one video input to one audio input this field reports all audio inputs this video input combines with.

New fields are `tuner` (reversing the former link from tuners to video inputs), `std` and `status`.

Accordingly struct `v4l2_output` lost its `capability` and `assoc_audio` fields. `audioset`, `modulator` and `std` where added instead.

5. The struct v4l2\_audio field `audio` was renamed to `index`, for consistency with other structures. A new capability flag `V4L2_AUDCAP_STEREO` was added to indicate if the audio input in question supports stereo sound. `V4L2_AUDCAP_EFFECTS` and the corresponding `V4L2_AUDMODE` flags were removed. This can be easily implemented using controls. (However the same applies to AVL which is still there.)

Again for consistency the struct v4l2\_audioout field `audio` was renamed to `index`.

6. The struct v4l2\_tuner `input` field was replaced by an `index` field, permitting devices with multiple tuners. The link between video inputs and tuners is now reversed, inputs point to their tuner. The `std` substructure became a simple set (more about this below) and moved into struct v4l2\_input. A `type` field was added.

Accordingly in struct v4l2\_modulator the `output` was replaced by an `index` field.

In struct v4l2\_frequency the `port` field was replaced by a `tuner` field containing the respective tuner or modulator index number. A `tuner type` field was added and the `reserved` field became larger for future extensions (satellite tuners in particular).

7. The idea of completely transparent video standards was dropped. Experience showed that applications must be able to work with video standards beyond presenting the user a menu. Instead of enumerating supported standards with an ioctl applications can now refer to standards by `v4l2_std_id` and symbols defined in the `videodev2.h` header file. For details see [Video Standards](#). The `VIDIOC_G_STD` and `VIDIOC_S_STD` now take a pointer to this type as argument. `ioctl VIDIOC_QUERYSTD, VIDIOC_SUBDEV_QUERYSTD` was added to autodetect the received standard, if the hardware has this capability. In struct v4l2\_standard an `index` field was added for `ioctl VIDIOC_ENUMSTD, VIDIOC_SUBDEV_ENUMSTD`. A `v4l2_std_id` field named `id` was added as machine readable identifier, also replacing the `transmission` field. The misleading `framerate` field was renamed to `frameperiod`. The now obsolete `colorstandard` information, originally needed to distinguish between variations of standards, were removed.

Struct `v4l2_enumstd` ceased to be. `ioctl VIDIOC_ENUMSTD, VIDIOC_SUBDEV_ENUMSTD` now takes a pointer to a struct v4l2\_standard directly. The information which standards are supported by a particular video input or output moved into struct v4l2\_input and struct v4l2\_output fields named `std`, respectively.

8. The struct `v4l2_queryctrl` fields `category` and `group` did not catch on and/or were not implemented as expected and therefore removed.
9. The `VIDIOC_TRY_FMT` ioctl was added to negotiate data formats as with `VIDIOC_S_FMT`, but without the overhead of programming the hardware and regardless of I/O in progress.

In struct v4l2\_format the `fmt` union was extended to contain `struct v4l2_window`. All image format negotiations are now possible with `VIDIOC_G_FMT`, `VIDIOC_S_FMT` and `VIDIOC_TRY_FMT`; ioctl. The `VIDIOC_G_WIN` and `VIDIOC_S_WIN` ioctls to prepare for a video overlay were removed. The `type` field changed to type enum `v4l2_buf_type` and the buffer type names changed as follows.

Old defines	enum v4l2_buf_type
V4L2_BUF_TYPE_CAPTURE	V4L2_BUF_TYPE_VIDEO_CAPTURE
V4L2_BUF_TYPE_CODECIN	Omitted for now
V4L2_BUF_TYPE_CODECOUT	Omitted for now
V4L2_BUF_TYPE_EFFECTSIN	Omitted for now
V4L2_BUF_TYPE_EFFECTSIN2	Omitted for now
V4L2_BUF_TYPE_EFFECTSOUT	Omitted for now
V4L2_BUF_TYPE_VIDE0OUT	V4L2_BUF_TYPE_VIDEO_OUTPUT
-	V4L2_BUF_TYPE_VIDEO_OVERLAY
-	V4L2_BUF_TYPE_VBI_CAPTURE
-	V4L2_BUF_TYPE_VBI_OUTPUT
-	V4L2_BUF_TYPE_SLICED_VBI_CAPTURE
-	V4L2_BUF_TYPE_SLICED_VBI_OUTPUT
V4L2_BUF_TYPE_PRIVATE_BASE	V4L2_BUF_TYPE_PRIVATE (but this is deprecated)

10. In struct `v4l2_fmtdesc` a enum `v4l2_buf_type` field named `type` was added as in struct `v4l2_format`. The `VIDIOC_ENUM_FBUFFMT` ioctl is no longer needed and was removed. These calls can be replaced by `ioctl VIDIOC_ENUM_FMT` with type `V4L2_BUF_TYPE_VIDEO_OVERLAY`.
11. In `struct v4l2_pix_format` the `depth` field was removed, assuming applications which recognize the format by its four-character-code already know the color depth, and others do not care about it. The same rationale lead to the removal of the `V4L2_FMT_FLAG_COMPRESSED` flag. The `V4L2_FMT_FLAG_SWCONVECOMPRESSED` flag was removed because drivers are not supposed to convert images in kernel space. A user library of conversion functions should be provided instead. The `V4L2_FMT_FLAG_BYTESPERLINE` flag was redundant. Applications can set the `bytesperline` field to zero to get a reasonable default. Since the remaining flags were replaced as well, the `flags` field itself was removed.

The interlace flags were replaced by a `enum v4l2_field` value in a newly added `field` field.

Old flag	<code>enum v4l2_field</code>
<code>V4L2_FMT_FLAG_NOT_INTERLACED</code>	?
<code>V4L2_FMT_FLAG_INTERLACED = V4L2_FMT_FLAG_COMBINED</code>	<code>V4L2_FIELD_INTERLACED</code>
<code>V4L2_FMT_FLAG_TOPFIELD = V4L2_FMT_FLAG_ODDFIELD</code>	<code>V4L2_FIELD_TOP</code>
<code>V4L2_FMT_FLAG_BOTFIELD = V4L2_FMT_FLAG_EVENFIELD</code>	<code>V4L2_FIELD_BOTTOM</code>
-	<code>V4L2_FIELD_SEQ_TB</code>
-	<code>V4L2_FIELD_SEQ_BT</code>
-	<code>V4L2_FIELD_ALTERNATE</code>

The color space flags were replaced by a `enum v4l2_colorspace` value in a newly added `colorspace` field, where one of `V4L2_COLORSPACE_SMPTE170M`, `V4L2_COLORSPACE_BT878`, `V4L2_COLORSPACE_470_SYSTEM_M` or `V4L2_COLORSPACE_470_SYSTEM_BG` replaces `V4L2_FMT_CS_601YUV`.

12. In struct `v4l2_requestbuffers` the `type` field was properly defined as enum `v4l2_buf_type`. Buffer types changed as mentioned above. A new `memory` field of type enum `v4l2_memory` was added to distinguish between I/O methods using buffers allocated by the driver or the application. See [Input/Output](#) for details.

13. In struct `v4l2_buffer` the `type` field was properly defined as enum `v4l2_buf_type`. Buffer types changed as mentioned above. A `field` field of type `enum v4l2_field` was added to indicate if a buffer contains a top or bottom field. The old field flags were removed. Since no unadjusted system time clock was added to the kernel as planned, the `timestamp` field changed back from type `stamp_t`, an unsigned 64 bit integer expressing the sample time in nanoseconds, to struct `timeval`. With the addition of a second memory mapping method the `offset` field moved into union `m`, and a new `memory` field of type enum `v4l2_memory` was added to distinguish between I/O methods. See [Input/Output](#) for details.

The `V4L2_BUF_REQ_CONTIG` flag was used by the V4L compatibility layer, after changes to this code it was no longer needed. The `V4L2_BUF_ATTR_DEVICEMEM` flag would indicate if the buffer was indeed allocated in device memory rather than DMA-able system memory. It was barely useful and so was removed.

14. In struct `v4l2_framebuffer` the `base[3]` array anticipating double- and triple-buffering in off-screen video memory, however without defining a synchronization mechanism, was replaced by a single pointer. The `V4L2_FBUF_CAP_SCALEUP` and `V4L2_FBUF_CAP_SCALEDOWN` flags were removed. Applications can determine this capability more accurately using the new cropping and scaling interface. The `V4L2_FBUF_CAP_CLIPPING` flag was replaced by `V4L2_FBUF_CAP_LIST_CLIPPING` and `V4L2_FBUF_CAP_BITMAP_CLIPPING`.
15. In `struct v4l2_clip` the `x`, `y`, `width` and `height` field moved into a `c` substructure of type `struct v4l2_rect`. The `x` and `y` fields were renamed to `left` and `top`, i. e. offsets to a context dependent origin.
16. In `struct v4l2_window` the `x`, `y`, `width` and `height` field moved into a `w` substructure as above. A `field` field of type `enum v4l2_field` was added to distinguish between field and frame (interlaced) overlay.
17. The digital zoom interface, including struct `v4l2_zoomcap`, struct `v4l2_zoom`, `V4L2_ZOOM_NONCAP` and `V4L2_ZOOM_WHILESTREAMING` was replaced by a new cropping and scaling interface. The previously unused struct `v4l2_croppcap` and struct `v4l2_crop` where redefined for this purpose. See [Image Cropping, Insertion and Scaling -- the CROP API](#) for details.
18. In struct `v4l2_vbi_format` the `SAMPLE_FORMAT` field now contains a four-character-code as used to identify video image formats and `V4L2_PIX_FMT_GREY` replaces the `V4L2_VBI_SF_UBYTE` define. The reserved field was extended.
19. In struct `v4l2_captureparm` the type of the `timeperframe` field changed from unsigned long to struct `v4l2_fract`. This allows the accurate expression of multiples of the NTSC-M frame rate 30000 / 1001. A new field `readbuffers` was added to control the driver behaviour in read I/O mode.
- Similar changes were made to struct `v4l2_outputparm`.
20. The struct `v4l2_performance` and `VIDIOC_G_PERF` ioctl were dropped. Except when using the [read/write I/O method](#), which is limited anyway, this information is already available to applications.
21. The example transformation from RGB to YCbCr color space in the old V4L2 documentation was inaccurate, this has been corrected in [Image Formats](#).

**V4L2 2003-06-19**

1. A new capability flag `V4L2_CAP_RADIO` was added for radio devices. Prior to this change radio devices would identify solely by having exactly one tuner whose type field reads `V4L2_TUNER_RADIO`.
2. An optional driver access priority mechanism was added, see [Application Priority](#) for details.
3. The audio input and output interface was found to be incomplete.

Previously the `VIDIOC_G_AUDIO` ioctl would enumerate the available audio inputs. An ioctl to determine the current audio input, if more than one combines with the current video input, did not exist. So `VIDIOC_G_AUDIO` was renamed to `VIDIOC_G_AUDIO_OLD`, this ioctl was removed on Kernel 2.6.39. The *ioctl VIDIOC\_ENUMAUDIO* ioctl was added to enumerate audio inputs, while `VIDIOC_G_AUDIO` now reports the current audio input.

The same changes were made to `VIDIOC_G_AUDOUT` and `VIDIOC_ENUMAUDOUT`.

Until further the "videodev" module will automatically translate between the old and new ioctls, but drivers and applications must be updated to successfully compile again.

4. The *ioctl VIDIOC\_OVERLAY* ioctl was incorrectly defined with write-read parameter. It was changed to write-only, while the write-read version was renamed to `VIDIOC_OVERLAY_OLD`. The old ioctl was removed on Kernel 2.6.39. Until further the "videodev" kernel module will automatically translate to the new version, so drivers must be recompiled, but not applications.
5. *Video Overlay Interface* incorrectly stated that clipping rectangles define regions where the video can be seen. Correct is that clipping rectangles define regions where *no* video shall be displayed and so the graphics surface can be seen.
6. The `VIDIOC_S_PARM` and `VIDIOC_S_CTRL` ioctls were defined with write-only parameter, inconsistent with other ioctls modifying their argument. They were changed to write-read, while a `_OLD` suffix was added to the write-only versions. The old ioctls were removed on Kernel 2.6.39. Drivers and applications assuming a constant parameter need an update.

**V4L2 2003-11-05**

1. In *RGB Formats* the following pixel formats were incorrectly transferred from Bill Dirks' V4L2 specification. Descriptions below refer to bytes in memory, in ascending address order.

Symbol	In this document prior to revision 0.5	Corrected
<code>V4L2_PIX_FMT_RGB24</code>	B, G, R	R, G, B
<code>V4L2_PIX_FMT_BGR24</code>	R, G, B	B, G, R
<code>V4L2_PIX_FMT_RGB32</code>	B, G, R, X	R, G, B, X
<code>V4L2_PIX_FMT_BGR32</code>	R, G, B, X	B, G, R, X

The `V4L2_PIX_FMT_BGR24` example was always correct.

In *Image Properties* the mapping of the `VIDEO_PALETTE_RGB24` and `VIDEO_PALETTE_RGB32` formats to V4L2 pixel formats was accordingly corrected.

2. Unrelated to the fixes above, drivers may still interpret some V4L2 RGB pixel formats differently. These issues have yet to be addressed, for details see [RGB Formats](#).

## V4L2 in Linux 2.6.6, 2004-05-09

1. The *ioctl VIDIOC\_CROPCAP* ioctl was incorrectly defined with read-only parameter. It is now defined as write-read ioctl, while the read-only version was renamed to `VIDIOC_CROPCAP_OLD`. The old ioctl was removed on Kernel 2.6.39.

## V4L2 in Linux 2.6.8

1. A new field `input` (former `reserved[0]`) was added to the struct `v4l2_buffer`. Purpose of this field is to alternate between video inputs (e. g. cameras) in step with the video capturing process. This function must be enabled with the new `V4L2_BUF_FLAG_INPUT` flag. The `flags` field is no longer read-only.

## V4L2 spec erratum 2004-08-01

1. The return value of the [V4L2 open\(\)](#) function was incorrectly documented.
2. Audio output ioctls end in `-AUDOUT`, not `-AUDIOOUT`.
3. In the Current Audio Input example the `VIDIOC_G_AUDIO` ioctl took the wrong argument.
4. The documentation of the *ioctl VIDIOC\_QBUF*, *VIDIOC\_DQBUF* and *VIDIOC\_DQBUF* ioctls did not mention the struct `v4l2_buffer` `memory` field. It was also missing from examples. Also on the `VIDIOC_DQBUF` page the `EIO` error code was not documented.

## V4L2 in Linux 2.6.14

1. A new sliced VBI interface was added. It is documented in [Sliced VBI Data Interface](#) and replaces the interface first proposed in V4L2 specification 0.8.

## V4L2 in Linux 2.6.15

1. The *ioctl VIDIOC\_LOG\_STATUS* ioctl was added.
2. New video standards `V4L2_STD_NTSC_443`, `V4L2_STD_SECAM_LC`, `V4L2_STD_SECAM_DK` (a set of SECAM D, K and K1), and `V4L2_STD_ATSC` (a set of `V4L2_STD_ATSC_8_VSB` and `V4L2_STD_ATSC_16_VSB`) were defined. Note the `V4L2_STD_525_60` set now includes `V4L2_STD_NTSC_443`. See also [typedef v4l2\\_std\\_id](#).
3. The `VIDIOC_G_COMP` and `VIDIOC_S_COMP` ioctl were renamed to `VIDIOC_G_MPEGCOMP` and `VIDIOC_S_MPEGCOMP` respectively. Their argument was replaced by a struct `v4l2_mpeg_compression` pointer. (The `VIDIOC_G_MPEGCOMP` and `VIDIOC_S_MPEGCOMP` ioctls were removed in Linux 2.6.25.)

## V4L2 spec erratum 2005-11-27

The capture example in *Video Capture Example* called the `VIDIOC_S_CROP` ioctl without checking if cropping is supported. In the video standard selection example in *Video Standards* the `VIDIOC_S_STD` call used the wrong argument type.

## V4L2 spec erratum 2006-01-10

1. The `V4L2_IN_ST_COLOR_KILL` flag in struct `v4l2_input` not only indicates if the color killer is enabled, but also if it is active. (The color killer disables color decoding when it detects no color in the video signal to improve the image quality.)
2. `VIDIOC_S_PARM` is a write-read ioctl, not write-only as stated on its reference page. The ioctl changed in 2003 as noted above.

## V4L2 spec erratum 2006-02-03

1. In struct `v4l2_captureparm` and struct `v4l2_outputparm` the `timeperframe` field gives the time in seconds, not microseconds.

## V4L2 spec erratum 2006-02-04

1. The `clips` field in `struct v4l2_window` must point to an array of `struct v4l2_clip`, not a linked list, because drivers ignore the `struct v4l2_clip`. `next` pointer.

## V4L2 in Linux 2.6.17

1. New video standard macros were added: `V4L2_STD_NTSC_M_KR` (NTSC M South Korea), and the sets `V4L2_STD_MN`, `V4L2_STD_B`, `V4L2_STD_GH` and `V4L2_STD_DK`. The `V4L2_STD_NTSC` and `V4L2_STD_SECAM` sets now include `V4L2_STD_NTSC_M_KR` and `V4L2_STD_SECAM_LC` respectively.
2. A new `V4L2_TUNER_MODE_LANG1_LANG2` was defined to record both languages of a bilingual program. The use of `V4L2_TUNER_MODE_STEREO` for this purpose is deprecated now. See the `VIDIOC_G_TUNER` section for details.

## V4L2 spec erratum 2006-09-23 (Draft 0.15)

1. In various places `V4L2_BUF_TYPE_SLICED_VBI_CAPTURE` and `V4L2_BUF_TYPE_SLICED_VBI_OUTPUT` of the sliced VBI interface were not mentioned along with other buffer types.
2. In `VIDIOC_G_AUDIO` it was clarified that the `struct v4l2_audio mode` field is a flags field.
3. `ioctl VIDIOC_QUERYCAP` did not mention the sliced VBI and radio capability flags.
4. In `VIDIOC_G_FREQUENCY` it was clarified that applications must initialize the tuner type field of struct `v4l2_frequency` before calling `VIDIOC_S_FREQUENCY`.

5. The reserved array in struct v4l2\_requestbuffers has 2 elements, not 32.
6. In *Video Output Interface* and *Raw VBI Data Interface* the device file names /dev/vout which never caught on were replaced by /dev/video.
7. With Linux 2.6.15 the possible range for VBI device minor numbers was extended from 224-239 to 224-255. Accordingly device file names /dev/vbi0 to /dev/vbi31 are possible now.

## V4L2 in Linux 2.6.18

1. New ioctls *VIDIOC\_G\_EXT\_CTRLS*, *VIDIOC\_S\_EXT\_CTRLS* and *VIDIOC\_TRY\_EXT\_CTRLS* were added, a flag to skip unsupported controls with *ioctls VIDIOC\_QUERYCTRL*, *VIDIOC\_QUERY\_EXT\_CTRL* and *VIDIOC\_QUERYMENU*, new control types *V4L2\_CTRL\_TYPE\_INTEGER64* and *V4L2\_CTRL\_TYPE\_CTRL\_CLASS* (enum *v4l2\_ctrl\_type*), and new control flags *V4L2\_CTRL\_FLAG\_READ\_ONLY*, *V4L2\_CTRL\_FLAG\_UPDATE*, *V4L2\_CTRL\_FLAG\_INACTIVE* and *V4L2\_CTRL\_FLAG\_SLIDER* (*Control Flags*). See *Extended Controls API* for details.

## V4L2 in Linux 2.6.19

1. In struct v4l2\_sliced\_vbi\_cap a buffer type field was added replacing a reserved field. Note on architectures where the size of enum types differs from int types the size of the structure changed. The *VIDIOC\_G\_SLICED\_VBI\_CAP* ioctl was redefined from being read-only to write-read. Applications must initialize the type field and clear the reserved fields now. These changes may *break the compatibility* with older drivers and applications.
2. The ioctls *ioctl VIDIOC\_ENUM\_FRAMESIZES* and *ioctl VIDIOC\_ENUM\_FRAMEINTERVALS* were added.
3. A new pixel format *V4L2\_PIX\_FMT\_RGB444* (*RGB Formats*) was added.

## V4L2 spec erratum 2006-10-12 (Draft 0.17)

1. *V4L2\_PIX\_FMT\_HM12* (*Reserved Image Formats*) is a YUV 4:2:0, not 4:2:2 format.

## V4L2 in Linux 2.6.21

1. The videodev2.h header file is now dual licensed under GNU General Public License version two or later, and under a 3-clause BSD-style license.

### V4L2 in Linux 2.6.22

1. Two new field orders V4L2\_FIELD\_INTERLACED\_TB and V4L2\_FIELD\_INTERLACED\_BT were added. See [enum v4l2\\_field](#) for details.
2. Three new clipping/blending methods with a global or straight or inverted local alpha value were added to the video overlay interface. See the description of the [VIDIOC\\_G\\_FBUF](#) and [VIDIOC\\_S\\_FBUF](#) ioctls for details.

A new `global_alpha` field was added to [`struct v4l2\_window`](#), extending the structure. This may **break compatibility** with applications using a [`struct v4l2\_window`](#) directly. However the [VIDIOC\\_G/S/TRY\\_FMT](#) ioctls, which take a pointer to a `struct v4l2_format` parent structure with padding bytes at the end, are not affected.

3. The format of the `chromakey` field in [`struct v4l2\_window`](#) changed from "host order RGB32" to a pixel value in the same format as the framebuffer. This may **break compatibility** with existing applications. Drivers supporting the "host order RGB32" format are not known.

### V4L2 in Linux 2.6.24

1. The pixel formats V4L2\_PIX\_FMT\_PAL8, V4L2\_PIX\_FMT\_YUV444, V4L2\_PIX\_FMT\_YUV555, V4L2\_PIX\_FMT\_YUV565 and V4L2\_PIX\_FMT\_YUV32 were added.

### V4L2 in Linux 2.6.25

1. The pixel formats [V4L2\\_PIX\\_FMT\\_Y16](#) and [V4L2\\_PIX\\_FMT\\_SBGGR16](#) were added.
2. New [`controls`](#) V4L2\_CID\_POWER\_LINE\_FREQUENCY, V4L2\_CID\_HUE\_AUTO, V4L2\_CID\_WHITE\_BALANCE\_TEMPERATURE, V4L2\_CID\_SHARPNESS and V4L2\_CID\_BACKLIGHT\_COMPENSATION were added. The controls V4L2\_CID\_BLACK\_LEVEL, V4L2\_CID\_WHITENESS, V4L2\_CID\_HCENTER and V4L2\_CID\_VCENTER were deprecated.
3. A [`Camera controls class`](#) was added, with the new controls V4L2\_CID\_EXPOSURE\_AUTO, V4L2\_CID\_EXPOSURE\_ABSOLUTE, V4L2\_CID\_EXPOSURE\_AUTO\_PRIORITY, V4L2\_CID\_PAN\_RELATIVE, V4L2\_CID\_TILT\_RELATIVE, V4L2\_CID\_PAN\_RESET, V4L2\_CID\_TILT\_RESET, V4L2\_CID\_PAN\_ABSOLUTE, V4L2\_CID\_TILT\_ABSOLUTE, V4L2\_CID\_FOCUS\_ABSOLUTE, V4L2\_CID\_FOCUS\_RELATIVE and V4L2\_CID\_FOCUS\_AUTO.
4. The VIDIOC\_G\_MPEGCOMP and VIDIOC\_S\_MPEGCOMP ioctls, which were superseded by the [`extended controls`](#) interface in Linux 2.6.18, where finally removed from the videodev2.h header file.

## V4L2 in Linux 2.6.26

1. The pixel formats V4L2\_PIX\_FMT\_Y16 and V4L2\_PIX\_FMT\_SBGGR16 were added.
2. Added user controls V4L2\_CID\_CHROMA\_AGC and V4L2\_CID\_COLOR\_KILLER.

## V4L2 in Linux 2.6.27

1. The *ioctl VIDIOC\_S\_HW\_FREQ\_SEEK* ioctl and the V4L2\_CAP\_HW\_FREQ\_SEEK capability were added.
2. The pixel formats V4L2\_PIX\_FMT\_YVYU, V4L2\_PIX\_FMT\_PCA501, V4L2\_PIX\_FMT\_PCA505, V4L2\_PIX\_FMT\_PCA508, V4L2\_PIX\_FMT\_PCA561, V4L2\_PIX\_FMT\_SGBRG8, V4L2\_PIX\_FMT\_PAC207 and V4L2\_PIX\_FMT\_PJPG were added.

## V4L2 in Linux 2.6.28

1. Added V4L2\_MPEG\_AUDIO\_ENCODING\_AAC and V4L2\_MPEG\_AUDIO\_ENCODING\_AC3 MPEG audio encodings.
2. Added V4L2\_MPEG\_VIDEO\_ENCODING\_MPEG\_4 AVC MPEG video encoding.
3. The pixel formats V4L2\_PIX\_FMT\_SGRBG10 and V4L2\_PIX\_FMT\_SGRBG10DPCM8 were added.

## V4L2 in Linux 2.6.29

1. The VIDIOC\_G\_CHIP\_IDENT ioctl was renamed to VIDIOC\_G\_CHIP\_IDENT\_OLD and VIDIOC\_DBG\_G\_CHIP\_IDENT was introduced in its place. The old struct v4l2\_chip\_ident was renamed to struct v4l2\_chip\_ident\_old.
2. The pixel formats V4L2\_PIX\_FMT\_VYUY, V4L2\_PIX\_FMT\_NV16 and V4L2\_PIX\_FMT\_NV61 were added.
3. Added camera controls V4L2\_CID\_ZOOM\_ABSOLUTE, V4L2\_CID\_ZOOM\_RELATIVE, V4L2\_CID\_ZOOM\_CONTINUOUS and V4L2\_CID\_PRIVACY.

## V4L2 in Linux 2.6.30

1. New control flag V4L2\_CTRL\_FLAG\_WRITE\_ONLY was added.
2. New control V4L2\_CID\_COLORM was added.

## V4L2 in Linux 2.6.32

1. In order to be easier to compare a V4L2 API and a kernel version, now V4L2 API is numbered using the Linux Kernel version numeration.
2. Finalized the RDS capture API. See [RDS Interface](#) for more information.
3. Added new capabilities for modulators and RDS encoders.
4. Add description for libv4l API.
5. Added support for string controls via new type `V4L2_CTRL_TYPE_STRING`.
6. Added `V4L2_CID_BAND_STOP_FILTER` documentation.
7. Added FM Modulator (FM TX) Extended Control Class: `V4L2_CTRL_CLASS_FM_TX` and their Control IDs.
8. Added FM Receiver (FM RX) Extended Control Class: `V4L2_CTRL_CLASS_FM_RX` and their Control IDs.
9. Added Remote Controller chapter, describing the default Remote Controller mapping for media devices.

## V4L2 in Linux 2.6.33

1. Added support for Digital Video timings in order to support HDTV receivers and transmitters.

## V4L2 in Linux 2.6.34

1. Added `V4L2_CID_IRIS_ABSOLUTE` and `V4L2_CID_IRIS_RELATIVE` controls to the [Camera controls class](#).

## V4L2 in Linux 2.6.37

1. Remove the vtx (videotext/teletext) API. This API was no longer used and no hardware exists to verify the API. Nor were any userspace applications found that used it. It was originally scheduled for removal in 2.6.35.

## V4L2 in Linux 2.6.39

1. The old `VIDIOC_*_OLD` symbols and V4L1 support were removed.
2. Multi-planar API added. Does not affect the compatibility of current drivers and applications. See [multi-planar API](#) for details.

## V4L2 in Linux 3.1

- VIDIOC\_QUERYCAP now returns a per-subsystem version instead of a per-driver one.  
Standardize an error code for invalid ioctl.  
Added V4L2\_CTRL\_TYPE\_BITMASK.

## V4L2 in Linux 3.2

- V4L2\_CTRL\_FLAG\_VOLATILE was added to signal volatile controls to userspace.
- Add selection API for extended control over cropping and composing. Does not affect the compatibility of current drivers and applications. See [selection API](#) for details.

## V4L2 in Linux 3.3

- Added V4L2\_CID\_ALPHA\_COMPONENT control to the [User controls class](#).
- Added the device\_caps field to struct v4l2\_capabilities and added the new V4L2\_CAP\_DEVICE\_CAPS capability.

## V4L2 in Linux 3.4

- Added [JPEG compression control class](#).
- Extended the DV Timings API: `ioctl VIDIOC_ENUM_DV_TIMINGS`, `VIDIOC_SUBDEV_ENUM_DV_TIMINGS`, `ioctl VIDIOC_QUERY_DV_TIMINGS` and `VIDIOC_DV_TIMINGS_CAP`, `VIDIOC_SUBDEV_DV_TIMINGS_CAP`.

## V4L2 in Linux 3.5

- Added integer menus, the new type will be V4L2\_CTRL\_TYPE\_INTEGER\_MENU.
- Added selection API for V4L2 subdev interface: `ioctl VIDIOC_SUBDEV_G_SELECTION`, `VIDIOC_SUBDEV_S_SELECTION` and `VIDIOC_SUBDEV_S_SELECTION`.
- Added V4L2\_COLORFX\_ANTIQUE, V4L2\_COLORFX\_ART\_FREEZE, V4L2\_COLORFX\_AQUA, V4L2\_COLORFX\_SILHOUETTE, V4L2\_COLORFX\_SOLARIZATION, V4L2\_COLORFX\_VIVID and V4L2\_COLORFX\_ARBITRARY\_CBCR menu items to the V4L2\_CID\_COLORFX control.
- Added V4L2\_CID\_COLORFX\_CBCR control.
- Added camera controls V4L2\_CID\_AUTO\_EXPOSURE\_BIAS, V4L2\_CID\_AUTO\_N\_PRESET\_WHITE\_BALANCE, V4L2\_CID\_IMAGE\_STABILIZATION, V4L2\_CID\_ISO\_SENSITIVITY, V4L2\_CID\_ISO\_SENSITIVITY\_AUTO, V4L2\_CID\_SCENE\_MODE, V4L2\_CID\_3A\_LOCK, V4L2\_CID\_EXPOSURE\_METERING, V4L2\_CID\_AUTO\_FOCUS\_STOP, V4L2\_CID\_AUTO\_FOCUS\_STATUS and V4L2\_CID\_AUTO\_FOCUS\_RANGE.

## V4L2 in Linux 3.6

1. Replaced `input` in struct `v4l2_buffer` by `reserved2` and removed `V4L2_BUF_FLAG_INPUT`.
2. Added `V4L2_CAP_VIDEO_M2M` and `V4L2_CAP_VIDEO_M2M_MPLANE` capabilities.
3. Added support for frequency band enumerations: *ioctl VIDIOC\_ENUM\_FREQ\_BANDS*.

## V4L2 in Linux 3.9

1. Added timestamp types to `flags` field in struct `v4l2_buffer`. See *Buffer Flags*.
2. Added `V4L2_EVENT_CTRL_CH_RANGE` control event changes flag. See *Control Changes*.

## V4L2 in Linux 3.10

1. Removed obsolete and unused DV\_PRESET ioctls `VIDIOC_G_DV_PRESET`, `VIDIOC_S_DV_PRESET`, `VIDIOC_QUERY_DV_PRESET` and `VIDIOC_ENUM_DV_PRESET`. Remove the related `v4l2_input/output` capability flags `V4L2_IN_CAP_PRESETS` and `V4L2_OUT_CAP_PRESETS`.
2. Added new debugging ioctl *ioctl VIDIOC\_DBG\_G\_CHIP\_INFO*.

## V4L2 in Linux 3.11

1. Remove obsolete `VIDIOC_DBG_G_CHIP_IDENT` ioctl.

## V4L2 in Linux 3.14

1. In `struct v4l2_rect`, the type of `width` and `height` fields changed from `_s32` to `_u32`.

## V4L2 in Linux 3.15

1. Added Software Defined Radio (SDR) Interface.

## V4L2 in Linux 3.16

1. Added event `V4L2_EVENT_SOURCE_CHANGE`.

## V4L2 in Linux 3.17

1. Extended `struct v4l2_pix_format`. Added format flags.
2. Added compound control types and `VIDIOC_QUERY_EXT_CTRL`.

## V4L2 in Linux 3.18

1. Added `V4L2_CID_PAN_SPEED` and `V4L2_CID_TILT_SPEED` camera controls.

## V4L2 in Linux 3.19

1. Rewrote Colorspace chapter, added new `enum v4l2_ycbcr_encoding` and `enum v4l2_quantization` fields to `struct v4l2_pix_format`, `struct v4l2_pix_format_mplane` and `struct v4l2_mbus_framefmt`.

## V4L2 in Linux 4.4

1. Renamed `V4L2_TUNER_ADC` to `V4L2_TUNER_SDR`. The use of `V4L2_TUNER_ADC` is deprecated now.
2. Added `V4L2_CID_RF_TUNER_RF_GAIN` RF Tuner control.
3. Added transmitter support for Software Defined Radio (SDR) Interface.

## Relation of V4L2 to other Linux multimedia APIs

### X Video Extension

The X Video Extension (abbreviated XVideo or just Xv) is an extension of the X Window system, implemented for example by the XFree86 project. Its scope is similar to V4L2, an API to video capture and output devices for X clients. Xv allows applications to display live video in a window, send window contents to a TV output, and capture or output still images in XPixmaps<sup>1</sup>. With their implementation XFree86 makes the extension available across many operating systems and architectures.

Because the driver is embedded into the X server Xv has a number of advantages over the V4L2 `video overlay interface`. The driver can easily determine the overlay target, i. e. visible graphics memory or off-screen buffers for a destructive overlay. It can program the RAMDAC for a non-destructive overlay, scaling or color-keying, or the clipping functions of the video capture hardware, always in sync with drawing operations or windows moving or changing their stacking order.

To combine the advantages of Xv and V4L a special Xv driver exists in XFree86 and XOrg, just programming any overlay capable Video4Linux device it finds. To enable it `/etc/X11/XF86Config` must contain these lines:

<sup>1</sup> This is not implemented in XFree86.

```
Section "Module"
    Load "v4l"
EndSection
```

As of XFree86 4.2 this driver still supports only V4L ioctls, however it should work just fine with all V4L2 devices through the V4L2 backward-compatibility layer. Since V4L2 permits multiple opens it is possible (if supported by the V4L2 driver) to capture video while an X client requested video overlay. Restrictions of simultaneous capturing and overlay are discussed in [Video Overlay Interface](#) apply.

Only marginally related to V4L2, XFree86 extended Xv to support hardware YUV to RGB conversion and scaling for faster video playback, and added an interface to MPEG-2 decoding hardware. This API is useful to display images captured with V4L2 devices.

## Digital Video

V4L2 does not support digital terrestrial, cable or satellite broadcast. A separate project aiming at digital receivers exists. You can find its homepage at <https://linuxtv.org>. The Linux DVB API has no connection to the V4L2 API except that drivers for hybrid hardware may support both.

## Audio Interfaces

[to do - OSS/ALSA]

## Experimental API Elements

The following V4L2 API elements are currently experimental and may change in the future.

- *ioctl VIDIOC\_DBG\_G\_REGISTER*, *VIDIOC\_DBG\_S\_REGISTER* and *VIDIOC\_DBG\_S\_REGISTER* ioctls.
- *ioctl VIDIOC\_DBG\_G\_CHIP\_INFO* ioctl.

## Obsolete API Elements

The following V4L2 API elements were superseded by new interfaces and should not be implemented in new drivers.

- *VIDIOC\_G\_MPEGCOMP* and *VIDIOC\_S\_MPEGCOMP* ioctls. Use Extended Controls, [Extended Controls API](#).
- *VIDIOC\_G\_DV\_PRESET*, *VIDIOC\_S\_DV\_PRESET*, *VIDIOC\_ENUM\_DV\_PRESETS* and *VIDIOC\_QUERY\_DV\_PRESET* ioctls. Use the DV Timings API ([Digital Video \(DV\) Timings](#)).
- *VIDIOC\_SUBDEV\_G\_CROP* and *VIDIOC\_SUBDEV\_S\_CROP* ioctls. *VIDIOC\_SUBDEV\_G\_SELECTION* and *VIDIOC\_SUBDEV\_S\_SELECTION*, *VIDIOC\_SUBDEV\_G\_SELECTION*, *VIDIOC\_SUBDEV\_S\_SELECTION*. Use *ioctl VIDIOC\_SUBDEV\_G\_SELECTION*, *VIDIOC\_SUBDEV\_S\_SELECTION*.

### 13.2.7 Function Reference

#### V4L2 close()

##### Name

v4l2-close - Close a V4L2 device

##### Synopsis

```
#include <unistd.h>
```

```
int close(int fd)
```

##### Arguments

###### fd

File descriptor returned by [open\(\)](#).

##### Description

Closes the device. Any I/O in progress is terminated and resources associated with the file descriptor are freed. However data format parameters, current input or output, control values or other properties remain unchanged.

##### Return Value

The function returns 0 on success, -1 on failure and the `errno` is set appropriately. Possible error codes:

###### EBADF

`fd` is not a valid open file descriptor.

#### V4L2 ioctl()

##### Name

v4l2-ioctl - Program a V4L2 device

## Synopsis

```
#include <sys/ioctl.h>
```

```
int ioctl(int fd, int request, void *argp)
```

## Arguments

### fd

File descriptor returned by [open\(\)](#).

### request

V4L2 ioctl request code as defined in the `videodev2.h` header file, for example VIDIOC\_QUERYCAP.

### argp

Pointer to a function parameter, usually a structure.

## Description

The [ioctl\(\)](#) function is used to program V4L2 devices. The argument `fd` must be an open file descriptor. An ioctl request has encoded in it whether the argument is an input, output or read/write parameter, and the size of the argument `argp` in bytes. Macros and defines specifying V4L2 ioctl requests are located in the `videodev2.h` header file. Applications should use their own copy, not include the version in the kernel sources on the system they compile on. All V4L2 ioctl requests, their respective function and parameters are specified in [Function Reference](#).

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

When an ioctl that takes an output or read/write parameter fails, the parameter remains unmodified.

## ioctl VIDIOC\_CREATE\_BUFS

### Name

VIDIOC\_CREATE\_BUFS - Create buffers for Memory Mapped or User Pointer or DMA Buffer I/O

## Synopsis

### **VIDIOC\_CREATE\_BUFS**

```
int ioctl(int fd, VIDIOC_CREATE_BUFS, struct v4l2_create_buffers *argp)
```

## Arguments

### **fd**

File descriptor returned by `open()`.

### **argp**

Pointer to struct `v4l2_create_buffers`.

## Description

This ioctl is used to create buffers for *memory mapped* or *user pointer* or *DMA buffer* I/O. It can be used as an alternative or in addition to the `ioctl VIDIOC_REQBUFS` ioctl, when a tighter control over buffers is required. This ioctl can be called multiple times to create buffers of different sizes.

To allocate the device buffers applications must initialize the relevant fields of the struct `v4l2_create_buffers` structure. The count field must be set to the number of requested buffers, the memory field specifies the requested I/O method and the reserved array must be zeroed.

The format field specifies the image format that the buffers must be able to handle. The application has to fill in this struct `v4l2_format`. Usually this will be done using the `VIDIOC_TRY_FMT` or `VIDIOC_G_FMT` ioctls to ensure that the requested format is supported by the driver. Based on the format's type field the requested buffer size (for single-planar) or plane sizes (for multi-planar formats) will be used for the allocated buffers. The driver may return an error if the size(s) are not supported by the hardware (usually because they are too small).

The buffers created by this ioctl will have as minimum size the size defined by the `format.pix.sizeimage` field (or the corresponding fields for other format types). Usually if the `format.pix.sizeimage` field is less than the minimum required for the given format, then an error will be returned since drivers will typically not allow this. If it is larger, then the value will be used as-is. In other words, the driver may reject the requested size, but if it is accepted the driver will use it unchanged.

When the ioctl is called with a pointer to this structure the driver will attempt to allocate up to the requested number of buffers and store the actual number allocated and the starting index in the count and the index fields respectively. On return count can be smaller than the number requested.

type `v4l2_create_buffers`

Table 160: struct v4l2\_create\_buffers

<code>_u32</code>	<code>index</code>	The starting buffer index, returned by the driver.
<code>_u32</code>	<code>count</code>	The number of buffers requested or granted. If <code>count == 0</code> , then <code>ioctl VIDIOC_CREATE_BUFS</code> will set <code>index</code> to the current number of created buffers, and it will check the validity of <code>memory</code> and <code>format.type</code> . If those are invalid -1 is returned and <code>errno</code> is set to <code>EINVAL</code> error code, otherwise <code>ioctl VIDIOC_CREATE_BUFS</code> returns 0. It will never set <code>errno</code> to <code>EBUSY</code> error code in this particular case.
<code>_u32</code>	<code>memory</code>	Applications set this field to <code>V4L2_MEMORY_MMAP</code> , <code>V4L2_MEMORY_DMABUF</code> or <code>V4L2_MEMORY_USERPTR</code> . See <code>v4l2_memory</code>
<code>struct v4l2_format</code>	<code>format</code>	Filled in by the application, preserved by the driver.
<code>_u32</code>	<code>capabilities</code>	Set by the driver. If 0, then the driver doesn't support capabilities. In that case all you know is that the driver is guaranteed to support <code>V4L2_MEMORY_MMAP</code> and <i>might</i> support other <code>v4l2_memory</code> types. It will not support any other capabilities. See <a href="#">here</a> for a list of the capabilities. If you want to just query the capabilities without making any other changes, then set <code>count</code> to 0, <code>memory</code> to <code>V4L2_MEMORY_MMAP</code> and <code>format.type</code> to the buffer type.
<code>_u32</code>	<code>flags</code>	Specifies additional buffer management attributes. See <a href="#">Memory Consistency Flags</a> .
<code>_u32</code>	<code>max_num_buffers</code>	If the <code>V4L2_BUF_CAP_SUPPORTS_MAX_NUM_BUFS</code> capability flag is set this field indicates the maximum possible number of buffers for this queue.
<code>_u32</code>	<code>reserved[5]</code>	A place holder for future extensions. Drivers and applications must set the array to zero.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### ENOMEM

No memory to allocate buffers for *memory mapped* I/O.

### EINVAL

The buffer type (`format.type` field), requested I/O method (`memory`) or format (`format` field) is not valid.

## ioctl VIDIOC\_CROPCAP

### Name

VIDIOC\_CROPCAP - Information about the video cropping and scaling abilities

### Synopsis

#### VIDIOC\_CROPCAP

```
int ioctl(int fd, VIDIOC_CROPCAP, struct v4l2_cropcap *argp)
```

### Arguments

#### fd

File descriptor returned by [open\(\)](#).

#### argp

Pointer to struct [\*v4l2\\_cropcap\*](#).

### Description

Applications use this function to query the cropping limits, the pixel aspect of images and to calculate scale factors. They set the `type` field of a `v4l2_cropcap` structure to the respective buffer (stream) type and call the `ioctl VIDIOC_CROPCAP` ioctl with a pointer to this structure. Drivers fill the rest of the structure. The results are constant except when switching the video standard. Remember this switch can occur implicit when switching the video input or output.

This ioctl must be implemented for video capture or output devices that support cropping and/or scaling and/or have non-square pixels, and for overlay devices.

type `v4l2_cropcap`

Table 161: struct v4l2\_cropcap

<code>_u32</code>	<code>type</code>	Type of the data stream, set by the application. Only these types are valid here: <code>V4L2_BUF_TYPE_VIDEO_CAPTURE</code> , <code>V4L2_BUF_TYPE_VIDEO_CAPTURE_MPLANE</code> , <code>V4L2_BUF_TYPE_VIDEO_OUTPUT</code> , <code>V4L2_BUF_TYPE_VIDEO_OUTPUT_MPLANE</code> and <code>V4L2_BUF_TYPE_VIDEO_OVERLAY</code> . See <a href="#">v4l2_buf_type</a> and the note below.
<code>struct v4l2_rect</code>	<code>bounds</code>	Defines the window within capturing or output is possible, this may exclude for example the horizontal and vertical blanking areas. The cropping rectangle cannot exceed these limits. Width and height are defined in pixels, the driver writer is free to choose origin and units of the coordinate system in the analog domain.
<code>struct v4l2_rect</code>	<code>defrect</code>	Default cropping rectangle, it shall cover the "whole picture". Assuming pixel aspect 1/1 this could be for example a $640 \times 480$ rectangle for NTSC, a $768 \times 576$ rectangle for PAL and SECAM centered over the active picture area. The same coordinate system as for <code>bounds</code> is used.
<code>struct v4l2_fract</code>	<code>pixelaspect</code>	This is the pixel aspect (y / x) when no scaling is applied, the ratio of the actual sampling frequency and the frequency required to get square pixels. When cropping coordinates refer to square pixels, the driver sets <code>pixelaspect</code> to 1/1. Other common values are 54/59 for PAL and SECAM, 11/10 for NTSC sampled according to <a href="#">[ITU BT.601]</a> .

**Note:** Unfortunately in the case of multiplanar buffer types (`V4L2_BUF_TYPE_VIDEO_CAPTURE_MPLANE` and `V4L2_BUF_TYPE_VIDEO_OUTPUT_MPLANE`) this API was messed up with regards to how the `v4l2_cropcap` type field should be filled in. Some drivers only accepted the `_MPLANE` buffer type while other drivers only accepted a non-multiplanar buffer type (i.e. without the `_MPLANE` at the end).

Starting with kernel 4.13 both variations are allowed.

Table 162: struct v4l2\_rect

<code>_s32</code>	<code>left</code>	Horizontal offset of the top, left corner of the rectangle, in pixels.
<code>_s32</code>	<code>top</code>	Vertical offset of the top, left corner of the rectangle, in pixels.
<code>_u32</code>	<code>width</code>	Width of the rectangle, in pixels.
<code>_u32</code>	<code>height</code>	Height of the rectangle, in pixels.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### EINVAL

The struct `v4l2_cropcap` type is invalid.

### ENODATA

Cropping is not supported for this input or output.

## ioctl VIDIOC\_DBG\_G\_CHIP\_INFO

### Name

`VIDIOC_DBG_G_CHIP_INFO` - Identify the chips on a TV card

### Synopsis

#### `VIDIOC_DBG_G_CHIP_INFO`

```
int ioctl(int fd, VIDIOC_DBG_G_CHIP_INFO, struct v4l2_dbg_chip_info *argp)
```

### Arguments

#### `fd`

File descriptor returned by `open()`.

#### `argp`

Pointer to struct `v4l2_dbg_chip_info`.

## Description

**Note:** This is an *Experimental API Elements* interface and may change in the future.

For driver debugging purposes this ioctl allows test applications to query the driver about the chips present on the TV card. Regular applications must not use it. When you found a chip specific bug, please contact the linux-media mailing list (<https://linuxtv.org/lists.php>) so it can be fixed.

Additionally the Linux kernel must be compiled with the CONFIG\_VIDEO\_ADV\_DEBUG option to enable this ioctl.

To query the driver applications must initialize the `match.type` and `match.addr` or `match.name` fields of a struct `v4l2_dbg_chip_info` and call `ioctl VIDIOC_DBG_G_CHIP_INFO` with a pointer to this structure. On success the driver stores information about the selected chip in the `name` and `flags` fields.

When `match.type` is `V4L2_CHIP_MATCH_BRIDGE`, `match.addr` selects the nth bridge 'chip' on the TV card. You can enumerate all chips by starting at zero and incrementing `match.addr` by one until `ioctl VIDIOC_DBG_G_CHIP_INFO` fails with an EINVAL error code. The number zero always selects the bridge chip itself, e. g. the chip connected to the PCI or USB bus. Non-zero numbers identify specific parts of the bridge chip such as an AC97 register block.

When `match.type` is `V4L2_CHIP_MATCH_SUBDEV`, `match.addr` selects the nth sub-device. This allows you to enumerate over all sub-devices.

On success, the `name` field will contain a chip name and the `flags` field will contain `V4L2_CHIP_FL_READABLE` if the driver supports reading registers from the device or `V4L2_CHIP_FL_WRITABLE` if the driver supports writing registers to the device.

We recommended the v4l2-dbg utility over calling this ioctl directly. It is available from the LinuxTV v4l-dvb repository; see <https://linuxtv.org/repo/> for access instructions.

Table 163: struct `v4l2_dbg_match`

<code>_u32</code>	<code>type</code>	See <i>Chip Match Types</i> for a list of possible types.
<code>union {</code>	<code>(anonymous)</code>	
<code>_u32</code>	<code>addr</code>	Match a chip by this number, interpreted according to the <code>type</code> field.
<code>char</code>	<code>name[32]</code>	Match a chip by this name, interpreted according to the <code>type</code> field. Currently unused.
<code>}</code>		

type **v4l2\_dbg\_chip\_info**

Table 164: struct v4l2\_dbg\_chip\_info

struct v4l2_dbg_match	match	How to match the chip, see <i>struct v4l2_dbg_match</i> .
char __u32	name[32]	The name of the chip.
__u32	flags	Set by the driver. If V4L2_CHIP_FL_READABLE is set, then the driver supports reading registers from the device. If V4L2_CHIP_FL_WRITABLE is set, then it supports writing registers.
__u32	reserved[8]	Reserved fields, both application and driver must set these to 0.

Table 165: Chip Match Types

V4L2_CHIP_MATCH_BRIDGE	0	Match the nth chip on the card, zero for the bridge chip. Does not match sub-devices.
V4L2_CHIP_MATCH_SUBDEV	4	Match the nth sub-device.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## EINVAL

The `match_type` is invalid or no device could be matched.

## ioctl VIDIOC\_DBG\_G\_REGISTER, VIDIOC\_DBG\_S\_REGISTER

### Name

VIDIOC\_DBG\_G\_REGISTER - VIDIOC\_DBG\_S\_REGISTER - Read or write hardware registers

### Synopsis

#### VIDIOC\_DBG\_G\_REGISTER

```
int ioctl(int fd, VIDIOC_DBG_G_REGISTER, struct v4l2_dbg_register *argp)
```

#### VIDIOC\_DBG\_S\_REGISTER

```
int ioctl(int fd, VIDIOC_DBG_S_REGISTER, const struct v4l2_dbg_register *argp)
```

### Arguments

#### fd

File descriptor returned by `open()`.

#### argp

Pointer to struct `v4l2_dbg_register`.

### Description

---

**Note:** This is an *Experimental API Elements* interface and may change in the future.

---

For driver debugging purposes these ioctls allow test applications to access hardware registers directly. Regular applications must not use them.

Since writing or even reading registers can jeopardize the system security, its stability and damage the hardware, both ioctls require superuser privileges. Additionally the Linux kernel must be compiled with the `CONFIG_VIDEO_ADV_DEBUG` option to enable these ioctls.

To write a register applications must initialize all fields of a struct `v4l2_dbg_register` except for `size` and call `VIDIOC_DBG_S_REGISTER` with a pointer to this structure. The `match.type` and `match.addr` or `match.name` fields select a chip on the TV card, the `reg` field specifies a register number and the `val` field the value to be written into the register.

To read a register applications must initialize the `match.type`, `match.addr` or `match.name` and `reg` fields, and call `VIDIOC_DBG_G_REGISTER` with a pointer to this structure. On success the driver stores the register value in the `val` field and the size (in bytes) of the value in `size`.

When `match.type` is `V4L2_CHIP_MATCH_BRIDGE`, `match.addr` selects the nth non-sub-device chip on the TV card. The number zero always selects the host chip, e. g. the chip connected to the PCI or USB bus. You can find out which chips are present with the *ioctl VIDIOC\_DBG\_G\_CHIP\_INFO* ioctl.

When `match.type` is `V4L2_CHIP_MATCH_SUBDEV`, `match.addr` selects the nth sub-device.

These ioctls are optional, not all drivers may support them. However when a driver supports these ioctls it must also support *ioctl VIDIOC\_DBG\_G\_CHIP\_INFO*. Conversely it may support `VIDIOC_DBG_G_CHIP_INFO` but not these ioctls.

`VIDIOC_DBG_G_REGISTER` and `VIDIOC_DBG_S_REGISTER` were introduced in Linux 2.6.21, but their API was changed to the one described here in kernel 2.6.29.

We recommended the `v4l2-dbg` utility over calling these ioctls directly. It is available from the LinuxTV v4l-dvb repository; see <https://linuxtv.org/repo/> for access instructions.

type `v4l2_dbg_match`

Table 166: struct v4l2\_dbg\_match

<code>_u32</code>	<code>type</code>	See <a href="#">Chip Match Types</a> for a list of possible types.
<code>union {</code>	<code>(anonymous)</code>	
<code>_u32</code>	<code>addr</code>	Match a chip by this number, interpreted according to the type field.
<code>char</code>	<code>name[32]</code>	Match a chip by this name, interpreted according to the type field. Currently unused.
<code>}</code>		

type `v4l2_dbg_register`

Table 167: struct v4l2\_dbg\_register

<code>struct v4l2_dbg_match</code>	<code>match</code>	How to match the chip, see <a href="#">v4l2_dbg_match</a> .
<code>_u32</code>	<code>size</code>	The register size in bytes.
<code>_u64</code>	<code>reg</code>	A register number.
<code>_u64</code>	<code>val</code>	The value read from, or to be written into the register.

Table 168: Chip Match Types

<code>V4L2_CHIP_MATCH_BRIDGE</code>	<code>0</code>	Match the nth chip on the card, zero for the bridge chip. Does not match sub-devices.
<code>V4L2_CHIP_MATCH_SUBDEV</code>	<code>4</code>	Match the nth sub-device.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## EPERM

Insufficient permissions. Root privileges are required to execute these ioctls.

## **ioctl VIDIOC\_DECODER\_CMD, VIDIOC\_TRY\_DECODER\_CMD**

### **Name**

VIDIOC\_DECODER\_CMD - VIDIOC\_TRY\_DECODER\_CMD - Execute an decoder command

### **Synopsis**

#### **VIDIOC\_DECODER\_CMD**

```
int ioctl(int fd, VIDIOC_DECODER_CMD, struct v4l2_decoder_cmd *argp)
```

#### **VIDIOC\_TRY\_DECODER\_CMD**

```
int ioctl(int fd, VIDIOC_TRY_DECODER_CMD, struct v4l2_decoder_cmd *argp)
```

### **Arguments**

#### **fd**

File descriptor returned by [open\(\)](#).

#### **argp**

pointer to struct [\*v4l2\\_decoder\\_cmd\*](#).

### **Description**

These ioctls control an audio/video (usually MPEG-) decoder. VIDIOC\_DECODER\_CMD sends a command to the decoder, VIDIOC\_TRY\_DECODER\_CMD can be used to try a command without actually executing it. To send a command applications must initialize all fields of a struct [\*v4l2\\_decoder\\_cmd\*](#) and call VIDIOC\_DECODER\_CMD or VIDIOC\_TRY\_DECODER\_CMD with a pointer to this structure.

The cmd field must contain the command code. Some commands use the flags field for additional information.

A [write\(\)](#) or [ioctl VIDIOC\\_STREAMON](#), [VIDIOC\\_STREAMOFF](#) call sends an implicit START command to the decoder if it has not been started yet. Applies to both queues of mem2mem decoders.

A [close\(\)](#) or [VIDIOC\\_STREAMOFF](#) call of a streaming file descriptor sends an implicit immediate STOP command to the decoder, and all buffered data is discarded. Applies to both queues of mem2mem decoders.

In principle, these ioctls are optional, not all drivers may support them. They were introduced in Linux 3.3. They are, however, mandatory for stateful mem2mem decoders (as further documented in [Memory-to-Memory Stateful Video Decoder Interface](#)).

type **v4l2\_decoder\_cmd**

Table 169: struct v4l2\_decoder\_cmd

<code>__u32</code>	<code>cmd</code>		The decoder command, see <a href="#">Decoder Commands</a> .
<code>__u32</code>	<code>flags</code>		Flags to go with the command. If no flags are defined for this command, drivers and applications must set this field to zero.
union {	(anonymous)		
struct	<code>start</code>		Structure containing additional data for the V4L2_DEC_CMD_START command.
	<code>__s32</code>	<code>speed</code>	Playback speed and direction. The playback speed is defined as <code>speed/1000</code> of the normal speed. So 1000 is normal playback. Negative numbers denote reverse playback, so -1000 does reverse playback at normal speed. Speeds -1, 0 and 1 have special meanings: speed 0 is shorthand for 1000 (normal playback). A speed of 1 steps just one frame forward, a speed of -1 steps just one frame back.
	<code>__u32</code>	<code>format</code>	Format restrictions. This field is set by the driver, not the application. Possible values are V4L2_DEC_START_FMT_NONE if there are no format restrictions or V4L2_DEC_START_FMT_GOP if the decoder operates on full GOPs ( <i>Group Of Pictures</i> ). This is usually the case for reverse playback: the decoder needs full GOPs, which it can then play in reverse order. So to implement reverse playback the application must feed the decoder the last GOP in the video file, then the GOP before that, etc. etc.
struct	<code>stop</code>		Structure containing additional data for the V4L2_DEC_CMD_STOP command.
	<code>__u64</code>	<code>pts</code>	Stop playback at this pts or immediately if the playback is already past that timestamp. Leave to 0 if you want to stop after the last frame was decoded.
struct	<code>raw</code>		
	<code>__u32</code>	<code>data[16]</code>	Reserved for future extensions. Drivers and applications must set the array to zero.
}			

Table 170: Decoder Commands

V4L2_DEC_CMD_START	0	<p>Start the decoder. When the decoder is already running or paused, this command will just change the playback speed. That means that calling V4L2_DEC_CMD_START when the decoder was paused will <i>not</i> resume the decoder. You have to explicitly call V4L2_DEC_CMD_RESUME for that. This command has one flag: V4L2_DEC_CMD_START_MUTE_AUDIO. If set, then audio will be muted when playing back at a non-standard speed.</p> <p>For a device implementing the <a href="#">Memory-to-Memory Stateful Video Decoder Interface</a>, once the drain sequence is initiated with the V4L2_DEC_CMD_STOP command, it must be driven to completion before this command can be invoked. Any attempt to invoke the command while the drain sequence is in progress will trigger an EBUSY error code. The command may be also used to restart the decoder in case of an implicit stop initiated by the decoder itself, without the V4L2_DEC_CMD_STOP being called explicitly. See <a href="#">Memory-to-Memory Stateful Video Decoder Interface</a> for more details.</p>
V4L2_DEC_CMD_STOP	1	<p>Stop the decoder. When the decoder is already stopped, this command does nothing. This command has two flags: if V4L2_DEC_CMD_STOP_TO_BLACK is set, then the decoder will set the picture to black after it stopped decoding. Otherwise the last image will repeat. If V4L2_DEC_CMD_STOP_IMMEDIATELY is set, then the decoder stops immediately (ignoring the pts value), otherwise it will keep decoding until timestamp <math>\geq</math> pts or until the last of the pending data from its internal buffers was decoded.</p> <p>For a device implementing the <a href="#">Memory-to-Memory Stateful Video Decoder Interface</a>, the command will initiate the drain sequence as documented in <a href="#">Memory-to-Memory Stateful Video Decoder Interface</a>. No flags or other arguments are accepted in this case. Any attempt to invoke the command again before the sequence completes will trigger an EBUSY error code.</p>
V4L2_DEC_CMD_PAUSE	2	<p>Pause the decoder. When the decoder has not been started yet, the driver will return an EPERM error code. When the decoder is already paused, this command does nothing. This command has one flag: if V4L2_DEC_CMD_PAUSE_TO_BLACK is set, then set the decoder output to black when paused.</p>
V4L2_DEC_CMD_RESUME	3	<p>Resume decoding after a PAUSE command. When the decoder has not been started yet, the driver will return an EPERM error code. When the decoder is already running, this command does nothing. No flags are defined for this command.</p>

continues on next page

Table 170 – continued from previous page

V4L2_DEC_CMD_FLUSH	4	Flush any held capture buffers. Only valid for stateless decoders. This command is typically used when the application reached the end of the stream and the last output buffer had the V4L2_BUF_FLAG_M2M_HOLD_CAPTURE_BUF flag set. This would prevent dequeuing the capture buffer containing the last decoded frame. So this command can be used to explicitly flush that final decoded frame. This command does nothing if there are no held capture buffers.
--------------------	---	---

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### EBUSY

A drain sequence of a device implementing the [Memory-to-Memory Stateful Video Decoder Interface](#) is still in progress. It is not allowed to issue another decoder command until it completes.

### EINVAL

The `cmd` field is invalid.

### EPERM

The application sent a PAUSE or RESUME command when the decoder was not running.

## ioctl VIDIOC\_DQEVENT

### Name

VIDIOC\_DQEVENT - Dequeue event

### Synopsis

#### VIDIOC\_DQEVENT

```
int ioctl(int fd, VIDIOC_DQEVENT, struct v4l2_event *argp)
```

### Arguments

#### fd

File descriptor returned by [open\(\)](#).

#### argp

Pointer to struct [v4l2\\_event](#).

## Description

Dequeue an event from a video device. No input is required for this ioctl. All the fields of the struct `v4l2_event` structure are filled by the driver. The file handle will also receive exceptions which the application may get by e.g. using the select system call.

type `v4l2_event`

Table 171: struct `v4l2_event`

<code>_u32</code>	<code>type</code>	Type of the event, see <i>Event Types</i> .
union {	<code>u</code>	
struct <code>v4l2_event_vsync</code>	<code>vsync</code>	Event data for event V4L2_EVENT_VSYNC.
struct <code>v4l2_event_ctrl</code>	<code>ctrl</code>	Event data for event V4L2_EVENT_CTRL.
struct <code>v4l2_event_frame_sync</code>	<code>frame_sync</code>	Event data for event V4L2_EVENT_FRAME_SYNC.
struct <code>v4l2_event_motion_det</code>	<code>motion_det</code>	Event data for event V4L2_EVENT_MOTION_DET.
struct <code>v4l2_event_src_change</code>	<code>src_change</code>	Event data for event V4L2_EVENT_SOURCE_CHANGE.
<code>_u8</code>	<code>data[64]</code>	Event data. Defined by the event type. The union should be used to define easily accessible type for events.
}		
<code>_u32</code>	<code>pending</code>	Number of pending events excluding this one.
<code>_u32</code>	<code>sequence</code>	Event sequence number. The sequence number is incremented for every subscribed event that takes place. If sequence numbers are not contiguous it means that events have been lost.
struct timespec	<code>timestamp</code>	Event timestamp. The timestamp has been taken from the CLOCK_MONOTONIC clock. To access the same clock outside V4L2, use <code>clock_gettime()</code> .
<code>u32</code>	<code>id</code>	The ID associated with the event source. If the event does not have an associated ID (this depends on the event type), then this is 0.
<code>_u32</code>	<code>reserved[8]</code>	Reserved for future extensions. Drivers must set the array to zero.

Table 172: Event Types

<code>V4L2_EVENT_ALL</code>	0	All events. <code>V4L2_EVENT_ALL</code> is valid only for VIDIOC_UNSUBSCRIBE_EVENT for unsubscribing all events at once.
<code>V4L2_EVENT_VSYNC</code>	1	This event is triggered on the vertical sync. This event has a struct <code>v4l2_event_vsync</code> associated with it.

continues on next page

Table 172 – continued from previous page

V4L2_EVENT_EOS	2	This event is triggered when the end of a stream is reached. This is typically used with MPEG decoders to report to the application when the last of the MPEG stream has been decoded.
V4L2_EVENT_CTRL	3	This event requires that the id matches the control ID from which you want to receive events. This event is triggered if the control's value changes, if a button control is pressed or if the control's flags change. This event has a struct <code>v4l2_event_ctrl</code> associated with it. This struct contains much of the same information as struct <code>v4l2_queryctrl</code> and struct <code>v4l2_control</code> . If the event is generated due to a call to <code>VIDIOC_S_CTRL</code> or <code>VIDIOC_S_EXT_CTRLS</code> , then the event will <i>not</i> be sent to the file handle that called the ioctl function. This prevents nasty feedback loops. If you <i>do</i> want to get the event, then set the V4L2_EVENT_SUB_FL_ALLOW_FEEDBACK flag. This event type will ensure that no information is lost when more events are raised than there is room internally. In that case the struct <code>v4l2_event_ctrl</code> of the second-oldest event is kept, but the <code>changes</code> field of the second-oldest event is ORed with the <code>changes</code> field of the oldest event.
V4L2_EVENT_FRAME_SYNC	4	Triggered immediately when the reception of a frame has begun. This event has a struct <code>v4l2_event_frame_sync</code> associated with it. If the hardware needs to be stopped in the case of a buffer underrun it might not be able to generate this event. In such cases the <code>frame_sequence</code> field in struct <code>v4l2_event_frame_sync</code> will not be incremented. This causes two consecutive frame sequence numbers to have n times frame interval in between them.

continues on next page

Table 172 – continued from previous page

V4L2_EVENT_SOURCE_CHANGE	5	<p>This event is triggered when a source parameter change is detected during runtime by the video device. It can be a runtime resolution change triggered by a video decoder or the format change happening on an input connector. This event requires that the id matches the input index (when used with a video device node) or the pad index (when used with a subdevice node) from which you want to receive events.</p> <p>This event has a struct <a href="#">v4l2_event_src_change</a> associated with it. The changes bitfield denotes what has changed for the subscribed pad. If multiple events occurred before application could dequeue them, then the changes will have the ORed value of all the events generated.</p>
V4L2_EVENT_MOTION_DET	6	Triggered whenever the motion detection state for one or more of the regions changes. This event has a struct <a href="#">v4l2_event_motion_det</a> associated with it.
V4L2_EVENT_PRIVATE_START	0x08000000	Base event number for driver-private events.

type **v4l2\_event\_vsync**

Table 173: struct v4l2\_event\_vsync

__u8	field	The upcoming field. See enum <a href="#">v4l2_field</a> .
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type **v4l2\_event\_ctrl**

Table 174: struct v4l2\_event\_ctrl

__u32	changes	A bitmask that tells what has changed. See <a href="#">Control Changes</a> .
__u32	type	The type of the control. See enum <a href="#">v4l2_ctrl_type</a> .
union {	(anonymous)	
__s32	value	The 32-bit value of the control for 32-bit control types. This is 0 for string controls since the value of a string cannot be passed using <a href="#">ioctl VIDIOC_DQEVENT</a> .
__s64	value64	The 64-bit value of the control for 64-bit control types.
}		
__u32	flags	The control flags. See <a href="#">Control Flags</a> .
__s32	minimum	The minimum value of the control. See struct <a href="#">v4l2_queryctrl</a> .
__s32	maximum	The maximum value of the control. See struct <a href="#">v4l2_queryctrl</a> .
__s32	step	The step value of the control. See struct <a href="#">v4l2_queryctrl</a> .
__s32	default_value	The default value of the control. See struct <a href="#">v4l2_queryctrl</a> .

type **v4l2\_event\_frame\_sync**

Table 175: struct v4l2\_event\_frame\_sync

<code>_u32</code>	<code>frame_sequence</code>	The sequence number of the frame being received.
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type **v4l2\_event\_src\_change**

Table 176: struct v4l2\_event\_src\_change

<code>_u32</code>	<code>changes</code>	A bitmask that tells what has changed. See <a href="#">Source Changes</a> .
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type **v4l2\_event\_motion\_det**

Table 177: struct v4l2\_event\_motion\_det

<code>_u32</code>	<code>flags</code>	Currently only one flag is available: if <code>V4L2_EVENT_MD_FL_HAVE_FRAME_SEQ</code> is set, then the <code>frame_sequence</code> field is valid, otherwise that field should be ignored.
<code>_u32</code>	<code>frame_sequence</code>	The sequence number of the frame being received. Only valid if the <code>V4L2_EVENT_MD_FL_HAVE_FRAME_SEQ</code> flag was set.
<code>_u32</code>	<code>region_mask</code>	The bitmask of the regions that reported motion. There is at least one region. If this field is 0, then no motion was detected at all. If there is no <code>V4L2_CID_DETECT_MD_REGION_GRID</code> control (see <a href="#">Detect Control Reference</a> ) to assign a different region to each cell in the motion detection grid, then that all cells are automatically assigned to the default region 0.

Table 178: Control Changes

V4L2_EVENT_CTRL_CH_VALUE	0x0001	This control event was triggered because the value of the control changed. Special cases: Volatile controls do no generate this event; If a control has the V4L2_CTRL_FLAG_EXECUTE_ON_WRITE flag set, then this event is sent as well, regardless its value.
V4L2_EVENT_CTRL_CH_FLAGS	0x0002	This control event was triggered because the control flags changed.
V4L2_EVENT_CTRL_CH_RANGE	0x0004	This control event was triggered because the minimum, maximum, step or the default value of the control changed.
V4L2_EVENT_CTRL_CH_DIMENSIONS	0x0008	This control event was triggered because the dimensions of the control changed. Note that the number of dimensions remains the same.

Table 179: Source Changes

V4L2_EVENT_SRC_CH_RESOLUTION	0x0001	<p>This event gets triggered when a resolution change is detected at an input. This can come from an input connector or from a video decoder. Applications will have to query the new resolution (if any, the signal may also have been lost). For stateful decoders follow the guidelines in <a href="#">Memory-to-Memory Stateful Video Decoder Interface</a>. Video Capture devices have to query the new timings using <code>ioctl VIDIOC_QUERY_DV_TIMINGS</code> or <code>VIDIOC_QUERYSTD</code>.</p> <p><i>Important:</i> even if the new video timings appear identical to the old ones, receiving this event indicates that there was an issue with the video signal and you must stop and restart streaming (<a href="#">VIDIOC_STREAMOFF</a> followed by <a href="#">VIDIOC_STREAMON</a>). The reason is that many Video Capture devices are not able to recover from a temporary loss of signal and so restarting streaming I/O is required in order for the hardware to synchronize to the video signal.</p>
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## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## `ioctl VIDIOC_DV_TIMINGS_CAP, VIDIOC_SUBDEV_DV_TIMINGS_CAP`

### Name

`VIDIOC_DV_TIMINGS_CAP` - `VIDIOC_SUBDEV_DV_TIMINGS_CAP` - The capabilities of the Digital Video receiver/transmitter

### Synopsis

#### `VIDIOC_DV_TIMINGS_CAP`

```
int ioctl(int fd, VIDIOC_DV_TIMINGS_CAP, struct v4l2_dv_timings_cap *argp)
```

#### `VIDIOC_SUBDEV_DV_TIMINGS_CAP`

```
int ioctl(int fd, VIDIOC_SUBDEV_DV_TIMINGS_CAP, struct v4l2_dv_timings_cap *argp)
```

### Arguments

#### `fd`

File descriptor returned by `open()`.

#### `argp`

Pointer to struct `v4l2_dv_timings_cap`.

### Description

To query the capabilities of the DV receiver/transmitter applications initialize the `pad` field to 0, zero the reserved array of struct `v4l2_dv_timings_cap` and call the `VIDIOC_DV_TIMINGS_CAP` ioctl on a video node and the driver will fill in the structure.

---

**Note:** Drivers may return different values after switching the video input or output.

When implemented by the driver DV capabilities of subdevices can be queried by calling the `VIDIOC_SUBDEV_DV_TIMINGS_CAP` ioctl directly on a subdevice node. The capabilities are specific to inputs (for DV receivers) or outputs (for DV transmitters), applications must specify the desired pad number in the struct `v4l2_dv_timings_cap` `pad` field and zero the reserved array. Attempts to query capabilities on a pad that doesn't support them will return an `EINVAL` error code.

type **v4l2\_bt\_timings\_cap**

Table 180: struct v4l2\_bt\_timings\_cap

<code>_u32</code>	<code>min_width</code>	Minimum width of the active video in pixels.
<code>_u32</code>	<code>max_width</code>	Maximum width of the active video in pixels.
<code>_u32</code>	<code>min_height</code>	Minimum height of the active video in lines.
<code>_u32</code>	<code>max_height</code>	Maximum height of the active video in lines.
<code>_u64</code>	<code>min_pixelclock</code>	Minimum pixelclock frequency in Hz.
<code>_u64</code>	<code>max_pixelclock</code>	Maximum pixelclock frequency in Hz.
<code>_u32</code>	<code>standards</code>	The video standard(s) supported by the hardware. See <a href="#">DV BT Timing standards</a> for a list of standards.
<code>_u32</code>	<code>capabilities</code>	Several flags giving more information about the capabilities. See <a href="#">DV BT Timing capabilities</a> for a description of the flags.
<code>_u32</code>	<code>reserved[16]</code>	Reserved for future extensions. Drivers must set the array to zero.

type **v4l2\_dv\_timings\_cap**

Table 181: struct v4l2\_dv\_timings\_cap

<code>_u32</code>	<code>type</code>	Type of DV timings as listed in <a href="#">DV Timing types</a> .
<code>_u32</code>	<code>pad</code>	Pad number as reported by the media controller API. This field is only used when operating on a subdevice node. When operating on a video node applications must set this field to zero.
<code>_u32</code>	<code>reserved[2]</code>	Reserved for future extensions. Drivers and applications must set the array to zero.
<code>union {</code>	<code>(anonymous)</code>	
<code>struct</code> <code>v4l2_bt_timings_cap</code>	<code>bt</code>	BT.656/1120 timings capabilities of the hardware.
<code>_u32</code>	<code>raw_data[32]</code>	
<code>}</code>		

Table 182: DV BT Timing capabilities

Flag	Description
<code>V4L2_DV_BT_CAP_INTERLACED</code>	Interlaced formats are supported.
<code>V4L2_DV_BT_CAP_PROGRESSIVE</code>	Progressive formats are supported.
<code>V4L2_DV_BT_CAP_REDUCED_BLANKING</code>	CVT/GTF specific: the timings can make use of reduced blanking (CVT) or the 'Secondary GTF' curve (GTF).
<code>V4L2_DV_BT_CAP_CUSTOM</code>	Can support non-standard timings, i.e. timings not belonging to the standards set in the <code>standards</code> field.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## ioctl VIDIOC\_ENCODER\_CMD, VIDIOC\_TRY\_ENCODER\_CMD

### Name

`VIDIOC_ENCODER_CMD` - `VIDIOC_TRY_ENCODER_CMD` - Execute an encoder command

### Synopsis

#### `VIDIOC_ENCODER_CMD`

```
int ioctl(int fd, VIDIOC_ENCODER_CMD, struct v4l2_encoder_cmd *argp)
```

#### `VIDIOC_TRY_ENCODER_CMD`

```
int ioctl(int fd, VIDIOC_TRY_ENCODER_CMD, struct v4l2_encoder_cmd *argp)
```

### Arguments

#### `fd`

File descriptor returned by [`open\(\)`](#).

#### `argp`

Pointer to struct [`v4l2\_encoder\_cmd`](#).

### Description

These ioctls control an audio/video (usually MPEG-) encoder. `VIDIOC_ENCODER_CMD` sends a command to the encoder, `VIDIOC_TRY_ENCODER_CMD` can be used to try a command without actually executing it.

To send a command applications must initialize all fields of a struct [`v4l2\_encoder\_cmd`](#) and call `VIDIOC_ENCODER_CMD` or `VIDIOC_TRY_ENCODER_CMD` with a pointer to this structure.

The `cmd` field must contain the command code. Some commands use the `flags` field for additional information.

After a STOP command, `read()` calls will read the remaining data buffered by the driver. When the buffer is empty, `read()` will return zero and the next `read()` call will restart the encoder.

A `read()` or `VIDIOC_STREAMON` call sends an implicit START command to the encoder if it has not been started yet. Applies to both queues of mem2mem encoders.

A `close()` or `VIDIOC_STREAMOFF` call of a streaming file descriptor sends an implicit immediate STOP to the encoder, and all buffered data is discarded. Applies to both queues of mem2mem encoders.

These ioctls are optional, not all drivers may support them. They were introduced in Linux 2.6.21. They are, however, mandatory for stateful mem2mem encoders (as further documented in [Memory-to-Memory Stateful Video Encoder Interface](#)).

type **v4l2\_encoder\_cmd**

Table 183: struct v4l2\_encoder\_cmd

<code>_u32</code>	<code>cmd</code>	The encoder command, see <a href="#">Encoder Commands</a> .
<code>_u32</code>	<code>flags</code>	Flags to go with the command, see <a href="#">Encoder Command Flags</a> . If no flags are defined for this command, drivers and applications must set this field to zero.
<code>_u32</code>	<code>data[8]</code>	Reserved for future extensions. Drivers and applications must set the array to zero.

Table 184: Encoder Commands

V4L2_ENC_CMD_START	0	<p>Start the encoder. When the encoder is already running or paused, this command does nothing. No flags are defined for this command.</p> <p>For a device implementing the <a href="#">Memory-to-Memory Stateful Video Encoder Interface</a>, once the drain sequence is initiated with the V4L2_ENC_CMD_STOP command, it must be driven to completion before this command can be invoked. Any attempt to invoke the command while the drain sequence is in progress will trigger an EBUSY error code. See <a href="#">Memory-to-Memory Stateful Video Encoder Interface</a> for more details.</p>
V4L2_ENC_CMD_STOP	1	<p>Stop the encoder. When the V4L2_ENC_CMD_STOP_AT_GOP_END flag is set, encoding will continue until the end of the current <i>Group Of Pictures</i>, otherwise encoding will stop immediately. When the encoder is already stopped, this command does nothing.</p> <p>For a device implementing the <a href="#">Memory-to-Memory Stateful Video Encoder Interface</a>, the command will initiate the drain sequence as documented in <a href="#">Memory-to-Memory Stateful Video Encoder Interface</a>. No flags or other arguments are accepted in this case. Any attempt to invoke the command again before the sequence completes will trigger an EBUSY error code.</p>
V4L2_ENC_CMD_PAUSE	2	<p>Pause the encoder. When the encoder has not been started yet, the driver will return an EPERM error code. When the encoder is already paused, this command does nothing. No flags are defined for this command.</p>
V4L2_ENC_CMD_RESUME	3	<p>Resume encoding after a PAUSE command. When the encoder has not been started yet, the driver will return an EPERM error code. When the encoder is already running, this command does nothing. No flags are defined for this command.</p>

Table 185: Encoder Command Flags

V4L2_ENC_CMD_STOP_AT_GOP_END	0x0001	Stop encoding at the end of the current <i>Group Of Pictures</i> , rather than immediately. Does not apply to <a href="#">Memory-to-Memory Stateful Video Encoder Interface</a> .
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## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## EBUSY

A drain sequence of a device implementing the [Memory-to-Memory Stateful Video Encoder Interface](#) is still in progress. It is not allowed to issue another encoder command until it completes.

## EINVAL

The `cmd` field is invalid.

## EPERM

The application sent a PAUSE or RESUME command when the encoder was not running.

## ioctl VIDIOC\_ENUMAUDIO

### Name

`VIDIOC_ENUMAUDIO` - Enumerate audio inputs

### Synopsis

#### `VIDIOC_ENUMAUDIO`

```
int ioctl(int fd, VIDIOC_ENUMAUDIO, struct v4l2_audio *argp)
```

### Arguments

#### `fd`

File descriptor returned by [`open\(\)`](#).

#### `argp`

Pointer to struct [`v4l2\_audio`](#).

### Description

To query the attributes of an audio input applications initialize the `index` field and zero out the reserved array of a struct [`v4l2\_audio`](#) and call the [`ioctl VIDIOC\_ENUMAUDIO`](#) ioctl with a pointer to this structure. Drivers fill the rest of the structure or return an EINVAL error code when the index is out of bounds. To enumerate all audio inputs applications shall begin at index zero, incrementing by one until the driver returns EINVAL.

See [`VIDIOC\_G\_AUDIO`](#) for a description of struct [`v4l2\_audio`](#).

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### EINVAL

The number of the audio input is out of bounds.

## ioctl VIDIOC\_ENUMAUDOUT

### Name

`VIDIOC_ENUMAUDOUT` - Enumerate audio outputs

### Synopsis

#### `VIDIOC_ENUMAUDOUT`

```
int ioctl(int fd, VIDIOC_ENUMAUDOUT, struct v4l2_audioout *argp)
```

### Arguments

#### `fd`

File descriptor returned by `open()`.

#### `argp`

Pointer to struct `v4l2_audioout`.

### Description

To query the attributes of an audio output applications initialize the `index` field and zero out the `reserved` array of a struct `v4l2_audioout` and call the `VIDIOC_G_AUDOUT` ioctl with a pointer to this structure. Drivers fill the rest of the structure or return an `EINVAL` error code when the index is out of bounds. To enumerate all audio outputs applications shall begin at index zero, incrementing by one until the driver returns `EINVAL`.

---

**Note:** Connectors on a TV card to loop back the received audio signal to a sound card are not audio outputs in this sense.

---

See `VIDIOC_G_AUDIOout` for a description of struct `v4l2_audioout`.

### Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### EINVAL

The number of the audio output is out of bounds.

## ioctl VIDIOC\_ENUM\_DV\_TIMINGS, VIDIOC\_SUBDEV\_ENUM\_DV\_TIMINGS

### Name

`VIDIOC_ENUM_DV_TIMINGS` - `VIDIOC_SUBDEV_ENUM_DV_TIMINGS` - Enumerate supported Digital Video timings

### Synopsis

#### `VIDIOC_ENUM_DV_TIMINGS`

```
int ioctl(int fd, VIDIOC_ENUM_DV_TIMINGS, struct v4l2_enum_dv_timings *argp)
```

#### `VIDIOC_SUBDEV_ENUM_DV_TIMINGS`

```
int ioctl(int fd, VIDIOC_SUBDEV_ENUM_DV_TIMINGS, struct v4l2_enum_dv_timings *argp)
```

### Arguments

#### `fd`

File descriptor returned by [`open\(\)`](#).

#### `argp`

Pointer to struct [`v4l2\_enum\_dv\_timings`](#).

### Description

While some DV receivers or transmitters support a wide range of timings, others support only a limited number of timings. With this ioctl applications can enumerate a list of known supported timings. Call [`ioctl VIDIOC\_DV\_TIMINGS\_CAP`](#), [`VIDIOC\_SUBDEV\_DV\_TIMINGS\_CAP`](#) to check if it also supports other standards or even custom timings that are not in this list.

To query the available timings, applications initialize the `index` field, set the `pad` field to 0, zero the reserved array of struct [`v4l2\_enum\_dv\_timings`](#) and call the `VIDIOC_ENUM_DV_TIMINGS` ioctl on a video node with a pointer to this structure. Drivers fill the rest of the structure or return an `EINVAL` error code when the `index` is out of bounds. To enumerate all supported DV timings, applications shall begin at index zero, incrementing by one until the driver returns `EINVAL`.

---

**Note:** Drivers may enumerate a different set of DV timings after switching the video input or output.

---

When implemented by the driver DV timings of subdevices can be queried by calling the VIDIOC\_SUBDEV\_ENUM\_DV\_TIMINGS ioctl directly on a subdevice node. The DV timings are specific to inputs (for DV receivers) or outputs (for DV transmitters), applications must specify the desired pad number in the struct `v4l2_enum_dv_timings` pad field. Attempts to enumerate timings on a pad that doesn't support them will return an EINVAL error code.

type `v4l2_enum_dv_timings`

Table 186: struct `v4l2_enum_dv_timings`

<code>_u32</code>	<code>index</code>	Number of the DV timings, set by the application.
<code>_u32</code>	<code>pad</code>	Pad number as reported by the media controller API. This field is only used when operating on a subdevice node. When operating on a video node applications must set this field to zero.
<code>_u32</code>	<code>reserved[2]</code>	Reserved for future extensions. Drivers and applications must set the array to zero.
struct <code>v4l2_dv_timings</code>	<code>timings</code>	The timings.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### EINVAL

The struct `v4l2_enum_dv_timings` index is out of bounds or the pad number is invalid.

### ENODATA

Digital video presets are not supported for this input or output.

## ioctl VIDIOC\_ENUM\_FMT

### Name

VIDIOC\_ENUM\_FMT - Enumerate image formats

### Synopsis

#### VIDIOC\_ENUM\_FMT

```
int ioctl(int fd, VIDIOC_ENUM_FMT, struct v4l2_fmtdesc *argp)
```

### Arguments

**fd**

File descriptor returned by `open()`.

**argp**

Pointer to struct `v4l2_fmtdesc`.

### Description

To enumerate image formats applications initialize the `type`, `mbus_code` and `index` fields of struct `v4l2_fmtdesc` and call the `ioctl VIDIOC_ENUM_FMT` ioctl with a pointer to this structure. Drivers fill the rest of the structure or return an `EINVAL` error code. All formats are enumerable by beginning at index zero and incrementing by one until `EINVAL` is returned. If applicable, drivers shall return formats in preference order, where preferred formats are returned before (that is, with lower `index` value) less-preferred formats.

Depending on the `V4L2_CAP_IO_MC` *capability*, the `mbus_code` field is handled differently:

- 1) `V4L2_CAP_IO_MC` is not set (also known as a 'video-node-centric' driver)

Applications shall initialize the `mbus_code` field to zero and drivers shall ignore the value of the field.

Drivers shall enumerate all image formats.

---

**Note:** After switching the input or output the list of enumerated image formats may be different.

---

- 2) `V4L2_CAP_IO_MC` is set (also known as an 'MC-centric' driver)

If the `mbus_code` field is zero, then all image formats shall be enumerated.

If the `mbus_code` field is initialized to a valid (non-zero) *media bus format code*, then drivers shall restrict enumeration to only the image formats that can produce (for video output devices) or be produced from (for video capture devices) that media bus code. If the `mbus_code` is unsupported by the driver, then `EINVAL` shall be returned.

Regardless of the value of the `mbus_code` field, the enumerated image formats shall not depend on the active configuration of the video device or device pipeline.

type `v4l2_fmtdesc`

Table 187: struct v4l2\_fmtdesc

<code>_u32</code>	<code>index</code>	Number of the format in the enumeration, set by the application. This is in no way related to the <code>pixelformat</code> field.
<code>_u32</code>	<code>type</code>	Type of the data stream, set by the application. Only these types are valid here: <code>V4L2_BUF_TYPE_VIDEO_CAPTURE</code> , <code>V4L2_BUF_TYPE_VIDEO_CAPTURE_MPLANE</code> , <code>V4L2_BUF_TYPE_VIDEO_OUTPUT</code> , <code>V4L2_BUF_TYPE_VIDEO_OUTPUT_MPLANE</code> , <code>V4L2_BUF_TYPE_VIDEO_OVERLAY</code> , <code>V4L2_BUF_TYPE_SDR_CAPTURE</code> , <code>V4L2_BUF_TYPE_SDR_OUTPUT</code> , <code>V4L2_BUF_TYPE_META_CAPTURE</code> and <code>V4L2_BUF_TYPE_META_OUTPUT</code> . See <a href="#">v4l2_buf_type</a> .
<code>_u32</code>	<code>flags</code>	See <a href="#">Image Format Description Flags</a>
<code>_u8</code>	<code>description[32]</code>	Description of the format, a NUL-terminated ASCII string. This information is intended for the user, for example: "YUV 4:2:2".
<code>_u32</code>	<code>pixelformat</code>	The image format identifier. This is a four character code as computed by the <code>v4l2_fourcc()</code> macro:

```
#define v4l2_fourcc(a,b,c,d)
(((u32)(a)<<0)|((u32)(b)<<8)|((u32)(c)<<16)|((u32)(d)<<24))
Several image formats are already defined by this specification in Image Formats.
```

**Attention:** These codes are not the same as those used in the Windows world.

<code>_u32</code>	<code>mbus_code</code>	Media bus code restricting the enumerated formats, set by the application. Only applicable to drivers that advertise the <code>V4L2_CAP_I0_MC</code> <a href="#">capability</a> , shall be 0 otherwise.
<code>_u32</code>	<code>reserved[3]</code>	Reserved for future extensions. Drivers must set the array to zero.

Table 188: Image Format Description Flags

<code>V4L2_FMT_FLAG_COMPRESSED</code>	0x0001	This is a compressed format.
<code>V4L2_FMT_FLAG_EMULATED</code>	0x0002	This format is not native to the device but emulated through software (usually libv4l2), where possible try to use a native format instead for better performance.

continues on next page

Table 188 – continued from previous page

V4L2_FMT_FLAG_CONTINUOUS_BYTESTREAM	0x0004	The hardware decoder for this compressed bytestream format (aka coded format) is capable of parsing a continuous bytestream. Applications do not need to parse the bytestream themselves to find the boundaries between frames/fields. This flag can only be used in combination with the V4L2_FMT_FLAG_COMPRESSED flag, since this applies to compressed formats only. This flag is valid for stateful decoders only.
V4L2_FMT_FLAG_DYN_RESOLUTION	0x0008	Dynamic resolution switching is supported by the device for this compressed bytestream format (aka coded format). It will notify the user via the event V4L2_EVENT_SOURCE_CHANGE when changes in the video parameters are detected. This flag can only be used in combination with the V4L2_FMT_FLAG_COMPRESSED flag, since this applies to compressed formats only. This flag is valid for stateful codecs only.

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Table 188 – continued from previous page

V4L2_FMT_FLAG_ENC_CAP_FRAME_INTERVAL	0x0010	<p>The hardware encoder supports setting the CAPTURE coded frame interval separately from the OUTPUT raw frame interval. Setting the OUTPUT raw frame interval with <a href="#">VIDIOC_S_PARM</a> also sets the CAPTURE coded frame interval to the same value. If this flag is set, then the CAPTURE coded frame interval can be set to a different value afterwards. This is typically used for offline encoding where the OUTPUT raw frame interval is used as a hint for reserving hardware encoder resources and the CAPTURE coded frame interval is the actual frame rate embedded in the encoded video stream.</p> <p>This flag can only be used in combination with the V4L2_FMT_FLAG_COMPRESSED flag, since this applies to compressed formats only. This flag is valid for stateful encoders only.</p>
V4L2_FMT_FLAG_CSC_COLORSPACE	0x0020	<p>The driver allows the application to try to change the default colorspace. This flag is relevant only for capture devices. The application can ask to configure the colorspace of the capture device when calling the <a href="#">VIDIOC_S_FMT</a> ioctl with <a href="#">V4L2_PIX_FMT_FLAG_SET_CSC</a> set.</p>
V4L2_FMT_FLAG_CSC_XFER_FUNC	0x0040	<p>The driver allows the application to try to change the default transfer function. This flag is relevant only for capture devices. The application can ask to configure the transfer function of the capture device when calling the <a href="#">VIDIOC_S_FMT</a> ioctl with <a href="#">V4L2_PIX_FMT_FLAG_SET_CSC</a> set.</p>

continues on next page

Table 188 – continued from previous page

V4L2_FMT_FLAG_CSC_YCBCR_ENC	0x0080	The driver allows the application to try to change the default Y'CbCr encoding. This flag is relevant only for capture devices. The application can ask to configure the Y'CbCr encoding of the capture device when calling the <code>VIDIOC_S_FMT</code> ioctl with <code>V4L2_PIX_FMT_FLAG_SET_CSC</code> set.
V4L2_FMT_FLAG_CSC_HSV_ENC	0x0080	The driver allows the application to try to change the default HSV encoding. This flag is relevant only for capture devices. The application can ask to configure the HSV encoding of the capture device when calling the <code>VIDIOC_S_FMT</code> ioctl with <code>V4L2_PIX_FMT_FLAG_SET_CSC</code> set.
V4L2_FMT_FLAG_CSC_QUANTIZATION	0x0100	The driver allows the application to try to change the default quantization. This flag is relevant only for capture devices. The application can ask to configure the quantization of the capture device when calling the <code>VIDIOC_S_FMT</code> ioctl with <code>V4L2_PIX_FMT_FLAG_SET_CSC</code> set.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## EINVAL

The struct `v4l2_fmtdesc` type is not supported or the `index` is out of bounds.

If `V4L2_CAP_IO_MC` is set and the specified `mbus_code` is unsupported, then also return this error code.

## ioctl VIDIOC\_ENUM\_FRAMESIZES

### Name

`VIDIOC_ENUM_FRAMESIZES` - Enumerate frame sizes

## Synopsis

### `VIDIOC_ENUM_FRAMESIZES`

```
int ioctl(int fd, VIDIOC_ENUM_FRAMESIZES, struct v4l2_frmsizeenum *argp)
```

## Arguments

### `fd`

File descriptor returned by `open()`.

### `argp`

Pointer to struct `v4l2_frmsizeenum` that contains an index and pixel format and receives a frame width and height.

## Description

This ioctl allows applications to enumerate all frame sizes (i. e. width and height in pixels) that the device supports for the given pixel format.

The supported pixel formats can be obtained by using the `ioctl VIDIOC_ENUM_FMT` function.

The return value and the content of the `v4l2_frmsizeenum.type` field depend on the type of frame sizes the device supports. Here are the semantics of the function for the different cases:

- **Discrete:** The function returns success if the given index value (zero-based) is valid. The application should increase the index by one for each call until `EINVAL` is returned. The `v4l2_frmsizeenum.type` field is set to `V4L2_FRMSIZE_TYPE_DISCRETE` by the driver. Of the union only the `discrete` member is valid.
- **Step-wise:** The function returns success if the given index value is zero and `EINVAL` for any other index value. The `v4l2_frmsizeenum.type` field is set to `V4L2_FRMSIZE_TYPE_STEPWISE` by the driver. Of the union only the `stepwise` member is valid.
- **Continuous:** This is a special case of the step-wise type above. The function returns success if the given index value is zero and `EINVAL` for any other index value. The `v4l2_frmsizeenum.type` field is set to `V4L2_FRMSIZE_TYPE_CONTINUOUS` by the driver. Of the union only the `stepwise` member is valid and the `step_width` and `step_height` values are set to 1.

When the application calls the function with index zero, it must check the `type` field to determine the type of frame size enumeration the device supports. Only for the `V4L2_FRMSIZE_TYPE_DISCRETE` type does it make sense to increase the index value to receive more frame sizes.

---

**Note:** The order in which the frame sizes are returned has no special meaning. In particular does it not say anything about potential default format sizes.

Applications can assume that the enumeration data does not change without any interaction from the application itself. This means that the enumeration data is consistent if the application does not perform any other ioctl calls while it runs the frame size enumeration.

## Structs

In the structs below, *IN* denotes a value that has to be filled in by the application, *OUT* denotes values that the driver fills in. The application should zero out all members except for the *IN* fields.

type **v4l2\_frmsize\_discrete**

Table 189: struct v4l2\_frmsize\_discrete

<code>_u32</code>	<code>width</code>	Width of the frame [pixel].
<code>_u32</code>	<code>height</code>	Height of the frame [pixel].

type **v4l2\_frmsize\_stepwise**

Table 190: struct v4l2\_frmsize\_stepwise

<code>_u32</code>	<code>min_width</code>	Minimum frame width [pixel].
<code>_u32</code>	<code>max_width</code>	Maximum frame width [pixel].
<code>_u32</code>	<code>step_width</code>	Frame width step size [pixel].
<code>_u32</code>	<code>min_height</code>	Minimum frame height [pixel].
<code>_u32</code>	<code>max_height</code>	Maximum frame height [pixel].
<code>_u32</code>	<code>step_height</code>	Frame height step size [pixel].

type **v4l2\_frmsizeenum**

Table 191: struct v4l2\_frmsizeenum

<code>_u32</code>	<code>index</code>	IN: Index of the given frame size in the enumeration.
<code>_u32</code>	<code>pixel_format</code>	IN: Pixel format for which the frame sizes are enumerated.
<code>_u32</code>	<code>type</code>	OUT: Frame size type the device supports.
union {	(anonymous)	OUT: Frame size with the given index.
<code>struct v4l2_frmsize_discrete</code>	<code>discrete</code>	
<code>struct v4l2_frmsize_stepwise</code>	<code>stepwise</code>	
}		
<code>_u32</code>	<code>reserved[2]</code>	Reserved space for future use. Must be zeroed by drivers and applications.

## Enums

type **v4l2\_frmsizetypes**

Table 192: enum v4l2\_frmsizetypes

<code>V4L2_FRMSIZE_TYPE_DISCRETE</code>	1	Discrete frame size.
<code>V4L2_FRMSIZE_TYPE_CONTINUOUS</code>	2	Continuous frame size.
<code>V4L2_FRMSIZE_TYPE_STEPWISE</code>	3	Step-wise defined frame size.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## ioctl VIDIOC\_ENUM\_FRAMEINTERVALS

### Name

`VIDIOC_ENUM_FRAMEINTERVALS` - Enumerate frame intervals

### Synopsis

#### `VIDIOC_ENUM_FRAMEINTERVALS`

```
int ioctl(int fd, VIDIOC_ENUM_FRAMEINTERVALS, struct v4l2_frmivalenum *argp)
```

### Arguments

#### `fd`

File descriptor returned by [`open\(\)`](#).

#### `argp`

Pointer to struct `v4l2_frmivalenum` that contains a pixel format and size and receives a frame interval.

### Description

This ioctl allows applications to enumerate all frame intervals that the device supports for the given pixel format and frame size.

The supported pixel formats and frame sizes can be obtained by using the `ioctl VIDIOC_ENUM_FMT` and `ioctl VIDIOC_ENUM_FRAMESIZES` functions.

The return value and the content of the `v4l2_frmivalenum.type` field depend on the type of frame intervals the device supports. Here are the semantics of the function for the different cases:

- **Discrete:** The function returns success if the given index value (zero-based) is valid. The application should increase the index by one for each call until `EINVAL` is returned. The `v4l2_frmivalenum.type` field is set to `V4L2_FRMIVAL_TYPE_DISCRETE` by the driver. Of the union only the `discrete` member is valid.
- **Step-wise:** The function returns success if the given index value is zero and `EINVAL` for any other index value. The `v4l2_frmivalenum.type` field is set to `V4L2_FRMIVAL_TYPE_STEPWISE` by the driver. Of the union only the `stepwise` member is valid.
- **Continuous:** This is a special case of the step-wise type above. The function returns success if the given index value is zero and `EINVAL` for any other index value. The

`v4l2_frmivalenum.type` field is set to `V4L2_FRMIVAL_TYPE_CONTINUOUS` by the driver. Of the union only the `stepwise` member is valid and the `step` value is set to 1.

When the application calls the function with index zero, it must check the `type` field to determine the type of frame interval enumeration the device supports. Only for the `V4L2_FRMIVAL_TYPE_DISCRETE` type does it make sense to increase the index value to receive more frame intervals.

---

**Note:** The order in which the frame intervals are returned has no special meaning. In particular does it not say anything about potential default frame intervals.

---

Applications can assume that the enumeration data does not change without any interaction from the application itself. This means that the enumeration data is consistent if the application does not perform any other ioctl calls while it runs the frame interval enumeration.

---

**Note: Frame intervals and frame rates:** The V4L2 API uses frame intervals instead of frame rates. Given the frame interval the frame rate can be computed as follows:

```
frame_rate = 1 / frame_interval
```

---

## Structs

In the structs below, *IN* denotes a value that has to be filled in by the application, *OUT* denotes values that the driver fills in. The application should zero out all members except for the *IN* fields.

type `v4l2_frmival_stepwise`

Table 193: struct `v4l2_frmival_stepwise`

<code>struct v4l2_fract</code>	<code>min</code>	Minimum frame interval [s].
<code>struct v4l2_fract</code>	<code>max</code>	Maximum frame interval [s].
<code>struct v4l2_fract</code>	<code>step</code>	Frame interval step size [s].

type `v4l2_frmivalenum`

Table 194: struct v4l2\_frmivalenum

<code>_u32</code>	<code>index</code>	IN: Index of the given frame interval in the enumeration.
<code>_u32</code>	<code>pixel_format</code>	IN: Pixel format for which the frame intervals are enumerated.
<code>_u32</code>	<code>width</code>	IN: Frame width for which the frame intervals are enumerated.
<code>_u32</code>	<code>height</code>	IN: Frame height for which the frame intervals are enumerated.
<code>_u32</code>	<code>type</code>	OUT: Frame interval type the device supports.
<code>union {</code>	<code>(anonymous)</code>	OUT: Frame interval with the given index.
<code>struct v4l2_fract</code>	<code>discrete</code>	Frame interval [s].
<code>struct v4l2_frmival_stepwise</code>	<code>stepwise</code>	
<code>}</code>		
<code>_u32</code>	<code>reserved[2]</code>	Reserved space for future use. Must be zeroed by drivers and applications.

## Enums

type `v4l2_frmivaltypes`

Table 195: enum v4l2\_frmivaltypes

<code>V4L2_FRMIVAL_TYPE_DISCRETE</code>	1	Discrete frame interval.
<code>V4L2_FRMIVAL_TYPE_CONTINUOUS</code>	2	Continuous frame interval.
<code>V4L2_FRMIVAL_TYPE_STEPWISE</code>	3	Step-wise defined frame interval.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## ioctl VIDIOC\_ENUM\_FREQ\_BANDS

### Name

`VIDIOC_ENUM_FREQ_BANDS` - Enumerate supported frequency bands

## Synopsis

### **VIDIOC\_ENUM\_FREQ\_BANDS**

```
int ioctl(int fd, VIDIOC_ENUM_FREQ_BANDS, struct v4l2_frequency_band *argp)
```

## Arguments

### **fd**

File descriptor returned by *open()*.

### **argp**

Pointer to struct *v4l2\_frequency\_band*.

## Description

Enumerates the frequency bands that a tuner or modulator supports. To do this applications initialize the `tuner`, `type` and `index` fields, and zero out the `reserved` array of a struct *v4l2\_frequency\_band* and call the *ioctl VIDIOC\_ENUM\_FREQ\_BANDS* ioctl with a pointer to this structure.

This ioctl is supported if the `V4L2_TUNER_CAP_FREQ_BANDS` capability of the corresponding tuner/modulator is set.

type **v4l2\_frequency\_band**

Table 196: struct v4l2\_frequency\_band

<code>_u32</code>	<code>tuner</code>	The tuner or modulator index number. This is the same value as in the struct <code>v4l2_input</code> tuner field and the struct <code>v4l2_tuner</code> index field, or the struct <code>v4l2_output</code> modulator field and the struct <code>v4l2_modulator</code> index field.
<code>_u32</code>	<code>type</code>	The tuner type. This is the same value as in the struct <code>v4l2_tuner</code> type field. The type must be set to V4L2_TUNER_RADIO for /dev/radioX device nodes, and to V4L2_TUNER_ANALOG_TV for all others. Set this field to V4L2_TUNER_RADIO for modulators (currently only radio modulators are supported). See <code>v4l2_tuner_type</code>
<code>_u32</code>	<code>index</code>	Identifies the frequency band, set by the application.
<code>_u32</code>	<code>capability</code>	The tuner/modulator capability flags for this frequency band, see <i>Tuner and Modulator Capability Flags</i> . The V4L2_TUNER_CAP_LOW or V4L2_TUNER_CAP_1HZ capability must be the same for all frequency bands of the selected tuner/modulator. So either all bands have that capability set, or none of them have that capability.
<code>_u32</code>	<code>rangelow</code>	The lowest tunable frequency in units of 62.5 kHz, or if the capability flag V4L2_TUNER_CAP_LOW is set, in units of 62.5 Hz, for this frequency band. A 1 Hz unit is used when the capability flag V4L2_TUNER_CAP_1HZ is set.
<code>_u32</code>	<code>rangehigh</code>	The highest tunable frequency in units of 62.5 kHz, or if the capability flag V4L2_TUNER_CAP_LOW is set, in units of 62.5 Hz, for this frequency band. A 1 Hz unit is used when the capability flag V4L2_TUNER_CAP_1HZ is set.
<code>_u32</code>	<code>modulation</code>	<p>The supported modulation systems of this frequency band. See <i>Band Modulation Systems</i>.</p> <p><b>Note:</b> Currently only one modulation system per frequency band is supported. More work will need to be done if multiple modulation systems are possible. Contact the linux-media mailing list (<a href="https://linuxtv.org/lists.php">https://linuxtv.org/lists.php</a>) if you need such functionality.</p>
<code>_u32</code>	<code>reserved[9]</code>	Reserved for future extensions. Applications and drivers must set the array to zero.

Table 197: Band Modulation Systems

<code>V4L2_BAND_MODULATION_VSB</code>	0x02	Vestigial Sideband modulation, used for analog TV.
<code>V4L2_BAND_MODULATION_FM</code>	0x04	Frequency Modulation, commonly used for analog radio.
<code>V4L2_BAND_MODULATION_AM</code>	0x08	Amplitude Modulation, commonly used for analog radio.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### EINVAL

The tuner or index is out of bounds or the type field is wrong.

## ioctl VIDIOC\_ENUMINPUT

### Name

`VIDIOC_ENUMINPUT` - Enumerate video inputs

### Synopsis

#### `VIDIOC_ENUMINPUT`

```
int ioctl(int fd, VIDIOC_ENUMINPUT, struct v4l2_input *argp)
```

### Arguments

#### `fd`

File descriptor returned by [`open\(\)`](#).

#### `argp`

Pointer to struct [`v4l2\_input`](#).

### Description

To query the attributes of a video input applications initialize the `index` field of struct [`v4l2\_input`](#) and call the `ioctl VIDIOC_ENUMINPUT` with a pointer to this structure. Drivers fill the rest of the structure or return an EINVAL error code when the index is out of bounds. To enumerate all inputs applications shall begin at index zero, incrementing by one until the driver returns EINVAL.

type [`v4l2\_input`](#)

Table 198: struct v4l2\_input

<code>_u32</code>	<code>index</code>	Identifies the input, set by the application.
<code>_u8</code>	<code>name[32]</code>	Name of the video input, a NUL-terminated ASCII string, for example: "Vin (Composite 2)". This information is intended for the user, preferably the connector label on the device itself.
<code>_u32</code>	<code>type</code>	Type of the input, see <a href="#">Input Types</a> .
<code>_u32</code>	<code>audioset</code>	Drivers can enumerate up to 32 video and audio inputs. This field shows which audio inputs were selectable as audio source if this was the currently selected video input. It is a bit mask. The LSB corresponds to audio input 0, the MSB to input 31. Any number of bits can be set, or none. When the driver does not enumerate audio inputs no bits must be set. Applications shall not interpret this as lack of audio support. Some drivers automatically select audio sources and do not enumerate them since there is no choice anyway. For details on audio inputs and how to select the current input see <a href="#">Audio Inputs and Outputs</a> .
<code>_u32</code>	<code>tuner</code>	Capture devices can have zero or more tuners (RF demodulators). When the type is set to <code>V4L2_INPUT_TYPE_TUNER</code> this is an RF connector and this field identifies the tuner. It corresponds to struct <code>v4l2_tuner</code> field <code>index</code> . For details on tuners see <a href="#">Tuners and Modulators</a> .
<code>v4l2_std_id</code>	<code>std</code>	Every video input supports one or more different video standards. This field is a set of all supported standards. For details on video standards and how to switch see <a href="#">Video Standards</a> .
<code>_u32</code>	<code>status</code>	This field provides status information about the input. See <a href="#">Input Status Flags</a> for flags. With the exception of the sensor orientation bits <code>status</code> is only valid when this is the current input.
<code>_u32</code>	<code>capabilities</code>	This field provides capabilities for the input. See <a href="#">Input capabilities</a> for flags.
<code>_u32</code>	<code>reserved[3]</code>	Reserved for future extensions. Drivers must set the array to zero.

Table 199: Input Types

<code>V4L2_INPUT_TYPE_TUNER</code>	1	This input uses a tuner (RF demodulator).
<code>V4L2_INPUT_TYPE_CAMERA</code>	2	Any non-tuner video input, for example Composite Video, S-Video, HDMI, camera sensor. The naming as <code>_TYPE_CAMERA</code> is historical, today we would have called it <code>_TYPE_VIDEO</code> .
<code>V4L2_INPUT_TYPE_TOUCH</code>	3	This input is a touch device for capturing raw touch data.

Table 200: Input Status Flags

General		
V4L2_IN_ST_NO_POWER	0x00000001	Attached device is off.
V4L2_IN_ST_NO_SIGNAL	0x00000002	
V4L2_IN_ST_NO_COLOR	0x00000004	The hardware supports color decoding, but does not detect color modulation in the signal.
Sensor Orientation		
V4L2_IN_ST_HFLIP	0x00000010	The input is connected to a device that produces a signal that is flipped horizontally and does not correct this before passing the signal to userspace.
V4L2_IN_ST_VFLIP	0x00000020	The input is connected to a device that produces a signal that is flipped vertically and does not correct this before passing the signal to userspace. .. note:: A 180 degree rotation is the same as HFLIP   VFLIP
Analog Video		
V4L2_IN_ST_NO_H_LOCK	0x00000100	No horizontal sync lock.
V4L2_IN_ST_COLOR_KILL	0x00000200	A color killer circuit automatically disables color decoding when it detects no color modulation. When this flag is set the color killer is enabled <i>and</i> has shut off color decoding.
V4L2_IN_ST_NO_V_LOCK	0x00000400	No vertical sync lock.
V4L2_IN_ST_NO_STD_LOCK	0x00000800	No standard format lock in case of auto-detection format by the component.
Digital Video		
V4L2_IN_ST_NO_SYNC	0x00010000	No synchronization lock.
V4L2_IN_ST_NO_EQU	0x00020000	No equalizer lock.
V4L2_IN_ST_NO_CARRIER	0x00040000	Carrier recovery failed.
VCR and Set-Top Box		
V4L2_IN_ST_MACROVISION	0x01000000	Macrovision is an analog copy prevention system mangling the video signal to confuse video recorders. When this flag is set Macrovision has been detected.
V4L2_IN_ST_NO_ACCESS	0x02000000	Conditional access denied.
V4L2_IN_ST_VTR	0x04000000	VTR time constant. [?]

Table 201: Input capabilities

V4L2_IN_CAP_DV_TIMINGS	0x00000002	This input supports setting video timings by using VIDIOC_S_DV_TIMINGS.
V4L2_IN_CAP_STD	0x00000004	This input supports setting the TV standard by using VIDIOC_S_STD.
V4L2_IN_CAP_NATIVE_SIZE	0x00000008	This input supports setting the native size using the V4L2_SEL_TGT_NATIVE_SIZE selection target, see <a href="#">Common selection definitions</a> .

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### EINVAL

The struct `v4l2_input` index is out of bounds.

## ioctl VIDIOC\_ENUMOUTPUT

### Name

`VIDIOC_ENUMOUTPUT` - Enumerate video outputs

### Synopsis

#### `VIDIOC_ENUMOUTPUT`

```
int ioctl(int fd, VIDIOC_ENUMOUTPUT, struct v4l2_output *argp)
```

### Arguments

#### `fd`

File descriptor returned by `open()`.

#### `argp`

Pointer to struct `v4l2_output`.

### Description

To query the attributes of a video outputs applications initialize the `index` field of struct `v4l2_output` and call the `ioctl VIDIOC_ENUMOUTPUT` with a pointer to this structure. Drivers fill the rest of the structure or return an EINVAL error code when the index is out of bounds. To enumerate all outputs applications shall begin at index zero, incrementing by one until the driver returns EINVAL.

type `v4l2_output`

Table 202: struct v4l2\_output

<code>_u32</code>	<code>index</code>	Identifies the output, set by the application.
<code>_u8</code>	<code>name[32]</code>	Name of the video output, a NUL-terminated ASCII string, for example: "Vout". This information is intended for the user, preferably the connector label on the device itself.
<code>_u32</code>	<code>type</code>	Type of the output, see <a href="#">Output Type</a> .
<code>_u32</code>	<code>audioset</code>	Drivers can enumerate up to 32 video and audio outputs. This field shows which audio outputs were selectable as the current output if this was the currently selected video output. It is a bit mask. The LSB corresponds to audio output 0, the MSB to output 31. Any number of bits can be set, or none. When the driver does not enumerate audio outputs no bits must be set. Applications shall not interpret this as lack of audio support. Drivers may automatically select audio outputs without enumerating them. For details on audio outputs and how to select the current output see <a href="#">Audio Inputs and Outputs</a> .
<code>_u32</code>	<code>modulator</code>	Output devices can have zero or more RF modulators. When the type is <code>V4L2_OUTPUT_TYPE_MODULATOR</code> this is an RF connector and this field identifies the modulator. It corresponds to struct <code>v4l2_modulator</code> field <code>index</code> . For details on modulators see <a href="#">Tuners and Modulators</a> .
<code>v4l2_std_id</code>	<code>std</code>	Every video output supports one or more different video standards. This field is a set of all supported standards. For details on video standards and how to switch see <a href="#">Video Standards</a> .
<code>_u32</code>	<code>capabilities</code>	This field provides capabilities for the output. See <a href="#">Output capabilities</a> for flags.
<code>_u32</code>	<code>reserved[3]</code>	Reserved for future extensions. Drivers must set the array to zero.

Table 203: Output Type

<code>V4L2_OUTPUT_TYPE_MODULATOR</code>	1	This output is an analog TV modulator.
<code>V4L2_OUTPUT_TYPE_ANALOG</code>	2	Any non-modulator video output, for example Composite Video, S-Video, HDMI. The naming as <code>_TYPE_ANALOG</code> is historical, today we would have called it <code>_TYPE_VIDEO</code> .
<code>V4L2_OUTPUT_TYPE_ANALOGVGAOVERLAY</code>	3	The video output will be copied to a <a href="#">video overlay</a> .

Table 204: Output capabilities

V4L2_OUT_CAP_DV_TIMINGS	0x00000002	This output supports setting video timings by using VIDIOC_S_DV_TIMINGS.
V4L2_OUT_CAP_STD	0x00000004	This output supports setting the TV standard by using VIDIOC_S_STD.
V4L2_OUT_CAP_NATIVE_SIZE	0x00000008	This output supports setting the native size using the V4L2_SEL_TGT_NATIVE_SIZE selection target, see <a href="#">Common selection definitions</a> .

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### EINVAL

The struct `v4l2_output` index is out of bounds.

## ioctl VIDIOC\_ENUMSTD, VIDIOC\_SUBDEV\_ENUMSTD

### Name

`VIDIOC_ENUMSTD` - `VIDIOC_SUBDEV_ENUMSTD` - Enumerate supported video standards

### Synopsis

#### `VIDIOC_ENUMSTD`

```
int ioctl(int fd, VIDIOC_ENUMSTD, struct v4l2_standard *argp)
```

#### `VIDIOC_SUBDEV_ENUMSTD`

```
int ioctl(int fd, VIDIOC_SUBDEV_ENUMSTD, struct v4l2_standard *argp)
```

### Arguments

#### `fd`

File descriptor returned by `open()`.

#### `argp`

Pointer to struct `v4l2_standard`.

## Description

To query the attributes of a video standard, especially a custom (driver defined) one, applications initialize the `index` field of struct `v4l2_standard` and call the `ioctl VIDIOC_ENUMSTD`, `VIDIOC_SUBDEV_ENUMSTD` ioctl with a pointer to this structure. Drivers fill the rest of the structure or return an EINVAL error code when the index is out of bounds. To enumerate all standards applications shall begin at index zero, incrementing by one until the driver returns EINVAL. Drivers may enumerate a different set of standards after switching the video input or output.<sup>1</sup>

type `v4l2_standard`

Table 205: struct `v4l2_standard`

<code>_u32</code>	<code>index</code>	Number of the video standard, set by the application.
<code>v4l2_std_id</code>	<code>id</code>	The bits in this field identify the standard as one of the common standards listed in <code>typedef v4l2_std_id</code> , or if bits 32 to 63 are set as custom standards. Multiple bits can be set if the hardware does not distinguish between these standards, however separate indices do not indicate the opposite. The <code>id</code> must be unique. No other enumerated struct <code>v4l2_standard</code> structure, for this input or output anyway, can contain the same set of bits.
<code>_u8</code>	<code>name[24]</code>	Name of the standard, a NUL-terminated ASCII string, for example: "PAL-B/G", "NTSC Japan". This information is intended for the user.
struct <code>v4l2_fract</code>	<code>frameperiod</code>	The frame period (not field period) is numerator / denominator. For example M/NTSC has a frame period of 1001 / 30000 seconds.
<code>_u32</code>	<code>framelines</code>	Total lines per frame including blanking, e.g. 625 for B/PAL.
<code>_u32</code>	<code>reserved[4]</code>	Reserved for future extensions. Drivers must set the array to zero.

type `v4l2_fract`

Table 206: struct `v4l2_fract`

<code>_u32</code>	<code>numerator</code>	
<code>_u32</code>	<code>denominator</code>	

<sup>1</sup> The supported standards may overlap and we need an unambiguous set to find the current standard returned by `VIDIOC_G_STD`.

Table 207: typedef v4l2\_std\_id

__u64	v4l2_std_id	This type is a set, each bit representing another video standard as listed below and in <a href="#">Video Standards (based on itu470)</a> . The 32 most significant bits are reserved for custom (driver defined) video standards.
-------	-------------	--

```
#define V4L2_STD_PAL_B      (((v4l2_std_id)0x00000001)
#define V4L2_STD_PAL_B1     (((v4l2_std_id)0x00000002)
#define V4L2_STD_PAL_G      (((v4l2_std_id)0x00000004)
#define V4L2_STD_PAL_H      (((v4l2_std_id)0x00000008)
#define V4L2_STD_PAL_I      (((v4l2_std_id)0x00000010)
#define V4L2_STD_PAL_D      (((v4l2_std_id)0x00000020)
#define V4L2_STD_PAL_D1     (((v4l2_std_id)0x00000040)
#define V4L2_STD_PAL_K      (((v4l2_std_id)0x00000080)

#define V4L2_STD_PAL_M      (((v4l2_std_id)0x00000100)
#define V4L2_STD_PAL_N      (((v4l2_std_id)0x00000200)
#define V4L2_STD_PAL_Nc     (((v4l2_std_id)0x00000400)
#define V4L2_STD_PAL_60     (((v4l2_std_id)0x00000800)
```

V4L2\_STD\_PAL\_60 is a hybrid standard with 525 lines, 60 Hz refresh rate, and PAL color modulation with a 4.43 MHz color subcarrier. Some PAL video recorders can play back NTSC tapes in this mode for display on a 50/60 Hz agnostic PAL TV.

```
#define V4L2_STD_NTSC_M      (((v4l2_std_id)0x00001000)
#define V4L2_STD_NTSC_M_JP    (((v4l2_std_id)0x00002000)
#define V4L2_STD_NTSC_443    (((v4l2_std_id)0x00004000))
```

V4L2\_STD\_NTSC\_443 is a hybrid standard with 525 lines, 60 Hz refresh rate, and NTSC color modulation with a 4.43 MHz color subcarrier.

```
#define V4L2_STD_NTSC_M_KR    (((v4l2_std_id)0x00008000)

#define V4L2_STD_SECAM_B      (((v4l2_std_id)0x00010000)
#define V4L2_STD_SECAM_D      (((v4l2_std_id)0x00020000)
#define V4L2_STD_SECAM_G      (((v4l2_std_id)0x00040000)
#define V4L2_STD_SECAM_H      (((v4l2_std_id)0x00080000)
#define V4L2_STD_SECAM_K      (((v4l2_std_id)0x00100000)
#define V4L2_STD_SECAM_K1     (((v4l2_std_id)0x00200000)
#define V4L2_STD_SECAM_L      (((v4l2_std_id)0x00400000)
#define V4L2_STD_SECAM_LC     (((v4l2_std_id)0x00800000)

/* ATSC/HDTV */
#define V4L2_STD_ATSC_8_VSB   (((v4l2_std_id)0x01000000)
#define V4L2_STD_ATSC_16_VSB   (((v4l2_std_id)0x02000000))
```

V4L2\_STD\_ATSC\_8\_VSB and V4L2\_STD\_ATSC\_16\_VSB are U.S. terrestrial digital TV standards. Presently the V4L2 API does not support digital TV. See also the Linux DVB API at <https://linuxtv.org>.

```

#define V4L2_STD_PAL_BG          (V4L2_STD_PAL_B
    V4L2_STD_PAL_B1           |
    V4L2_STD_PAL_G)
#define V4L2_STD_B               (V4L2_STD_PAL_B
    V4L2_STD_PAL_B1           |
    V4L2_STD_SECAM_B)
#define V4L2_STD_GH              (V4L2_STD_PAL_G
    V4L2_STD_PAL_H            |
    V4L2_STD_SECAM_G          |
    V4L2_STD_SECAM_H)
#define V4L2_STD_PAL_DK          (V4L2_STD_PAL_D
    V4L2_STD_PAL_D1           |
    V4L2_STD_PAL_K)
#define V4L2_STD_PAL              (V4L2_STD_PAL_BG
    V4L2_STD_PAL_DK           |
    V4L2_STD_PAL_H            |
    V4L2_STD_PAL_I)
#define V4L2_STD_NTSC             (V4L2_STD_NTSC_M
    V4L2_STD_NTSC_M_JP         |
    V4L2_STD_NTSC_M_KR)
#define V4L2_STD_MN              (V4L2_STD_PAL_M
    V4L2_STD_PAL_N            |
    V4L2_STD_PAL_Nc           |
    V4L2_STD_NTSC)
#define V4L2_STD_SECAM_DK         (V4L2_STD_SECAM_D
    V4L2_STD_SECAM_K           |
    V4L2_STD_SECAM_K1)
#define V4L2_STD_DK               (V4L2_STD_PAL_DK
    V4L2_STD_SECAM_DK)
#define V4L2_STD_SECAM             (V4L2_STD_SECAM_B
    V4L2_STD_SECAM_G           |
    V4L2_STD_SECAM_H           |
    V4L2_STD_SECAM_DK          |
    V4L2_STD_SECAM_L           |
    V4L2_STD_SECAM_LC)
#define V4L2_STD_525_60             (V4L2_STD_PAL_M
    V4L2_STD_PAL_60             |
    V4L2_STD_NTSC               |
    V4L2_STD_NTSC_443)
#define V4L2_STD_625_50             (V4L2_STD_PAL
    V4L2_STD_PAL_N              |
    V4L2_STD_PAL_Nc             |
    V4L2_STD_SECAM)
#define V4L2_STD_UNKNOWN            0
#define V4L2_STD_ALL                (V4L2_STD_525_60
    V4L2_STD_625_50)

```

Table 208: Video Standards (based on ITU BT.470)

Characteris-tics	M/NTSC <sup>Page 6</sup>	M/PAL	N/PAL <sup>3</sup>	B, B1, G/PAL	D, K/PAL	D1,	H/PAL	I/PAL	B, G/SECAM	D, K/SECAM	K1/SECAM	L/SECAM
Frame lines	525		625									
Frame pe-riod (s)	1001/30000		1/25									
Chromi-nance sub-carrier fre-quency (Hz)	3579545 ± 10	3579611.49 ± 10	4433618.75 ± 5 (3582056.25 ± 5)	4433618.75 ± 5					4433618.75 ± 1	$f_{OB} = 4406250 \pm 2000$ , $f_{OB} = 4250000 \pm 2000$		
Nominal radio-frequency channel bandwidth (MHz)	6	6	6	B: 7; B1, G: 8	8	8	8	8	8	8	8	8
Sound car-rier relative to vision car-rier (MHz)	4.5	4.5	4.5	5.5 0.001 <sup>4567</sup>	± 6.5 0.001	± 5.5	5.9996 0.0005	± 5.5 ± 0.001	6.5 0.001	± 6.5		6.5 <sup>8</sup>

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### EINVAL

The struct `v4l2_standard` index is out of bounds.

### ENODATA

Standard video timings are not supported for this input or output.

## ioctl VIDIOC\_EXPBUF

### Name

`VIDIOC_EXPBUF` - Export a buffer as a DMABUF file descriptor.

<sup>2</sup> Japan uses a standard similar to M/NTSC (`V4L2_STD_NTSC_M_JP`).

<sup>3</sup> The values in brackets apply to the combination N/PAL a.k.a. Nc used in Argentina (`V4L2_STD_PAL_Nc`).

<sup>4</sup> In the Federal Republic of Germany, Austria, Italy, the Netherlands, Slovakia and Switzerland a system of two sound carriers is used, the frequency of the second carrier being 242.1875 kHz above the frequency of the first sound carrier. For stereophonic sound transmissions a similar system is used in Australia.

<sup>5</sup> New Zealand uses a sound carrier displaced  $5.4996 \pm 0.0005$  MHz from the vision carrier.

<sup>6</sup> In Denmark, Finland, New Zealand, Sweden and Spain a system of two sound carriers is used. In Iceland, Norway and Poland the same system is being introduced. The second carrier is 5.85 MHz above the vision carrier and is DQPSK modulated with 728 kbit/s sound and data multiplex. (NICAM system)

<sup>7</sup> In the United Kingdom, a system of two sound carriers is used. The second sound carrier is 6.552 MHz above the vision carrier and is DQPSK modulated with a 728 kbit/s sound and data multiplex able to carry two sound channels. (NICAM system)

<sup>8</sup> In France, a digital carrier 5.85 MHz away from the vision carrier may be used in addition to the main sound carrier. It is modulated in differentially encoded QPSK with a 728 kbit/s sound and data multiplexer capable of carrying two sound channels. (NICAM system)

## Synopsis

### **VIDIOC\_EXPBUF**

```
int ioctl(int fd, VIDIOC_EXPBUF, struct v4l2_exportbuffer *argp)
```

## Arguments

### **fd**

File descriptor returned by *open()*.

### **argp**

Pointer to struct *v4l2\_exportbuffer*.

## Description

This ioctl is an extension to the *memory mapping* I/O method, therefore it is available only for V4L2\_MEMORY\_MMAP buffers. It can be used to export a buffer as a DMABUF file at any time after buffers have been allocated with the *ioctl VIDIOC\_REQBUFS* ioctl.

To export a buffer, applications fill struct *v4l2\_exportbuffer*. The type field is set to the same buffer type as was previously used with struct *v4l2\_requestbuffers* type. Applications must also set the index field. Valid index numbers range from zero to the number of buffers allocated with *ioctl VIDIOC\_REQBUFS* (struct *v4l2\_requestbuffers* count) minus one. For the multi-planar API, applications set the plane field to the index of the plane to be exported. Valid planes range from zero to the maximal number of valid planes for the currently active format. For the single-planar API, applications must set plane to zero. Additional flags may be posted in the flags field. Refer to a manual for *open()* for details. Currently only O\_CLOEXEC, O\_RDONLY, O\_WRONLY, and O\_RDWR are supported. All other fields must be set to zero. In the case of multi-planar API, every plane is exported separately using multiple *ioctl VIDIOC\_EXPBUF* calls.

After calling *ioctl VIDIOC\_EXPBUF* the fd field will be set by a driver. This is a DMABUF file descriptor. The application may pass it to other DMABUF-aware devices. Refer to *DMABUF importing* for details about importing DMABUF files into V4L2 nodes. It is recommended to close a DMABUF file when it is no longer used to allow the associated memory to be reclaimed.

## Examples

```
int buffer_export(int v4lfd, enum v4l2_buf_type bt, int index, int *dmafd)
{
    struct v4l2_exportbuffer expbuf;

    memset(&expbuf, 0, sizeof(expbuf));
    expbuf.type = bt;
    expbuf.index = index;
    if (ioctl(v4lfd, VIDIOC_EXPBUF, &expbuf) == -1) {
        perror("VIDIOC_EXPBUF");
        return -1;
    }
}
```

```
*dmafd = expbuf.fd;  
  
    return 0;  
}
```

```
int buffer_export_mp(int v4lfd, enum v4l2_buf_type bt, int index,  
    int dmafd[], int n_planes)  
{  
    int i;  
  
    for (i = 0; i < n_planes; ++i) {  
        struct v4l2_exportbuffer expbuf;  
  
        memset(&expbuf, 0, sizeof(expbuf));  
        expbuf.type = bt;  
        expbuf.index = index;  
        expbuf.plane = i;  
        if (ioctl(v4lfd, VIDIOC_EXPBUF, &expbuf) == -1) {  
            perror("VIDIOC_EXPBUF");  
            while (i)  
                close(dmafd[--i]);  
            return -1;  
        }  
        dmafd[i] = expbuf.fd;  
    }  
  
    return 0;  
}
```

type **v4l2\_exportbuffer**

Table 209: struct v4l2\_exportbuffer

<code>_u32</code>	<code>type</code>	Type of the buffer, same as struct <code>v4l2_format</code> type or struct <code>v4l2_requestbuffers</code> type, set by the application. See <code>v4l2_buf_type</code>
<code>_u32</code>	<code>index</code>	Number of the buffer, set by the application. This field is only used for <i>memory mapping</i> I/O and can range from zero to the number of buffers allocated with the <code>ioctl VIDIOC_REQBUFS</code> and/or <code>ioctl VIDIOC_CREATE_BUFS</code> ioctls.
<code>_u32</code>	<code>plane</code>	Index of the plane to be exported when using the multi-planar API. Otherwise this value must be set to zero.
<code>_u32</code>	<code>flags</code>	Flags for the newly created file, currently only <code>O_CLOEXEC</code> , <code>O_RDONLY</code> , <code>O_WRONLY</code> , and <code>O_RDWR</code> are supported, refer to the manual of <code>open()</code> for more details.
<code>_s32</code>	<code>fd</code>	The DMABUF file descriptor associated with a buffer. Set by the driver.
<code>_u32</code>	<code>reserved[11]</code>	Reserved field for future use. Drivers and applications must set the array to zero.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## EINVAL

A queue is not in MMAP mode or DMABUF exporting is not supported or `flags` or `type` or `index` or `plane` fields are invalid.

## `ioctl VIDIOC_G_AUDIO, VIDIOC_S_AUDIO`

### Name

`VIDIOC_G_AUDIO` - `VIDIOC_S_AUDIO` - Query or select the current audio input and its attributes

## Synopsis

### **VIDIOC\_G\_AUDIO**

```
int ioctl(int fd, VIDIOC_G_AUDIO, struct v4l2_audio *argp)
```

### **VIDIOC\_S\_AUDIO**

```
int ioctl(int fd, VIDIOC_S_AUDIO, const struct v4l2_audio *argp)
```

## Arguments

### **fd**

File descriptor returned by `open()`.

### **argp**

Pointer to struct `v4l2_audio`.

## Description

To query the current audio input applications zero out the reserved array of a struct `v4l2_audio` and call the `VIDIOC_G_AUDIO` ioctl with a pointer to this structure. Drivers fill the rest of the structure or return an EINVAL error code when the device has no audio inputs, or none which combine with the current video input.

Audio inputs have one writable property, the audio mode. To select the current audio input *and* change the audio mode, applications initialize the index and mode fields, and the reserved array of a struct `v4l2_audio` structure and call the `VIDIOC_S_AUDIO` ioctl. Drivers may switch to a different audio mode if the request cannot be satisfied. However, this is a write-only ioctl, it does not return the actual new audio mode.

type `v4l2_audio`

Table 210: struct `v4l2_audio`

<code>_u32</code>	<code>index</code>	Identifies the audio input, set by the driver or application.
<code>_u8</code>	<code>name[32]</code>	Name of the audio input, a NUL-terminated ASCII string, for example: "Line In". This information is intended for the user, preferably the connector label on the device itself.
<code>_u32</code>	<code>capability</code>	Audio capability flags, see <a href="#">Audio Capability Flags</a> .
<code>_u32</code>	<code>mode</code>	Audio mode flags set by drivers and applications (on <code>VIDIOC_S_AUDIO</code> ioctl), see <a href="#">Audio Mode Flags</a> .
<code>_u32</code>	<code>reserved[2]</code>	Reserved for future extensions. Drivers and applications must set the array to zero.

Table 211: Audio Capability Flags

V4L2_AUDCAP_STEREO	0x00001	This is a stereo input. The flag is intended to automatically disable stereo recording etc. when the signal is always monaural. The API provides no means to detect if stereo is <i>received</i> , unless the audio input belongs to a tuner.
V4L2_AUDCAP_AVL	0x00002	Automatic Volume Level mode is supported.

Table 212: Audio Mode Flags

V4L2_AUDMODE_AVL	0x00001	AVL mode is on.
------------------	---------	-----------------

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## EINVAL

No audio inputs combine with the current video input, or the number of the selected audio input is out of bounds or it does not combine.

## ioctl VIDIOC\_G\_AUDOUT, VIDIOC\_S\_AUDOUT

### Name

`VIDIOC_G_AUDOUT` - `VIDIOC_S_AUDOUT` - Query or select the current audio output

### Synopsis

#### `VIDIOC_G_AUDOUT`

```
int ioctl(int fd, VIDIOC_G_AUDOUT, struct v4l2_audioout *argp)
```

#### `VIDIOC_S_AUDOUT`

```
int ioctl(int fd, VIDIOC_S_AUDOUT, const struct v4l2_audioout *argp)
```

### Arguments

#### `fd`

File descriptor returned by [`open\(\)`](#).

#### `argp`

Pointer to struct `v4l2_audioout`.

## Description

To query the current audio output applications zero out the reserved array of a struct `v4l2_audioout` and call the VIDIOC\_G\_AUDOUT ioctl with a pointer to this structure. Drivers fill the rest of the structure or return an EINVAL error code when the device has no audio inputs, or none which combine with the current video output.

Audio outputs have no writable properties. Nevertheless, to select the current audio output applications can initialize the index field and reserved array (which in the future may contain writable properties) of a struct `v4l2_audioout` structure and call the VIDIOC\_S\_AUDOUT ioctl. Drivers switch to the requested output or return the EINVAL error code when the index is out of bounds. This is a write-only ioctl, it does not return the current audio output attributes as VIDIOC\_G\_AUDOUT does.

---

**Note:** Connectors on a TV card to loop back the received audio signal to a sound card are not audio outputs in this sense.

---

### type `v4l2_audioout`

Table 213: struct `v4l2_audioout`

<code>_u32</code>	<code>index</code>	Identifies the audio output, set by the driver or application.
<code>_u8</code>	<code>name[32]</code>	Name of the audio output, a NUL-terminated ASCII string, for example: "Line Out". This information is intended for the user, preferably the connector label on the device itself.
<code>_u32</code>	<code>capability</code>	Audio capability flags, none defined yet. Drivers must set this field to zero.
<code>_u32</code>	<code>mode</code>	Audio mode, none defined yet. Drivers and applications (on VIDIOC_S_AUDOUT) must set this field to zero.
<code>_u32</code>	<code>reserved[2]</code>	Reserved for future extensions. Drivers and applications must set the array to zero.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### EINVAL

No audio outputs combine with the current video output, or the number of the selected audio output is out of bounds or it does not combine.

## **ioctl VIDIOC\_G\_CROP, VIDIOC\_S\_CROP**

### **Name**

VIDIOC\_G\_CROP - VIDIOC\_S\_CROP - Get or set the current cropping rectangle

### **Synopsis**

#### **VIDIOC\_G\_CROP**

```
int ioctl(int fd, VIDIOC_G_CROP, struct v4l2_crop *argp)
```

#### **VIDIOC\_S\_CROP**

```
int ioctl(int fd, VIDIOC_S_CROP, const struct v4l2_crop *argp)
```

### **Arguments**

#### **fd**

File descriptor returned by [open\(\)](#).

#### **argp**

Pointer to struct [\*v4l2\\_crop\*](#).

### **Description**

To query the cropping rectangle size and position applications set the `type` field of a struct [\*v4l2\\_crop\*](#) structure to the respective buffer (stream) type and call the [\*VIDIOC\\_G\\_CROP\*](#) ioctl with a pointer to this structure. The driver fills the rest of the structure or returns the `EINVAL` error code if cropping is not supported.

To change the cropping rectangle applications initialize the `type` and struct [\*v4l2\\_rect\*](#) sub-structure named `c` of a `v4l2_crop` structure and call the [\*VIDIOC\\_S\\_CROP\*](#) ioctl with a pointer to this structure.

The driver first adjusts the requested dimensions against hardware limits, i. e. the bounds given by the capture/output window, and it rounds to the closest possible values of horizontal and vertical offset, width and height. In particular the driver must round the vertical offset of the cropping rectangle to frame lines modulo two, such that the field order cannot be confused.

Second the driver adjusts the image size (the opposite rectangle of the scaling process, source or target depending on the data direction) to the closest size possible while maintaining the current horizontal and vertical scaling factor.

Finally the driver programs the hardware with the actual cropping and image parameters. [\*VIDIOC\\_S\\_CROP\*](#) is a write-only ioctl, it does not return the actual parameters. To query them applications must call [\*VIDIOC\\_G\\_CROP\*](#) and [\*ioctl VIDIOC\\_G\\_FMT, VIDIOC\\_S\\_FMT, VIDIOC\\_TRY\\_FMT\*](#). When the parameters are unsuitable the application may modify the cropping or image parameters and repeat the cycle until satisfactory parameters have been negotiated.

When cropping is not supported then no parameters are changed and [\*VIDIOC\\_S\\_CROP\*](#) returns the `EINVAL` error code.

type `v4l2_crop`

Table 214: struct `v4l2_crop`

<code>_u32</code>	<code>type</code>	Type of the data stream, set by the application. Only these types are valid here: <code>V4L2_BUF_TYPE_VIDEO_CAPTURE</code> , <code>V4L2_BUF_TYPE_VIDEO_CAPTURE_MPLANE</code> , <code>V4L2_BUF_TYPE_VIDEO_OUTPUT</code> , <code>V4L2_BUF_TYPE_VIDEO_OUTPUT_MPLANE</code> and <code>V4L2_BUF_TYPE_VIDEO_OVERLAY</code> . See <a href="#"><code>v4l2_buf_type</code></a> and the note below.
<code>struct v4l2_rect</code>	<code>c</code>	Cropping rectangle. The same co-ordinate system as for struct <code>v4l2_cropcap</code> bounds is used.

---

**Note:** Unfortunately in the case of multiplanar buffer types (`V4L2_BUF_TYPE_VIDEO_CAPTURE_MPLANE` and `V4L2_BUF_TYPE_VIDEO_OUTPUT_MPLANE`) this API was messed up with regards to how the `v4l2_crop` type field should be filled in. Some drivers only accepted the `_MPLANE` buffer type while other drivers only accepted a non-multiplanar buffer type (i.e. without the `_MPLANE` at the end).

Starting with kernel 4.13 both variations are allowed.

---

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## ENODATA

Cropping is not supported for this input or output.

## ioctl VIDIOC\_G\_CTRL, VIDIOC\_S\_CTRL

### Name

`VIDIOC_G_CTRL` - `VIDIOC_S_CTRL` - Get or set the value of a control

### Synopsis

#### `VIDIOC_G_CTRL`

```
int ioctl(int fd, VIDIOC_G_CTRL, struct v4l2_control *argp)
```

#### `VIDIOC_S_CTRL`

```
int ioctl(int fd, VIDIOC_S_CTRL, struct v4l2_control *argp)
```

## Arguments

### fd

File descriptor returned by `open()`.

### argp

Pointer to struct `v4l2_control`.

## Description

To get the current value of a control applications initialize the `id` field of a struct `v4l2_control` and call the `VIDIOC_G_CTRL` ioctl with a pointer to this structure. To change the value of a control applications initialize the `id` and `value` fields of a struct `v4l2_control` and call the `VIDIOC_S_CTRL` ioctl.

When the `id` is invalid drivers return an `EINVAL` error code. When the `value` is out of bounds drivers can choose to take the closest valid value or return an `ERANGE` error code, whatever seems more appropriate. However, `VIDIOC_S_CTRL` is a write-only ioctl, it does not return the actual new value. If the `value` is inappropriate for the control (e.g. if it refers to an unsupported menu index of a menu control), then `EINVAL` error code is returned as well.

These ioctls work only with user controls. For other control classes the `VIDIOC_G_EXT_CTRLS`, `VIDIOC_S_EXT_CTRLS` or `VIDIOC_TRY_EXT_CTRLS` must be used.

### type `v4l2_control`

Table 215: struct `v4l2_control`

<code>__u32</code>	<code>id</code>	Identifies the control, set by the application.
<code>__s32</code>	<code>value</code>	New value or current value.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### `EINVAL`

The struct `v4l2_control` `id` is invalid or the `value` is inappropriate for the given control (i.e. if a menu item is selected that is not supported by the driver according to `VIDIOC_QUERYMENU`).

### `ERANGE`

The struct `v4l2_control` `value` is out of bounds.

### `EBUSY`

The control is temporarily not changeable, possibly because another applications took over control of the device function this control belongs to.

### `EACCES`

Attempt to set a read-only control or to get a write-only control.

Or if there is an attempt to set an inactive control and the driver is not capable of caching the new value until the control is active again.

## ioctl VIDIOC\_G\_DV\_TIMINGS, VIDIOC\_S\_DV\_TIMINGS

### Name

VIDIOC\_G\_DV\_TIMINGS - VIDIOC\_S\_DV\_TIMINGS - VIDIOC\_SUBDEV\_G\_DV\_TIMINGS - VIDIOC\_SUBDEV\_S\_DV\_TIMINGS - Get or set DV timings for input or output

### Synopsis

#### **VIDIOC\_G\_DV\_TIMINGS**

```
int ioctl(int fd, VIDIOC_G_DV_TIMINGS, struct v4l2_dv_timings *argp)
```

#### **VIDIOC\_S\_DV\_TIMINGS**

```
int ioctl(int fd, VIDIOC_S_DV_TIMINGS, struct v4l2_dv_timings *argp)
```

#### **VIDIOC\_SUBDEV\_G\_DV\_TIMINGS**

```
int ioctl(int fd, VIDIOC_SUBDEV_G_DV_TIMINGS, struct v4l2_dv_timings *argp)
```

#### **VIDIOC\_SUBDEV\_S\_DV\_TIMINGS**

```
int ioctl(int fd, VIDIOC_SUBDEV_S_DV_TIMINGS, struct v4l2_dv_timings *argp)
```

### Arguments

#### **fd**

File descriptor returned by `open()`.

#### **argp**

Pointer to struct `v4l2_dv_timings`.

### Description

To set DV timings for the input or output, applications use the `VIDIOC_S_DV_TIMINGS` ioctl and to get the current timings, applications use the `VIDIOC_G_DV_TIMINGS` ioctl. The detailed timing information is filled in using the structure struct `v4l2_dv_timings`. These ioctls take a pointer to the struct `v4l2_dv_timings` structure as argument. If the ioctl is not supported or the timing values are not correct, the driver returns EINVAL error code.

Calling `VIDIOC_SUBDEV_S_DV_TIMINGS` on a subdev device node that has been registered in read-only mode is not allowed. An error is returned and the errno variable is set to -EPERM.

The `linux/v4l2-dv-timings.h` header can be used to get the timings of the formats in the `CEA-861-E` and `VESA DMT` standards. If the current input or output does not support DV timings (e.g. if `ioctl VIDIOC_ENUMINPUT` does not set the `V4L2_IN_CAP_DV_TIMINGS` flag), then ENODATA error code is returned.

**Return Value**

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

**EINVAL**

This ioctl is not supported, or the `VIDIOC_S_DV_TIMINGS` parameter was unsuitable.

**ENODATA**

Digital video timings are not supported for this input or output.

**EBUSY**

The device is busy and therefore can not change the timings.

**EPERM**

`VIDIOC_SUBDEV_S_DV_TIMINGS` has been called on a read-only subdevice.

type `v4l2_bt_timings`

Table 216: struct `v4l2_bt_timings`

<code>__u32</code>	<code>width</code>	Width of the active video in pixels.
<code>__u32</code>	<code>height</code>	Height of the active video frame in lines. So for interlaced formats the height of the active video in each field is <code>height</code> /2.
<code>__u32</code>	<code>interlaced</code>	Progressive ( <code>V4L2_DV_PROGRESSIVE</code> ) or interlaced ( <code>V4L2_DV_INTERLACED</code> ).
<code>__u32</code>	<code>polarities</code>	This is a bit mask that defines polarities of sync signals. bit 0 ( <code>V4L2_DV_VSYNC_POS_POL</code> ) is for vertical sync polarity and bit 1 ( <code>V4L2_DV_HSYNC_POS_POL</code> ) is for horizontal sync polarity. If the bit is set (1) it is positive polarity and if is cleared (0), it is negative polarity.
<code>__u64</code>	<code>pixelclock</code>	Pixel clock in Hz. Ex. 74.25MHz->74250000
<code>__u32</code>	<code>hfrontporch</code>	Horizontal front porch in pixels
<code>__u32</code>	<code>hsync</code>	Horizontal sync length in pixels
<code>__u32</code>	<code>hbackporch</code>	Horizontal back porch in pixels
<code>__u32</code>	<code>vfrontporch</code>	Vertical front porch in lines. For interlaced formats this refers to the odd field (aka field 1).
<code>__u32</code>	<code>vsync</code>	Vertical sync length in lines. For interlaced formats this refers to the odd field (aka field 1).
<code>__u32</code>	<code>vbackporch</code>	Vertical back porch in lines. For interlaced formats this refers to the odd field (aka field 1).
<code>__u32</code>	<code>il_vfrontporch</code>	Vertical front porch in lines for the even field (aka field 2) of interlaced field formats. Must be 0 for progressive formats.

continues on next page

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<code>_u32</code>	<code>il_vsync</code>	Vertical sync length in lines for the even field (aka field 2) of interlaced field formats. Must be 0 for progressive formats.
<code>_u32</code>	<code>il_vbackporch</code>	Vertical back porch in lines for the even field (aka field 2) of interlaced field formats. Must be 0 for progressive formats.
<code>_u32</code>	<code>standards</code>	The video standard(s) this format belongs to. This will be filled in by the driver. Applications must set this to 0. See <a href="#">DV BT Timing standards</a> for a list of standards.
<code>_u32</code>	<code>flags</code>	Several flags giving more information about the format. See <a href="#">DV BT Timing flags</a> for a description of the flags.
<code>struct v4l2_fract</code>	<code>picture_aspect</code>	The picture aspect if the pixels are not square. Only valid if the <code>V4L2_DV_FL_HAS_PICTURE_ASPECT</code> flag is set.
<code>_u8</code>	<code>cea861_vic</code>	The Video Identification Code according to the CEA-861 standard. Only valid if the <code>V4L2_DV_FL_HAS_CEA861_VIC</code> flag is set.
<code>_u8</code>	<code>hdmi_vic</code>	The Video Identification Code according to the HDMI standard. Only valid if the <code>V4L2_DV_FL_HAS_HDMI_VIC</code> flag is set.
<code>_u8</code>	<code>reserved[46]</code>	Reserved for future extensions. Drivers and applications must set the array to zero.

type `v4l2_dv_timings`

Table 217: struct `v4l2_dv_timings`

<code>_u32</code>	<code>type</code>	Type of DV timings as listed in <a href="#">DV Timing types</a> .
<code>union {</code>	<code>(anonymous)</code>	
<code>struct v4l2_bt_timings</code>	<code>bt</code>	Timings defined by BT.656/1120 specifications
<code>_u32</code>	<code>reserved[32]</code>	
<code>}</code>		

Table 218: DV Timing types

Timing type	value	Description
<code>V4L2_DV_BT_656_1120</code>	0	BT.656/1120 timings

Table 219: DV BT Timing standards

Timing standard	Description
<code>V4L2_DV_BT_STD_CEA861</code>	The timings follow the CEA-861 Digital TV Profile standard

continues on next page

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V4L2_DV_BT_STD_DMT	The timings follow the VESA Discrete Monitor Timings standard
V4L2_DV_BT_STD_CVT	The timings follow the VESA Coordinated Video Timings standard
V4L2_DV_BT_STD_GTF	The timings follow the VESA Generalized Timings Formula standard
V4L2_DV_BT_STD_SDI	The timings follow the SDI Timings standard. There are no horizontal syncs/porches at all in this format. Total blanking timings must be set in hsync or vsync fields only.

Table 220: DV BT Timing flags

Flag	Description
V4L2_DV_FL_REDUCED_BLANKING	CVT/GTF specific: the timings use reduced blanking (CVT) or the 'Secondary GTF' curve (GTF). In both cases the horizontal and/or vertical blanking intervals are reduced, allowing a higher resolution over the same bandwidth. This is a read-only flag, applications must not set this.
V4L2_DV_FL_CAN_REDUCE_FPS	CEA-861 specific: set for CEA-861 formats with a framerate that is a multiple of six. These formats can be optionally played at 1 / 1.001 speed to be compatible with 60 Hz based standards such as NTSC and PAL-M that use a framerate of 29.97 frames per second. If the transmitter can't generate such frequencies, then the flag will also be cleared. This is a read-only flag, applications must not set this.
V4L2_DV_FL_REDUCED_FPS	CEA-861 specific: only valid for video transmitters or video receivers that have the V4L2_DV_FL_CAN_DETECT_REDUCED_FPS set. This flag is cleared otherwise. It is also only valid for formats with the V4L2_DV_FL_CAN_REDUCE_FPS flag set, for other formats the flag will be cleared by the driver. If the application sets this flag for a transmitter, then the pixelclock used to set up the transmitter is divided by 1.001 to make it compatible with NTSC framerates. If the transmitter can't generate such frequencies, then the flag will be cleared. If a video receiver detects that the format uses a reduced framerate, then it will set this flag to signal this to the application.

continues on next page

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V4L2_DV_FL_HALF_LINE	Specific to interlaced formats: if set, then the vertical frontporch of field 1 (aka the odd field) is really one half-line longer and the vertical backporch of field 2 (aka the even field) is really one half-line shorter, so each field has exactly the same number of half-lines. Whether half-lines can be detected or used depends on the hardware.
V4L2_DV_FL_IS_CE_VIDEO	If set, then this is a Consumer Electronics (CE) video format. Such formats differ from other formats (commonly called IT formats) in that if R'G'B' encoding is used then by default the R'G'B' values use limited range (i.e. 16-235) as opposed to full range (i.e. 0-255). All formats defined in CEA-861 except for the 640x480p59.94 format are CE formats.
V4L2_DV_FL_FIRST_FIELD_EXTRA_LINE	Some formats like SMPTE-125M have an interlaced signal with a odd total height. For these formats, if this flag is set, the first field has the extra line. Else, it is the second field.
V4L2_DV_FL_HAS_PICTURE_ASPECT	If set, then the picture_aspect field is valid. Otherwise assume that the pixels are square, so the picture aspect ratio is the same as the width to height ratio.
V4L2_DV_FL_HAS_CEA861_VIC	If set, then the cea861_vic field is valid and contains the Video Identification Code as per the CEA-861 standard.
V4L2_DV_FL_HAS_HDMI_VIC	If set, then the hdmi_vic field is valid and contains the Video Identification Code as per the HDMI standard (HDMI Vendor Specific InfoFrame).
V4L2_DV_FL_CAN_DETECT_REDUCED_FPS	CEA-861 specific: only valid for video receivers, the flag is cleared by transmitters. If set, then the hardware can detect the difference between regular framerates and framerates reduced by 1000/1001. E.g.: 60 vs 59.94 Hz, 30 vs 29.97 Hz or 24 vs 23.976 Hz.

**ioctl VIDIOC\_G\_EDID, VIDIOC\_S\_EDID, VIDIOC\_SUBDEV\_G\_EDID, VIDIOC\_SUBDEV\_S\_EDID**

#### Name

VIDIOC\_G\_EDID - VIDIOC\_S\_EDID - VIDIOC\_SUBDEV\_G\_EDID - VIDIOC\_SUBDEV\_S\_EDID - Get or set the EDID of a video receiver/transmitter

### Synopsis

#### **VIDIOC\_G\_EDID**

```
int ioctl(int fd, VIDIOC_G_EDID, struct v4l2_edid *argp)
```

#### **VIDIOC\_S\_EDID**

```
int ioctl(int fd, VIDIOC_S_EDID, struct v4l2_edid *argp)
```

#### **VIDIOC\_SUBDEV\_G\_EDID**

```
int ioctl(int fd, VIDIOC_SUBDEV_G_EDID, struct v4l2_edid *argp)
```

#### **VIDIOC\_SUBDEV\_S\_EDID**

```
int ioctl(int fd, VIDIOC_SUBDEV_S_EDID, struct v4l2_edid *argp)
```

### Arguments

#### **fd**

File descriptor returned by [open\(\)](#).

#### **argp**

Pointer to struct [\*v4l2\\_edid\*](#).

### Description

These ioctls can be used to get or set an EDID associated with an input from a receiver or an output of a transmitter device. They can be used with subdevice nodes (/dev/v4l-subdevX) or with video nodes (/dev/videoX).

When used with video nodes the pad field represents the input (for video capture devices) or output (for video output devices) index as is returned by [ioctl VIDIOC\\_ENUMINPUT](#) and [ioctl VIDIOC\\_ENUMOUTPUT](#) respectively. When used with subdevice nodes the pad field represents the input or output pad of the subdevice. If there is no EDID support for the given pad value, then the EINVAL error code will be returned.

To get the EDID data the application has to fill in the pad, start\_block, blocks and edid fields, zero the reserved array and call [\*VIDIOC\\_G\\_EDID\*](#). The current EDID from block start\_block and of size blocks will be placed in the memory edid points to. The edid pointer must point to memory at least blocks \* 128 bytes large (the size of one block is 128 bytes).

If there are fewer blocks than specified, then the driver will set blocks to the actual number of blocks. If there are no EDID blocks available at all, then the error code ENODATA is set.

If blocks have to be retrieved from the sink, then this call will block until they have been read.

If start\_block and blocks are both set to 0 when [\*VIDIOC\\_G\\_EDID\*](#) is called, then the driver will set blocks to the total number of available EDID blocks and it will return 0 without copying any data. This is an easy way to discover how many EDID blocks there are.

---

**Note:** If there are no EDID blocks available at all, then the driver will set blocks to 0 and it returns 0.

---

To set the EDID blocks of a receiver the application has to fill in the `pad`, `blocks` and `edid` fields, set `start_block` to 0 and zero the `reserved` array. It is not possible to set part of an EDID, it is always all or nothing. Setting the EDID data is only valid for receivers as it makes no sense for a transmitter.

The driver assumes that the full EDID is passed in. If there are more EDID blocks than the hardware can handle then the EDID is not written, but instead the error code `E2BIG` is set and `blocks` is set to the maximum that the hardware supports. If `start_block` is any value other than 0 then the error code `EINVAL` is set.

To disable an EDID you set `blocks` to 0. Depending on the hardware this will drive the hotplug pin low and/or block the source from reading the EDID data in some way. In any case, the end result is the same: the EDID is no longer available.

type `v4l2_edid`

Table 221: struct `v4l2_edid`

<code>_u32</code>	<code>pad</code>	Pad for which to get/set the EDID blocks. When used with a video device node the pad represents the input or output index as returned by <code>ioctl VIDIOC_ENUMINPUT</code> and <code>ioctl VIDIOC_ENUMOUTPUT</code> respectively.
<code>_u32</code>	<code>start_block</code>	Read the EDID from starting with this block. Must be 0 when setting the EDID.
<code>_u32</code>	<code>blocks</code>	The number of blocks to get or set. Must be less or equal to 256 (the maximum number of blocks as defined by the standard). When you set the EDID and <code>blocks</code> is 0, then the EDID is disabled or erased.
<code>_u32</code>	<code>reserved[5]</code>	Reserved for future extensions. Applications and drivers must set the array to zero.
<code>_u8 *</code>	<code>edid</code>	Pointer to memory that contains the EDID. The minimum size is <code>blocks * 128</code> .

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### ENODATA

The EDID data is not available.

### E2BIG

The EDID data you provided is more than the hardware can handle.

### ioctl VIDIOC\_G\_ENC\_INDEX

#### Name

VIDIOC\_G\_ENC\_INDEX - Get meta data about a compressed video stream

#### Synopsis

##### VIDIOC\_G\_ENC\_INDEX

```
int ioctl(int fd, VIDIOC_G_ENC_INDEX, struct v4l2_enc_idx *argp)
```

#### Arguments

##### fd

File descriptor returned by [open\(\)](#).

##### argp

Pointer to struct [`v4l2\_enc\_idx`](#).

#### Description

The [`VIDIOC\_G\_ENC\_INDEX`](#) ioctl provides meta data about a compressed video stream the same or another application currently reads from the driver, which is useful for random access into the stream without decoding it.

To read the data applications must call [`VIDIOC\_G\_ENC\_INDEX`](#) with a pointer to a struct [`v4l2\_enc\_idx`](#). On success the driver fills the entry array, stores the number of elements written in the `entries` field, and initializes the `entries_cap` field.

Each element of the entry array contains meta data about one picture. A [`VIDIOC\_G\_ENC\_INDEX`](#) call reads up to `V4L2_ENC_IDX_ENTRIES` entries from a driver buffer, which can hold up to `entries_cap` entries. This number can be lower or higher than `V4L2_ENC_IDX_ENTRIES`, but not zero. When the application fails to read the meta data in time the oldest entries will be lost. When the buffer is empty or no capturing/encoding is in progress, `entries` will be zero.

Currently this ioctl is only defined for MPEG-2 program streams and video elementary streams.

type [`v4l2\_enc\_idx`](#)

Table 222: struct v4l2\_enc\_idx

<code>_u32</code>	<code>entries</code>	The number of entries the driver stored in the <code>entry</code> array.
<code>_u32</code>	<code>entries_cap</code>	The number of entries the driver can buffer. Must be greater than zero.
<code>_u32</code>	<code>reserved[4]</code>	Reserved for future extensions. Drivers must set the array to zero.
<code>struct v4l2_enc_idx_entry</code>	<code>entry[V4L2_ENC_IDX_ENTRIES]</code>	Meta data about a compressed video stream. Each element of the array corresponds to one picture, sorted in ascending order by their <code>offset</code> .

type `v4l2_enc_idx_entry`

Table 223: struct v4l2\_enc\_idx\_entry

<code>_u64</code>	<code>offset</code>	The offset in bytes from the beginning of the compressed video stream to the beginning of this picture, that is a <i>PES packet header</i> as defined in <a href="#">ISO 13818-1</a> or a <i>picture header</i> as defined in <a href="#">ISO 13818-2</a> . When the encoder is stopped, the driver resets the offset to zero.
<code>_u64</code>	<code>pts</code>	The 33 bit <i>Presentation Time Stamp</i> of this picture as defined in <a href="#">ISO 13818-1</a> .
<code>_u32</code>	<code>length</code>	The length of this picture in bytes.
<code>_u32</code>	<code>flags</code>	Flags containing the coding type of this picture, see <a href="#">Index Entry Flags</a> .
<code>_u32</code>	<code>reserved[2]</code>	Reserved for future extensions. Drivers must set the array to zero.

Table 224: Index Entry Flags

<code>V4L2_ENC_IDX_FRAME_I</code>	<code>0x00</code>	This is an Intra-coded picture.
<code>V4L2_ENC_IDX_FRAME_P</code>	<code>0x01</code>	This is a Predictive-coded picture.
<code>V4L2_ENC_IDX_FRAME_B</code>	<code>0x02</code>	This is a Bidirectionally predictive-coded picture.
<code>V4L2_ENC_IDX_FRAME_MASK</code>	<code>0x0F</code>	AND the flags field with this mask to obtain the picture coding type.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## **ioctl VIDIOC\_G\_EXT\_CTRLS, VIDIOC\_S\_EXT\_CTRLS, VIDIOC\_TRY\_EXT\_CTRLS**

### Name

`VIDIOC_G_EXT_CTRLS` - `VIDIOC_S_EXT_CTRLS` - `VIDIOC_TRY_EXT_CTRLS` - Get or set the value of several controls, try control values

### Synopsis

#### `VIDIOC_G_EXT_CTRLS`

```
int ioctl(int fd, VIDIOC_G_EXT_CTRLS, struct v4l2_ext_controls *argp)
```

#### `VIDIOC_S_EXT_CTRLS`

```
int ioctl(int fd, VIDIOC_S_EXT_CTRLS, struct v4l2_ext_controls *argp)
```

#### `VIDIOC_TRY_EXT_CTRLS`

```
int ioctl(int fd, VIDIOC_TRY_EXT_CTRLS, struct v4l2_ext_controls *argp)
```

### Arguments

#### `fd`

File descriptor returned by [`open\(\)`](#).

#### `argp`

Pointer to struct [`v4l2\_ext\_controls`](#).

### Description

These ioctls allow the caller to get or set multiple controls atomically. Control IDs are grouped into control classes (see [Control classes](#)) and all controls in the control array must belong to the same control class.

Applications must always fill in the `count`, which, `controls` and `reserved` fields of struct [`v4l2\_ext\_controls`](#), and initialize the struct [`v4l2\_ext\_control`](#) array pointed to by the `controls` fields.

To get the current value of a set of controls applications initialize the `id`, `size` and `reserved2` fields of each struct [`v4l2\_ext\_control`](#) and call the [`VIDIOC\_G\_EXT\_CTRLS`](#) ioctl. String controls must also set the `string` field. Controls of compound types (`V4L2_CTRL_FLAG_HAS_PAYLOAD` is set) must set the `ptr` field.

If the `size` is too small to receive the control result (only relevant for pointer-type controls like strings), then the driver will set `size` to a valid value and return an ENOSPC error code. You

should re-allocate the memory to this new size and try again. For the string type it is possible that the same issue occurs again if the string has grown in the meantime. It is recommended to call `iocls VIDIOC_QUERYCTRL, VIDIOC_QUERY_EXT_CTRL and VIDIOC_QUERYMENU` first and use `maximum+1` as the new `size` value. It is guaranteed that that is sufficient memory.

N-dimensional arrays are set and retrieved row-by-row. You cannot set a partial array, all elements have to be set or retrieved. The total size is calculated as `elems * elem_size`. These values can be obtained by calling `VIDIOC_QUERY_EXT_CTRL`.

To change the value of a set of controls applications initialize the `id`, `size`, `reserved2` and `value/value64/string/ptr` fields of each struct `v4l2_ext_control` and call the `VIDIOC_S_EXT_CTRLS` ioctl. The controls will only be set if *all* control values are valid.

To check if a set of controls have correct values applications initialize the `id`, `size`, `reserved2` and `value/value64/string/ptr` fields of each struct `v4l2_ext_control` and call the `VIDIOC_TRY_EXT_CTRLS` ioctl. It is up to the driver whether wrong values are automatically adjusted to a valid value or if an error is returned.

When the `id` or `which` is invalid drivers return an `EINVAL` error code. When the value is out of bounds drivers can choose to take the closest valid value or return an `ERANGE` error code, whatever seems more appropriate. In the first case the new value is set in struct `v4l2_ext_control`. If the new control value is inappropriate (e.g. the given menu index is not supported by the menu control), then this will also result in an `EINVAL` error code.

If `request_fd` is set to a not-yet-queued `request` file descriptor and `which` is set to `V4L2_CTRL WHICH_REQUEST_VAL`, then the controls are not applied immediately when calling `VIDIOC_S_EXT_CTRLS`, but instead are applied by the driver for the buffer associated with the same request. If the device does not support requests, then `EACCES` will be returned. If requests are supported but an invalid request file descriptor is given, then `EINVAL` will be returned.

An attempt to call `VIDIOC_S_EXT_CTRLS` for a request that has already been queued will result in an `EBUSY` error.

If `request_fd` is specified and `which` is set to `V4L2_CTRL WHICH_REQUEST_VAL` during a call to `VIDIOC_G_EXT_CTRLS`, then it will return the values of the controls at the time of request completion. If the request is not yet completed, then this will result in an `EACCES` error.

The driver will only set/get these controls if all control values are correct. This prevents the situation where only some of the controls were set/get. Only low-level errors (e. g. a failed i2c command) can still cause this situation.

#### type `v4l2_ext_control`

Table 225: struct `v4l2_ext_control`

<code>_u32</code>	<code>id</code>	Identifies the control, set by the application.
<code>_u32</code>	<code>size</code>	The total size in bytes of the payload of this control.

The `size` field is normally 0, but for pointer controls this should be set to the size of the memory that contains the payload or that will receive the payload. If `VIDIOC_G_EXT_CTRLS` finds that this value is less than is required to store the payload result, then it is set to a value large enough to store the payload result and `ENOSPC` is returned.

**Note:** For string controls, this `size` field should not be confused with the length of the string. This field refers to the size of the memory that contains the string. The actual *length* of the string may well be much smaller.

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<code>_u32</code>	<code>reserved2[1]</code>	Reserved for future extensions. Drivers and applications must set the array to zero.
<code>union {</code>	<code>(anonymous)</code>	
<code>_s32</code>	<code>value</code>	New value or current value. Valid if this control is not of type <code>V4L2_CTRL_TYPE_INTEGER64</code> and <code>V4L2_CTRL_FLAG_HAS_PAYLOAD</code> is not set.
<code>_s64</code>	<code>value64</code>	New value or current value. Valid if this control is of type <code>V4L2_CTRL_TYPE_INTEGER64</code> and <code>V4L2_CTRL_FLAG_HAS_PAYLOAD</code> is not set.
<code>char *</code>	<code>string</code>	A pointer to a string. Valid if this control is of type <code>V4L2_CTRL_TYPE_STRING</code> .
<code>_u8 *</code>	<code>p_u8</code>	A pointer to a matrix control of unsigned 8-bit values. Valid if this control is of type <code>V4L2_CTRL_TYPE_U8</code> .
<code>_u16 *</code>	<code>p_u16</code>	A pointer to a matrix control of unsigned 16-bit values. Valid if this control is of type <code>V4L2_CTRL_TYPE_U16</code> .
<code>_u32 *</code>	<code>p_u32</code>	A pointer to a matrix control of unsigned 32-bit values. Valid if this control is of type <code>V4L2_CTRL_TYPE_U32</code> .
<code>_s32 *</code>	<code>p_s32</code>	A pointer to a matrix control of signed 32-bit values. Valid if this control is of type <code>V4L2_CTRL_TYPE_INTEGER</code> and <code>V4L2_CTRL_FLAG_HAS_PAYLOAD</code> is set.
<code>_s64 *</code>	<code>p_s64</code>	A pointer to a matrix control of signed 64-bit values. Valid if this control is of type <code>V4L2_CTRL_TYPE_INTEGER64</code> and <code>V4L2_CTRL_FLAG_HAS_PAYLOAD</code> is set.
<code>struct v4l2_area *</code>	<code>p_area</code>	A pointer to a struct <code>v4l2_area</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_AREA</code> .
<code>struct v4l2_ctrl_h264_sps *</code>	<code>p_h264_sps</code>	A pointer to a struct <code>v4l2_ctrl_h264_sps</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_H264_SPS</code> .
<code>struct v4l2_ctrl_h264_pps *</code>	<code>p_h264_pps</code>	A pointer to a struct <code>v4l2_ctrl_h264_pps</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_H264_PPS</code> .
<code>struct v4l2_ctrl_h264_scaling_matrix *</code>	<code>p_h264_scaling_matrix</code>	A pointer to a struct <code>v4l2_ctrl_h264_scaling_matrix</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_H264_SCALING_MATRIX</code> .
<code>struct v4l2_ctrl_h264_pred_weights *</code>	<code>p_h264_pred_weights</code>	A pointer to a struct <code>v4l2_ctrl_h264_pred_weights</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_H264_PRED_WEIGHTS</code> .
<code>struct v4l2_ctrl_h264_slice_params *</code>	<code>p_h264_slice_params</code>	A pointer to a struct <code>v4l2_ctrl_h264_slice_params</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_H264_SLICE_PARAMS</code> .
<code>struct v4l2_ctrl_h264_decode_params *</code>	<code>p_h264_decode_params</code>	A pointer to a struct <code>v4l2_ctrl_h264_decode_params</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_H264_DECODE_PARAMS</code> .

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<code>struct v4l2_ctrl_fwht_params *</code>	<code>p_fwht_params</code>	A pointer to a struct <code>v4l2_ctrl_fwht_params</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_FWHT_PARAMS</code> .
<code>struct v4l2_ctrl_vp8_frame *</code>	<code>p_vp8_frame</code>	A pointer to a struct <code>v4l2_ctrl_vp8_frame</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_VP8_FRAME</code> .
<code>struct v4l2_ctrl_mpeg2_sequence *</code>	<code>p_mpeg2_sequence</code>	A pointer to a struct <code>v4l2_ctrl_mpeg2_sequence</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_MPEG2_SEQUENCE</code> .
<code>struct v4l2_ctrl_mpeg2_picture *</code>	<code>p_mpeg2_picture</code>	A pointer to a struct <code>v4l2_ctrl_mpeg2_picture</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_MPEG2_PICTURE</code> .
<code>struct v4l2_ctrl_mpeg2_quantisation *</code>	<code>p_mpeg2_quantisation</code>	A pointer to a struct <code>v4l2_ctrl_mpeg2_quantisation</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_MPEG2_QUANTISATION</code> .
<code>struct v4l2_ctrl_vp9_compressed_hdr *</code>	<code>p_vp9_compressed_hdr</code>	A pointer to a struct <code>v4l2_ctrl_vp9_compressed_hdr</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_VP9_COMPRESSED_HDR</code> .
<code>struct v4l2_ctrl_vp9_frame *</code>	<code>p_vp9_frame</code>	A pointer to a struct <code>v4l2_ctrl_vp9_frame</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_VP9_FRAME</code> .
<code>struct v4l2_ctrl_hdr10_cll_info *</code>	<code>p_hdr10_cll</code>	A pointer to a struct <code>v4l2_ctrl_hdr10_cll_info</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_HDR10_CLL_INFO</code> .
<code>struct v4l2_ctrl_hdr10_mastering_display *</code>	<code>p_hdr10_mastering</code>	A pointer to a struct <code>v4l2_ctrl_hdr10_mastering_display</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_HDR10_MASTERING_DISPLAY</code> .
<code>struct v4l2_ctrl_hevc_sps *</code>	<code>p_hevc_sps</code>	A pointer to a struct <code>v4l2_ctrl_hevc_sps</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_HEVC_SPS</code> .
<code>struct v4l2_ctrl_hevc_pps *</code>	<code>p_hevc_pps</code>	A pointer to a struct <code>v4l2_ctrl_hevc_pps</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_HEVC_PPS</code> .
<code>struct v4l2_ctrl_hevc_slice_params *</code>	<code>p_hevc_slice_params</code>	A pointer to a struct <code>v4l2_ctrl_hevc_slice_params</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_HEVC_SLICE_PARAMS</code> .
<code>struct v4l2_ctrl_hevc_scaling_matrix *</code>	<code>p_hevc_scaling_matrix</code>	A pointer to a struct <code>v4l2_ctrl_hevc_scaling_matrix</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_HEVC_SCALING_MATRIX</code> .
<code>struct v4l2_ctrl_hevc_decode_params *</code>	<code>p_hevc_decode_params</code>	A pointer to a struct <code>v4l2_ctrl_hevc_decode_params</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_HEVC_DECODE_PARAMS</code> .
<code>struct v4l2_ctrl_av1_sequence *</code>	<code>p_av1_sequence</code>	A pointer to a struct <code>v4l2_ctrl_av1_sequence</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_AV1_SEQUENCE</code> .

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<code>struct v4l2_ctrl_av1_tile_group_entry *</code>	<code>p_av1_tile_group_entry</code>	A pointer to a struct <code>v4l2_ctrl_av1_tile_group_entry</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_AV1_TILE_GROUP_ENTRY</code> .
<code>struct v4l2_ctrl_av1_frame *</code>	<code>p_av1_frame</code>	A pointer to a struct <code>v4l2_ctrl_av1_frame</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_AV1_FRAME</code> .
<code>struct v4l2_ctrl_av1_film_grain *</code>	<code>p_av1_film_grain</code>	A pointer to a struct <code>v4l2_ctrl_av1_film_grain</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_AV1_FILM_GRAIN</code> .
<code>struct v4l2_ctrl_hdr10_cll_info *</code>	<code>p_hdr10_cll_info</code>	A pointer to a struct <code>v4l2_ctrl_hdr10_cll_info</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_HDR10_CLL_INFO</code> .
<code>struct v4l2_ctrl_hdr10_mastering_display *</code>	<code>p_hdr10_mastering_display</code>	A pointer to a struct <code>v4l2_ctrl_hdr10_mastering_display</code> . Valid if this control is of type <code>V4L2_CTRL_TYPE_HDR10_MASTERING_DISPLAY</code> .
<code>void *</code>	<code>ptr</code>	A pointer to a compound type which can be an N-dimensional array and/or a compound type (the control's type is $\geq V4L2_CTRL_COMPOUND_TYPES$ ). Valid if <code>V4L2_CTRL_FLAG_HAS_PAYLOAD</code> is set for this control.
<code>}</code>		

## type `v4l2_ext_controls`

Table 226: struct `v4l2_ext_controls`

<code>union {</code>	<code>(anonymous)</code>	
<code>_u32 which</code>		Which value of the control to get/set/try.  V4L2_CTRL WHICH_CUR_VAL will return the current value of the control, V4L2_CTRL WHICH_DEF_VAL will return the default value of the control and V4L2_CTRL WHICH_REQUEST_VAL indicates that these controls have to be retrieved from a request or tried/set for a request. In the latter case the request_fd field contains the file descriptor of the request that should be used. If the device does not support requests, then EACCES will be returned.  When using V4L2_CTRL WHICH_DEF_VAL be aware that you can only get the default value of the control, you cannot set or try it.  For backwards compatibility you can also use a control class here (see <a href="#">Control classes</a> ). In that case all controls have to belong to that control class. This usage is deprecated, instead just use V4L2_CTRL WHICH_CUR_VAL. There are some very old drivers that do not yet support V4L2_CTRL WHICH_CUR_VAL and that require a control class here. You can test for such drivers by setting which to V4L2_CTRL WHICH_CUR_VAL and calling <code>VIDIOC_TRY_EXT_CTRLS</code> with a count of 0. If that fails, then the driver does not support V4L2_CTRL WHICH_CUR_VAL.
<code>__u32 ctrl_class</code>		
		Deprecated name kept for backwards compatibility. Use which instead.
<code>}</code>		
<code>_u32 count</code>		The number of controls in the controls array. May also be zero.

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__u32	error_idx	Index of the failing control. Set by the driver in case of an error.
<p>If the error is associated with a particular control, then <code>error_idx</code> is set to the index of that control. If the error is not related to a specific control, or the validation step failed (see below), then <code>error_idx</code> is set to <code>count</code>. The value is undefined if the ioctl returned 0 (success).</p> <p>Before controls are read from/written to hardware a validation step takes place: this checks if all controls in the list are valid controls, if no attempt is made to write to a read-only control or read from a write-only control, and any other up-front checks that can be done without accessing the hardware. The exact validations done during this step are driver dependent since some checks might require hardware access for some devices, thus making it impossible to do those checks up-front. However, drivers should make a best-effort to do as many up-front checks as possible.</p> <p>This check is done to avoid leaving the hardware in an inconsistent state due to easy-to-avoid problems. But it leads to another problem: the application needs to know whether an error came from the validation step (meaning that the hardware was not touched) or from an error during the actual reading from/writing to hardware.</p> <p>The, in hindsight quite poor, solution for that is to set <code>error_idx</code> to <code>count</code> if the validation failed. This has the unfortunate side-effect that it is not possible to see which control failed the validation. If the validation was successful and the error happened while accessing the hardware, then <code>error_idx</code> is less than <code>count</code> and only the controls up to <code>error_idx-1</code> were read or written correctly, and the state of the remaining controls is undefined.</p> <p>Since <code>VIDIOC_TRY_EXT_CTRLS</code> does not access hardware there is also no need to handle the validation step in this special way, so <code>error_idx</code> will just be set to the control that failed the validation step instead of to <code>count</code>. This means that if <code>VIDIOC_S_EXT_CTRLS</code> fails with <code>error_idx</code> set to <code>count</code>, then you can call <code>VIDIOC_TRY_EXT_CTRLS</code> to try to discover the actual control that failed the validation step. Unfortunately, there is no TRY equivalent for <code>VIDIOC_G_EXT_CTRLS</code>.</p>		
__s32	request_fd	File descriptor of the request to be used by this operation. Only valid if <code>which</code> is set to <code>V4L2_CTRL_WHICH_REQUEST_VAL</code> . If the device does not support requests, then <code>EACCES</code> will be returned. If requests are supported but an invalid request file descriptor is given, then <code>EINVAL</code> will be returned.
__u32	reserved[1]	Reserved for future extensions. Drivers and applications must set the array to zero.
struct <code>v4l2_ext_control</code> *	controls	Pointer to an array of <code>count</code> <code>v4l2_ext_control</code> structures. Ignored if <code>count</code> equals zero.

Table 227: Control classes

V4L2_CTRL_CLASS_USER	0x980000	The class containing user controls. These controls are described in <a href="#">User Controls</a> . All controls that can be set using the <code>VIDIOC_S_CTRL</code> and <code>VIDIOC_G_CTRL</code> ioctl belong to this class.
V4L2_CTRL_CLASS_CODEC	0x990000	The class containing stateful codec controls. These controls are described in <a href="#">Codec Control Reference</a> .

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V4L2_CTRL_CLASS_CAMERA	0x9a0000	The class containing camera controls. These controls are described in <a href="#">Camera Control Reference</a> .
V4L2_CTRL_CLASS_FM_TX	0x9b0000	The class containing FM Transmitter (FM TX) controls. These controls are described in <a href="#">FM Transmitter Control Reference</a> .
V4L2_CTRL_CLASS_FLASH	0x9c0000	The class containing flash device controls. These controls are described in <a href="#">Flash Control Reference</a> .
V4L2_CTRL_CLASS_JPEG	0x9d0000	The class containing JPEG compression controls. These controls are described in <a href="#">JPEG Control Reference</a> .
V4L2_CTRL_CLASS_IMAGE_SOURCE	0x9e0000	The class containing image source controls. These controls are described in <a href="#">Image Source Control Reference</a> .
V4L2_CTRL_CLASS_IMAGE_PROC	0x9f0000	The class containing image processing controls. These controls are described in <a href="#">Image Process Control Reference</a> .
V4L2_CTRL_CLASS_FM_RX	0xa10000	The class containing FM Receiver (FM RX) controls. These controls are described in <a href="#">FM Receiver Control Reference</a> .
V4L2_CTRL_CLASS_RF_TUNER	0xa20000	The class containing RF tuner controls. These controls are described in <a href="#">RF Tuner Control Reference</a> .
V4L2_CTRL_CLASS_DETECT	0xa30000	The class containing motion or object detection controls. These controls are described in <a href="#">Detect Control Reference</a> .
V4L2_CTRL_CLASS_CODEC_STATELESS	0xa40000	The class containing stateless codec controls. These controls are described in <a href="#">Stateless Codec Control Reference</a> .
V4L2_CTRL_CLASS_COLORIMETRY	0xa50000	The class containing colorimetry controls. These controls are described in <a href="#">Colorimetry Control Reference</a> .

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## EINVAL

The struct `v4l2_ext_control` id is invalid, or the struct `v4l2_ext_controls` which is invalid, or the struct `v4l2_ext_control` value was inappropriate (e.g. the given menu index is not supported by the driver), or the which field was set to `V4L2_CTRL WHICH REQUEST VAL` but the given `request_fd` was invalid or `V4L2_CTRL WHICH REQUEST VAL` is not supported by the kernel. This error code is also returned by the `VIDIOC_S_EXT_CTRLS` and `VIDIOC_TRY_EXT_CTRLS` ioctls if two or more control values are in conflict.

**ERANGE**

The struct `v4l2_ext_control` value is out of bounds.

**EBUSY**

The control is temporarily not changeable, possibly because another applications took over control of the device function this control belongs to, or (if the `which` field was set to `V4L2_CTRL_WHICH_REQUEST_VAL`) the request was queued but not yet completed.

**ENOSPC**

The space reserved for the control's payload is insufficient. The field `size` is set to a value that is enough to store the payload and this error code is returned.

**EACCES**

Attempt to try or set a read-only control, or to get a write-only control, or to get a control from a request that has not yet been completed.

Or the `which` field was set to `V4L2_CTRL_WHICH_REQUEST_VAL` but the device does not support requests.

Or if there is an attempt to set an inactive control and the driver is not capable of caching the new value until the control is active again.

**ioctl VIDIOC\_G\_FBUF, VIDIOC\_S\_FBUF****Name**

`VIDIOC_G_FBUF` - `VIDIOC_S_FBUF` - Get or set frame buffer overlay parameters

**Synopsis****VIDIOC\_G\_FBUF**

```
int ioctl(int fd, VIDIOC_G_FBUF, struct v4l2_framebuffer *argp)
```

**VIDIOC\_S\_FBUF**

```
int ioctl(int fd, VIDIOC_S_FBUF, const struct v4l2_framebuffer *argp)
```

**Arguments****fd**

File descriptor returned by `open()`.

**argp**

Pointer to struct `v4l2_framebuffer`.

## Description

Applications can use the `VIDIOC_G_FBUF` and `VIDIOC_S_FBUF` ioctl to get and set the frame-buffer parameters for a *Video Overlay* or *Video Output Overlay* (OSD). The type of overlay is implied by the device type (capture or output device) and can be determined with the `ioctl VIDIOC_QUERYCAP` ioctl. One /dev/videoN device must not support both kinds of overlay.

The V4L2 API distinguishes destructive and non-destructive overlays. A destructive overlay copies captured video images into the video memory of a graphics card. A non-destructive overlay blends video images into a VGA signal or graphics into a video signal. *Video Output Overlays* are always non-destructive.

Destructive overlay support has been removed: with modern GPUs and CPUs this is no longer needed, and it was always a very dangerous feature.

To get the current parameters applications call the `VIDIOC_G_FBUF` ioctl with a pointer to a struct `v4l2_framebuffer` structure. The driver fills all fields of the structure or returns an EINVAL error code when overlays are not supported.

To set the parameters for a *Video Output Overlay*, applications must initialize the `flags` field of a struct `v4l2_framebuffer`. Since the framebuffer is implemented on the TV card all other parameters are determined by the driver. When an application calls `VIDIOC_S_FBUF` with a pointer to this structure, the driver prepares for the overlay and returns the framebuffer parameters as `VIDIOC_G_FBUF` does, or it returns an error code.

To set the parameters for a *Video Capture Overlay* applications must initialize the `flags` field, the `fmt` substructure, and call `VIDIOC_S_FBUF`. Again the driver prepares for the overlay and returns the framebuffer parameters as `VIDIOC_G_FBUF` does, or it returns an error code.

**type v4l2\_framebuffer**

Table 228: struct `v4l2_framebuffer`

<code>_u32</code>	<code>capability</code>		Overlay capability flags set by the driver, see <a href="#">Frame Buffer Capability Flags</a> .
<code>_u32</code>	<code>flags</code>		Overlay control flags set by application and driver, see <a href="#">Frame Buffer Flags</a>

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void *	base		Physical base address of the framebuffer, that is the address of the pixel in the top left corner of the framebuffer. For <a href="#">VIDIOC_S_FBUF</a> this field is no longer supported and the kernel will always set this to NULL. For <i>Video Output Overlays</i> the driver will return a valid base address, so applications can find the corresponding Linux framebuffer device (see <a href="#">Video Output Overlay Interface</a> ). For <i>Video Capture Overlays</i> this field will always be NULL.
struct	fmt		Layout of the frame buffer.
	__u32	width	Width of the frame buffer in pixels.
	__u32	height	Height of the frame buffer in pixels.
	__u32	pixelformat	The pixel format of the framebuffer.
			For <i>non-destructive Video Overlays</i> this field only defines a format for the struct <a href="#">v4l2_window</a> chromakey field.
			For <i>Video Output Overlays</i> the driver must return a valid format.
			Usually this is an RGB format (for example <a href="#">V4L2_PIX_FMT_RGB565</a> ) but YUV formats (only packed YUV formats when chroma keying is used, not including <a href="#">V4L2_PIX_FMT_YUYV</a> and <a href="#">V4L2_PIX_FMT_UYVY</a> ) and the <a href="#">V4L2_PIX_FMT_PAL8</a> format are also permitted. The behavior of the driver when an application requests a compressed format is undefined. See <a href="#">Image Formats</a> for information on pixel formats.
	enum <a href="#">v4l2_field</a>	field	Drivers and applications shall ignore this field. If applicable, the field order is selected with the <a href="#">VIDIOC_S_FMT</a> ioctl, using the field field of struct <a href="#">v4l2_window</a> .
	__u32	bytesperline	Distance in bytes between the left-most pixels in two adjacent lines.

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<p>This field is irrelevant to <i>non-destructive Video Overlays</i>. For <i>Video Output Overlays</i> the driver must return a valid value.</p> <p>Video hardware may access padding bytes, therefore they must reside in accessible memory. Consider for example the case where padding bytes after the last line of an image cross a system page boundary. Capture devices may write padding bytes, the value is undefined. Output devices ignore the contents of padding bytes.</p> <p>When the image format is planar the <code>bytesperline</code> value applies to the first plane and is divided by the same factor as the <code>width</code> field for the other planes. For example the Cb and Cr planes of a YUV 4:2:0 image have half as many padding bytes following each line as the Y plane. To avoid ambiguities drivers must return a <code>bytesperline</code> value rounded up to a multiple of the scale factor.</p>			
	<code>_u32</code>	<code>sizeimage</code>	<p>This field is irrelevant to <i>non-destructive Video Overlays</i>. For <i>Video Output Overlays</i> the driver must return a valid format.</p> <p>Together with <code>base</code> it defines the framebuffer memory accessible by the driver.</p>
	<code>enum v4l2_colorspace</code>	<code>colorspace</code>	<p>This information supplements the <code>pixelformat</code> and must be set by the driver, see <a href="#">Colorspaces</a>.</p>
	<code>_u32</code>	<code>priv</code>	Reserved. Drivers and applications must set this field to zero.

Table 229: Frame Buffer Capability Flags

V4L2_FBUF_CAP_EXTERNOVERLAY	0x0001	The device is capable of non-destructive overlays. When the driver clears this flag, only destructive overlays are supported. There are no drivers yet which support both destructive and non-destructive overlays. Video Output Overlays are in practice always non-destructive.
V4L2_FBUF_CAP_CHROMAKEY	0x0002	The device supports clipping by chroma-keying the images. That is, image pixels replace pixels in the VGA or video signal only where the latter assume a certain color. Chroma-keying makes no sense for destructive overlays.
V4L2_FBUF_CAP_LIST_CLIPPING	0x0004	The device supports clipping using a list of clip rectangles. Note that this is no longer supported.
V4L2_FBUF_CAP_BITMAP_CLIPPING	0x0008	The device supports clipping using a bit mask. Note that this is no longer supported.
V4L2_FBUF_CAP_LOCAL_ALPHA	0x0010	The device supports clipping/blending using the alpha channel of the framebuffer or VGA signal. Alpha blending makes no sense for destructive overlays.
V4L2_FBUF_CAP_GLOBAL_ALPHA	0x0020	The device supports alpha blending using a global alpha value. Alpha blending makes no sense for destructive overlays.
V4L2_FBUF_CAP_LOCAL_INV_ALPHA	0x0040	The device supports clipping/blending using the inverted alpha channel of the framebuffer or VGA signal. Alpha blending makes no sense for destructive overlays.
V4L2_FBUF_CAP_SRC_CHROMAKEY	0x0080	The device supports Source Chroma-keying. Video pixels with the chroma-key colors are replaced by framebuffer pixels, which is exactly opposite of V4L2_FBUF_CAP_CHROMAKEY

Table 230: Frame Buffer Flags

V4L2_FBUF_FLAG_PRIMARY	0x0001	The framebuffer is the primary graphics surface. In other words, the overlay is destructive. This flag is typically set by any driver that doesn't have the V4L2_FBUF_CAP_EXTERNOVERLAY capability and it is cleared otherwise.
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Table 230 – continued from previous page

V4L2_FBUF_FLAG_OVERLAY	0x0002	If this flag is set for a video capture device, then the driver will set the initial overlay size to cover the full framebuffer size, otherwise the existing overlay size (as set by <a href="#">VIDIOC_S_FMT</a> ) will be used. Only one video capture driver (btv) supports this flag. The use of this flag for capture devices is deprecated. There is no way to detect which drivers support this flag, so the only reliable method of setting the overlay size is through <a href="#">VIDIOC_S_FMT</a> . If this flag is set for a video output device, then the video output overlay window is relative to the top-left corner of the framebuffer and restricted to the size of the framebuffer. If it is cleared, then the video output overlay window is relative to the video output display.
V4L2_FBUF_FLAG_CHROMAKEY	0x0004	Use chroma-keying. The chroma-key color is determined by the chromakey field of struct <a href="#">v4l2_window</a> and negotiated with the <a href="#">VIDIOC_S_FMT</a> ioctl, see <a href="#">Video Overlay Interface</a> and <a href="#">Video Output Overlay Interface</a> .
There are no flags to enable clipping using a list of clip rectangles or a bitmap. These methods are negotiated with the <a href="#">VIDIOC_S_FMT</a> ioctl, see <a href="#">Video Overlay Interface</a> and <a href="#">Video Output Overlay Interface</a> .		
V4L2_FBUF_FLAG_LOCAL_ALPHA	0x0008	Use the alpha channel of the framebuffer to clip or blend framebuffer pixels with video images. The blend function is: $\text{output} = \text{framebuffer pixel} * \text{alpha} + \text{video pixel} * (1 - \text{alpha})$ . The actual alpha depth depends on the framebuffer pixel format.
V4L2_FBUF_FLAG_GLOBAL_ALPHA	0x0010	Use a global alpha value to blend the framebuffer with video images. The blend function is: $\text{output} = (\text{framebuffer pixel} * \text{alpha} + \text{video pixel} * (255 - \text{alpha})) / 255$ . The alpha value is determined by the <code>global_alpha</code> field of struct <a href="#">v4l2_window</a> and negotiated with the <a href="#">VIDIOC_S_FMT</a> ioctl, see <a href="#">Video Overlay Interface</a> and <a href="#">Video Output Overlay Interface</a> .

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V4L2_FBUF_FLAG_LOCAL_INV_ALPHA	0x0020	Like V4L2_FBUF_FLAG_LOCAL_ALPHA, use the alpha channel of the framebuffer to clip or blend framebuffer pixels with video images, but with an inverted alpha value. The blend function is: output = framebuffer pixel * (1 - alpha) + video pixel * alpha. The actual alpha depth depends on the framebuffer pixel format.
V4L2_FBUF_FLAG_SRC_CHROMAKEY	0x0040	Use source chroma-keying. The source chroma-key color is determined by the chromakey field of struct <i>v4l2_window</i> and negotiated with the VIDIOC_S_FMT ioctl, see <i>Video Overlay Interface</i> and <i>Video Output Overlay Interface</i> . Both chroma-keying are mutual exclusive to each other, so same chromakey field of struct <i>v4l2_window</i> is being used.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the *Generic Error Codes* chapter.

### EPERM

`VIDIOC_S_FBUF` can only be called by a privileged user to negotiate the parameters for a destructive overlay.

### EINVAL

The `VIDIOC_S_FBUF` parameters are unsuitable.

## ioctl VIDIOC\_G\_FMT, VIDIOC\_S\_FMT, VIDIOC\_TRY\_FMT

### Name

`VIDIOC_G_FMT` - `VIDIOC_S_FMT` - `VIDIOC_TRY_FMT` - Get or set the data format, try a format

### Synopsis

#### VIDIOC\_G\_FMT

```
int ioctl(int fd, VIDIOC_G_FMT, struct v4l2_format *argp)
```

#### VIDIOC\_S\_FMT

```
int ioctl(int fd, VIDIOC_S_FMT, struct v4l2_format *argp)
```

#### VIDIOC\_TRY\_FMT

```
int ioctl(int fd, VIDIOC_TRY_FMT, struct v4l2_format *argp)
```

## Arguments

### **fd**

File descriptor returned by `open()`.

### **argp**

Pointer to struct `v4l2_format`.

## Description

These ioctls are used to negotiate the format of data (typically image format) exchanged between driver and application.

To query the current parameters applications set the type field of a struct `v4l2_format` to the respective buffer (stream) type. For example video capture devices use `V4L2_BUF_TYPE_VIDEO_CAPTURE` or `V4L2_BUF_TYPE_VIDEO_CAPTURE_MPLANE`. When the application calls the `VIDIOC_G_FMT` ioctl with a pointer to this structure the driver fills the respective member of the `fmt` union. In case of video capture devices that is either the struct `v4l2_pix_format` `pix` or the struct `v4l2_pix_format_mplane` `pix_mp` member. When the requested buffer type is not supported drivers return an `EINVAL` error code.

To change the current format parameters applications initialize the type field and all fields of the respective `fmt` union member. For details see the documentation of the various devices types in [Interfaces](#). Good practice is to query the current parameters first, and to modify only those parameters not suitable for the application. When the application calls the `VIDIOC_S_FMT` ioctl with a pointer to a struct `v4l2_format` structure the driver checks and adjusts the parameters against hardware abilities. Drivers should not return an error code unless the type field is invalid, this is a mechanism to fathom device capabilities and to approach parameters acceptable for both the application and driver. On success the driver may program the hardware, allocate resources and generally prepare for data exchange. Finally the `VIDIOC_S_FMT` ioctl returns the current format parameters as `VIDIOC_G_FMT` does. Very simple, inflexible devices may even ignore all input and always return the default parameters. However all V4L2 devices exchanging data with the application must implement the `VIDIOC_G_FMT` and `VIDIOC_S_FMT` ioctl. When the requested buffer type is not supported drivers return an `EINVAL` error code on a `VIDIOC_S_FMT` attempt. When I/O is already in progress or the resource is not available for other reasons drivers return the `EBUSY` error code.

The `VIDIOC_TRY_FMT` ioctl is equivalent to `VIDIOC_S_FMT` with one exception: it does not change driver state. It can also be called at any time, never returning `EBUSY`. This function is provided to negotiate parameters, to learn about hardware limitations, without disabling I/O or possibly time consuming hardware preparations. Although strongly recommended drivers are not required to implement this ioctl.

The format as returned by `VIDIOC_TRY_FMT` must be identical to what `VIDIOC_S_FMT` returns for the same input or output.

type `v4l2_format`

Table 231: struct v4l2\_format

<code>_u32</code>	<code>type</code>	Type of the data stream, see <a href="#"><code>v4l2_buf_type</code></a> .
<code>union {</code>	<code>fmt</code>	
<code>struct v4l2_pix_format</code>	<code>pix</code>	Definition of an image format, see <a href="#"><i>Image Formats</i></a> , used by video capture and output devices.
<code>struct v4l2_pix_format_mpPlane</code>	<code>pix_mp</code>	Definition of an image format, see <a href="#"><i>Image Formats</i></a> , used by video capture and output devices that support the <i>multi-planar version of the API</i> .
<code>struct v4l2_window</code>	<code>win</code>	Definition of an overlaid image, see <a href="#"><i>Video Overlay Interface</i></a> , used by video overlay devices.
<code>struct v4l2_vbi_format</code>	<code>vbi</code>	Raw VBI capture or output parameters. This is discussed in more detail in <a href="#"><i>Raw VBI Data Interface</i></a> . Used by raw VBI capture and output devices.
<code>struct v4l2_sliced_vbi_format</code>	<code>sliced</code>	Sliced VBI capture or output parameters. See <a href="#"><i>Sliced VBI Data Interface</i></a> for details. Used by sliced VBI capture and output devices.
<code>struct v4l2_sdr_format</code>	<code>sdr</code>	Definition of a data format, see <a href="#"><i>Image Formats</i></a> , used by SDR capture and output devices.
<code>struct v4l2_meta_format</code>	<code>meta</code>	Definition of a metadata format, see <a href="#"><i>Metadata Formats</i></a> , used by metadata capture devices.
<code>_u8</code>	<code>raw_data[200]</code>	Place holder for future extensions.
<code>}</code>		

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### EINVAL

The struct `v4l2_format` type field is invalid or the requested buffer type not supported.

### EBUSY

The device is busy and cannot change the format. This could be because or the device is streaming or buffers are allocated or queued to the driver. Relevant for `VIDIOC_S_FMT` only.

## ioctl VIDIOC\_G\_FREQUENCY, VIDIOC\_S\_FREQUENCY

### Name

`VIDIOC_G_FREQUENCY` - `VIDIOC_S_FREQUENCY` - Get or set tuner or modulator radio frequency

### Synopsis

#### `VIDIOC_G_FREQUENCY`

```
int ioctl(int fd, VIDIOC_G_FREQUENCY, struct v4l2_frequency *argp)
```

#### `VIDIOC_S_FREQUENCY`

```
int ioctl(int fd, VIDIOC_S_FREQUENCY, const struct v4l2_frequency *argp)
```

### Arguments

#### `fd`

File descriptor returned by `open()`.

#### `argp`

Pointer to struct `v4l2_frequency`.

### Description

To get the current tuner or modulator radio frequency applications set the `tuner` field of a struct `v4l2_frequency` to the respective tuner or modulator number (only input devices have tuners, only output devices have modulators), zero out the `reserved` array and call the `VIDIOC_G_FREQUENCY` ioctl with a pointer to this structure. The driver stores the current frequency in the `frequency` field.

To change the current tuner or modulator radio frequency applications initialize the `tuner`, `type` and `frequency` fields, and the `reserved` array of a struct `v4l2_frequency` and call the `VIDIOC_S_FREQUENCY` ioctl with a pointer to this structure. When the requested frequency is not possible the driver assumes the closest possible value. However `VIDIOC_S_FREQUENCY` is a write-only ioctl, it does not return the actual new frequency.

type **v4l2\_frequency**

Table 232: struct v4l2\_frequency

__u32	tuner	The tuner or modulator index number. This is the same value as in the struct <i>v4l2_input</i> tuner field and the struct <i>v4l2_tuner</i> index field, or the struct <i>v4l2_output</i> modulator field and the struct <i>v4l2_modulator</i> index field.
__u32	type	The tuner type. This is the same value as in the struct <i>v4l2_tuner</i> type field. The type must be set to V4L2_TUNER_RADIO for /dev/radioX device nodes, and to V4L2_TUNER_ANALOG_TV for all others. Set this field to V4L2_TUNER_RADIO for modulators (currently only radio modulators are supported). See <i>v4l2_tuner_type</i>
__u32	frequency	Tuning frequency in units of 62.5 kHz, or if the struct <i>v4l2_tuner</i> or struct <i>v4l2_modulator</i> capability flag V4L2_TUNER_CAP_LOW is set, in units of 62.5 Hz. A 1 Hz unit is used when the capability flag V4L2_TUNER_CAP_1HZ is set.
__u32	reserved[8]	Reserved for future extensions. Drivers and applications must set the array to zero.

## Return Value

On success 0 is returned, on error -1 and the *errno* variable is set appropriately. The generic error codes are described at the *Generic Error Codes* chapter.

### EINVAL

The tuner index is out of bounds or the value in the type field is wrong.

### EBUSY

A hardware seek is in progress.

## ioctl VIDIOC\_G\_INPUT, VIDIOC\_S\_INPUT

### Name

VIDIOC\_G\_INPUT - VIDIOC\_S\_INPUT - Query or select the current video input

## Synopsis

### **VIDIOC\_G\_INPUT**

```
int ioctl(int fd, VIDIOC_G_INPUT, int *argp)
```

### **VIDIOC\_S\_INPUT**

```
int ioctl(int fd, VIDIOC_S_INPUT, int *argp)
```

## Arguments

### **fd**

File descriptor returned by [open\(\)](#).

### **argp**

Pointer an integer with input index.

## Description

To query the current video input applications call the [\*\*VIDIOC\\_G\\_INPUT\*\*](#) ioctl with a pointer to an integer where the driver stores the number of the input, as in the struct [\*v4l2\\_input\*](#) index field. This ioctl will fail only when there are no video inputs, returning EINVAL.

To select a video input applications store the number of the desired input in an integer and call the [\*\*VIDIOC\\_S\\_INPUT\*\*](#) ioctl with a pointer to this integer. Side effects are possible. For example inputs may support different video standards, so the driver may implicitly switch the current standard. Because of these possible side effects applications must select an input before querying or negotiating any other parameters.

Information about video inputs is available using the [\*ioctl VIDIOC\\_ENUMINPUT\*](#) ioctl.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### **EINVAL**

The number of the video input is out of bounds.

## **ioctl VIDIOC\_G\_JPEGCOMP, VIDIOC\_S\_JPEGCOMP**

### Name

VIDIOC\_G\_JPEGCOMP - VIDIOC\_S\_JPEGCOMP

## Synopsis

### `VIDIOC_G_JPEGCOMP`

```
int ioctl(int fd, VIDIOC_G_JPEGCOMP, v4l2_jpegcompression *argp)
```

### `VIDIOC_S_JPEGCOMP`

```
int ioctl(int fd, VIDIOC_S_JPEGCOMP, const v4l2_jpegcompression *argp)
```

## Arguments

### `fd`

File descriptor returned by `open()`.

### `argp`

Pointer to struct `v4l2_jpegcompression`.

## Description

These ioctls are **deprecated**. New drivers and applications should use *JPEG class controls* for image quality and JPEG markers control.

[to do]

Ronald Bultje elaborates:

APP is some application-specific information. The application can set it itself, and it'll be stored in the JPEG-encoded fields (eg; interlacing information for in an AVI or so). COM is the same, but it's comments, like 'encoded by me' or so.

`jpeg_markers` describes whether the huffman tables, quantization tables and the restart interval information (all JPEG-specific stuff) should be stored in the JPEG-encoded fields. These define how the JPEG field is encoded. If you omit them, applications assume you've used standard encoding. You usually do want to add them.

### type `v4l2_jpegcompression`

Table 233: struct `v4l2_jpegcompression`

int	<code>quality</code>	Deprecated. If <code>V4L2_CID_JPEG_COMPRESSION_QUALITY</code> control is exposed by a driver applications should use it instead and ignore this field.
int	<code>APPn</code>	
int	<code>APP_len</code>	
char	<code>APP_data[60]</code>	
int	<code>COM_len</code>	
char	<code>COM_data[60]</code>	
<code>_u32</code>	<code>jpeg_markers</code>	See <i>JPEG Markers Flags</i> . Deprecated. If <code>V4L2_CID_JPEG_ACTIVE_MARKER</code> control is exposed by a driver applications should use it instead and ignore this field.

Table 234: JPEG Markers Flags

V4L2_JPEG_MARKER_DHT	(1<<3)	Define Huffman Tables
V4L2_JPEG_MARKER_DQT	(1<<4)	Define Quantization Tables
V4L2_JPEG_MARKER_DRI	(1<<5)	Define Restart Interval
V4L2_JPEG_MARKER_COM	(1<<6)	Comment segment
V4L2_JPEG_MARKER_APP	(1<<7)	App segment, driver will always use APP0

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## ioctl VIDIOC\_G\_MODULATOR, VIDIOC\_S\_MODULATOR

### Name

`VIDIOC_G_MODULATOR` - `VIDIOC_S_MODULATOR` - Get or set modulator attributes

### Synopsis

#### `VIDIOC_G_MODULATOR`

```
int ioctl(int fd, VIDIOC_G_MODULATOR, struct v4l2_modulator *argp)
```

#### `VIDIOC_S_MODULATOR`

```
int ioctl(int fd, VIDIOC_S_MODULATOR, const struct v4l2_modulator *argp)
```

### Arguments

#### `fd`

File descriptor returned by `open()`.

#### `argp`

Pointer to struct `v4l2_modulator`.

### Description

To query the attributes of a modulator applications initialize the `index` field and zero out the `reserved` array of a struct `v4l2_modulator` and call the `VIDIOC_G_MODULATOR` ioctl with a pointer to this structure. Drivers fill the rest of the structure or return an EINVAL error code when the index is out of bounds. To enumerate all modulators applications shall begin at index zero, incrementing by one until the driver returns EINVAL.

Modulators have two writable properties, an audio modulation set and the radio frequency. To change the modulated audio subprograms, applications initialize the `index` and `txsubchans` fields and the `reserved` array and call the `VIDIOC_S_MODULATOR` ioctl. Drivers may choose a

different audio modulation if the request cannot be satisfied. However this is a write-only ioctl, it does not return the actual audio modulation selected.

*SDR* specific modulator types are `V4L2_TUNER_SDR` and `V4L2_TUNER_RF`. For SDR devices `txsubchans` field must be initialized to zero. The term 'modulator' means SDR transmitter in this context.

To change the radio frequency the `VIDIOC_S_FREQUENCY` ioctl is available.

type `v4l2_modulator`

Table 235: struct `v4l2_modulator`

<code>_u32</code>	<code>index</code>	Identifies the modulator, set by the application.
<code>_u8</code>	<code>name[32]</code>	Name of the modulator, a NUL-terminated ASCII string. This information is intended for the user.
<code>_u32</code>	<code>capability</code>	Modulator capability flags. No flags are defined for this field, the tuner flags in struct <code>v4l2_tuner</code> are used accordingly. The audio flags indicate the ability to encode audio subprograms. They will <i>not</i> change for example with the current video standard.
<code>_u32</code>	<code>rangelow</code>	The lowest tunable frequency in units of 62.5 KHz, or if the capability flag <code>V4L2_TUNER_CAP_LOW</code> is set, in units of 62.5 Hz, or if the capability flag <code>V4L2_TUNER_CAP_1HZ</code> is set, in units of 1 Hz.
<code>_u32</code>	<code>rangehigh</code>	The highest tunable frequency in units of 62.5 KHz, or if the capability flag <code>V4L2_TUNER_CAP_LOW</code> is set, in units of 62.5 Hz, or if the capability flag <code>V4L2_TUNER_CAP_1HZ</code> is set, in units of 1 Hz.
<code>_u32</code>	<code>txsubchans</code>	With this field applications can determine how audio subcarriers shall be modulated. It contains a set of flags as defined in <a href="#">Modulator Audio Transmission Flags</a> .
<b>Note:</b> The tuner <code>rxsubchans</code> flags are reused, but the semantics are different. Video output devices are assumed to have an analog or PCM audio input with 1-3 channels. The <code>txsubchans</code> flags select one or more channels for modulation, together with some audio subprogram indicator, for example, a stereo pilot tone.		
<code>_u32</code>	<code>type</code>	Type of the modulator, see <a href="#">v4l2_tuner_type</a> .
<code>_u32</code>	<code>reserved[3]</code>	Reserved for future extensions. Drivers and applications must set the array to zero.

Table 236: Modulator Audio Transmission Flags

<code>V4L2_TUNER_SUB_MONO</code>	0x0001	Modulate channel 1 as mono audio, when the input has more channels, a down-mix of channel 1 and 2. This flag does not combine with <code>V4L2_TUNER_SUB_STEREO</code> or <code>V4L2_TUNER_SUB_LANG1</code> .
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Table 236 – continued from previous page

V4L2_TUNER_SUB_STEREO	0x0002	Modulate channel 1 and 2 as left and right channel of a stereo audio signal. When the input has only one channel or two channels and V4L2_TUNER_SUB_SAP is also set, channel 1 is encoded as left and right channel. This flag does not combine with V4L2_TUNER_SUB_MONO or V4L2_TUNER_SUB_LANG1. When the driver does not support stereo audio it shall fall back to mono.
V4L2_TUNER_SUB_LANG1	0x0008	Modulate channel 1 and 2 as primary and secondary language of a bilingual audio signal. When the input has only one channel it is used for both languages. It is not possible to encode the primary or secondary language only. This flag does not combine with V4L2_TUNER_SUB_MONO, V4L2_TUNER_SUB_STEREO or V4L2_TUNER_SUB_SAP. If the hardware does not support the respective audio matrix, or the current video standard does not permit bilingual audio the <a href="#">VIDIOC_S_MODULATOR</a> ioctl shall return an EINVAL error code and the driver shall fall back to mono or stereo mode.
V4L2_TUNER_SUB_LANG2	0x0004	Same effect as V4L2_TUNER_SUB_SAP.
V4L2_TUNER_SUB_SAP	0x0004	When combined with V4L2_TUNER_SUB_MONO the first channel is encoded as mono audio, the last channel as Second Audio Program. When the input has only one channel it is used for both audio tracks. When the input has three channels the mono track is a down-mix of channel 1 and 2. When combined with V4L2_TUNER_SUB_STEREO channel 1 and 2 are encoded as left and right stereo audio, channel 3 as Second Audio Program. When the input has only two channels, the first is encoded as left and right channel and the second as SAP. When the input has only one channel it is used for all audio tracks. It is not possible to encode a Second Audio Program only. This flag must combine with V4L2_TUNER_SUB_MONO or V4L2_TUNER_SUB_STEREO. If the hardware does not support the respective audio matrix, or the current video standard does not permit SAP the <a href="#">VIDIOC_S_MODULATOR</a> ioctl shall return an EINVAL error code and driver shall fall back to mono or stereo mode.
V4L2_TUNER_SUB_RDS	0x0010	Enable the RDS encoder for a radio FM transmitter.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### EINVAL

The struct `v4l2_modulator` index is out of bounds.

## ioctl VIDIOC\_G\_OUTPUT, VIDIOC\_S\_OUTPUT

### Name

`VIDIOC_G_OUTPUT` - `VIDIOC_S_OUTPUT` - Query or select the current video output

### Synopsis

#### `VIDIOC_G_OUTPUT`

```
int ioctl(int fd, VIDIOC_G_OUTPUT, int *argp)
```

#### `VIDIOC_S_OUTPUT`

```
int ioctl(int fd, VIDIOC_S_OUTPUT, int *argp)
```

### Arguments

#### `fd`

File descriptor returned by [`open\(\)`](#).

#### `argp`

Pointer to an integer with output index.

### Description

To query the current video output applications call the `VIDIOC_G_OUTPUT` ioctl with a pointer to an integer where the driver stores the number of the output, as in the struct `v4l2_output` index field. This ioctl will fail only when there are no video outputs, returning the `EINVAL` error code.

To select a video output applications store the number of the desired output in an integer and call the `VIDIOC_S_OUTPUT` ioctl with a pointer to this integer. Side effects are possible. For example outputs may support different video standards, so the driver may implicitly switch the current standard. Because of these possible side effects applications must select an output before querying or negotiating any other parameters.

Information about video outputs is available using the `ioctl VIDIOC_ENUMOUTPUT` ioctl.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### EINVAL

The number of the video output is out of bounds, or there are no video outputs at all.

## ioctl VIDIOC\_G\_PARM, VIDIOC\_S\_PARM

### Name

`VIDIOC_G_PARM` - `VIDIOC_S_PARM` - Get or set streaming parameters

### Synopsis

#### `VIDIOC_G_PARM`

```
int ioctl(int fd, VIDIOC_G_PARM, v4l2_streamparm *argp)
```

#### `VIDIOC_S_PARM`

```
int ioctl(int fd, VIDIOC_S_PARM, v4l2_streamparm *argp)
```

### Arguments

#### `fd`

File descriptor returned by [`open\(\)`](#).

#### `argp`

Pointer to struct [`v4l2\_streamparm`](#).

### Description

Applications can request a different frame interval. The capture or output device will be reconfigured to support the requested frame interval if possible. Optionally drivers may choose to skip or repeat frames to achieve the requested frame interval.

For stateful encoders (see [Memory-to-Memory Stateful Video Encoder Interface](#)) this represents the frame interval that is typically embedded in the encoded video stream.

Changing the frame interval shall never change the format. Changing the format, on the other hand, may change the frame interval.

Further these ioctls can be used to determine the number of buffers used internally by a driver in read/write mode. For implications see the section discussing the [`read\(\)`](#) function.

To get and set the streaming parameters applications call the `VIDIOC_G_PARM` and `VIDIOC_S_PARM` ioctl, respectively. They take a pointer to a struct [`v4l2\_streamparm`](#) which contains a union holding separate parameters for input and output devices.

type **v4l2\_streamparm**

Table 237: struct v4l2\_streamparm

<code>_u32</code>	<code>type</code>	The buffer (stream) type, same as struct <code>v4l2_format</code> type, set by the application. See <code>v4l2_buf_type</code> .
<code>union {</code>	<code>parm</code>	
<code>struct</code> <code>v4l2_captureparam</code>	<code>capture</code>	Parameters for capture devices, used when type is <code>V4L2_BUF_TYPE_VIDEO_CAPTURE</code> or <code>V4L2_BUF_TYPE_VIDEO_CAPTURE_MPLANE</code> .
<code>struct</code> <code>v4l2_outputparam</code>	<code>output</code>	Parameters for output devices, used when type is <code>V4L2_BUF_TYPE_VIDEO_OUTPUT</code> or <code>V4L2_BUF_TYPE_VIDEO_OUTPUT_MPLANE</code> .
<code>_u8</code>	<code>raw_data[200]</code>	A place holder for future extensions.
<code>}</code>		

type **v4l2\_captureparam**

Table 238: struct v4l2\_captureparm

<code>_u32</code>	<code>capability</code>	See <a href="#">Streaming Parameters Capabilities</a> .
<code>_u32</code>	<code>capturemode</code>	Set by drivers and applications, see <a href="#">Capture Parameters Flags</a> .
struct <code>v4l2_fract</code>	<code>timeperframe</code>	This is the desired period between successive frames captured by the driver, in seconds.

This will configure the speed at which the video source (e.g. a sensor) generates video frames. If the speed is fixed, then the driver may choose to skip or repeat frames in order to achieve the requested frame rate.

For stateful encoders (see [Memory-to-Memory Stateful Video Encoder Interface](#)) this represents the frame interval that is typically embedded in the encoded video stream.

Applications store here the desired frame period, drivers return the actual frame period. Changing the video standard (also implicitly by switching the video input) may reset this parameter to the nominal frame period. To reset manually applications can just set this field to zero.

Drivers support this function only when they set the `V4L2_CAP_TIMEPERFRAME` flag in the `capability` field.

<code>_u32</code>	<code>extendedmode</code>	Custom (driver specific) streaming parameters. When unused, applications and drivers must set this field to zero. Applications using this field should check the driver name and version, see <a href="#">Querying Capabilities</a> .
<code>_u32</code>	<code>readbuffers</code>	Applications set this field to the desired number of buffers used internally by the driver in <code>read()</code> mode. Drivers return the actual number of buffers. When an application requests zero buffers, drivers should just return the current setting rather than the minimum or an error code. For details see <a href="#">Read/Write</a> .
<code>_u32</code>	<code>reserved[4]</code>	Reserved for future extensions. Drivers and applications must set the array to zero.

type `v4l2_outputparm`

Table 239: struct v4l2\_outputparm

<code>_u32</code>	<code>capability</code>	See <a href="#">Streaming Parameters Capabilities</a> .
<code>_u32</code>	<code>outputmode</code>	Set by drivers and applications, see <a href="#">Capture Parameters Flags</a> .
struct <code>v4l2_fract</code>	<code>timeperframe</code>	This is the desired period between successive frames output by the driver, in seconds.

The field is intended to repeat frames on the driver side in `write()` mode (in streaming mode timestamps can be used to throttle the output), saving I/O bandwidth.

For stateful encoders (see [Memory-to-Memory Stateful Video Encoder Interface](#)) this represents the frame interval that is typically embedded in the encoded video stream and it provides a hint to the encoder of the speed at which raw frames are queued up to the encoder.

Applications store here the desired frame period, drivers return the actual frame period. Changing the video standard (also implicitly by switching the video output) may reset this parameter to the nominal frame period. To reset manually applications can just set this field to zero.

Drivers support this function only when they set the `V4L2_CAP_TIMEPERFRAME` flag in the `capability` field.

<code>_u32</code>	<code>extendedmode</code>	Custom (driver specific) streaming parameters. When unused, applications and drivers must set this field to zero. Applications using this field should check the driver name and version, see <a href="#">Querying Capabilities</a> .
<code>_u32</code>	<code>writebuffers</code>	Applications set this field to the desired number of buffers used internally by the driver in <code>write()</code> mode. Drivers return the actual number of buffers. When an application requests zero buffers, drivers should just return the current setting rather than the minimum or an error code. For details see <a href="#">Read/Write</a> .
<code>_u32</code>	<code>reserved[4]</code>	Reserved for future extensions. Drivers and applications must set the array to zero.

Table 240: Streaming Parameters Capabilities

<code>V4L2_CAP_TIMEPERFRAME</code>	0x1000	The frame period can be modified by setting the <code>timeperframe</code> field.
------------------------------------	--------	--

Table 241: Capture Parameters Flags

V4L2_MODE_HIGHQUALITY	0x0001	<p>High quality imaging mode. High quality mode is intended for still imaging applications. The idea is to get the best possible image quality that the hardware can deliver. It is not defined how the driver writer may achieve that; it will depend on the hardware and the ingenuity of the driver writer. High quality mode is a different mode from the regular motion video capture modes. In high quality mode:</p> <ul style="list-style-type: none"> <li>• The driver may be able to capture higher resolutions than for motion capture.</li> <li>• The driver may support fewer pixel formats than motion capture (eg; true color).</li> <li>• The driver may capture and arithmetically combine multiple successive fields or frames to remove color edge artifacts and reduce the noise in the video data.</li> <li>• The driver may capture images in slices like a scanner in order to handle larger format images than would otherwise be possible.</li> <li>• An image capture operation may be significantly slower than motion capture.</li> <li>• Moving objects in the image might have excessive motion blur.</li> <li>• Capture might only work through the <a href="#">read()</a> call.</li> </ul>
-----------------------	--------	--

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## ioctl VIDIOC\_G\_PRIORITY, VIDIOC\_S\_PRIORITY

### Name

VIDIOC\_G\_PRIORITY - VIDIOC\_S\_PRIORITY - Query or request the access priority associated with a file descriptor

### Synopsis

#### VIDIOC\_G\_PRIORITY

```
int ioctl(int fd, VIDIOC_G_PRIORITY, enum v4l2_priority *argp)
```

#### VIDIOC\_S\_PRIORITY

```
int ioctl(int fd, VIDIOC_S_PRIORITY, const enum v4l2_priority *argp)
```

### Arguments

#### fd

File descriptor returned by `open()`.

#### argp

Pointer to an enum `v4l2_priority` type.

### Description

To query the current access priority applications call the `VIDIOC_G_PRIORITY` ioctl with a pointer to an enum `v4l2_priority` variable where the driver stores the current priority.

To request an access priority applications store the desired priority in an enum `v4l2_priority` variable and call `VIDIOC_S_PRIORITY` ioctl with a pointer to this variable.

type `v4l2_priority`

Table 242: enum v4l2\_priority

V4L2_PRIORITY_UNSET	0	
V4L2_PRIORITY_BACKGROUND	1	Lowest priority, usually applications running in background, for example monitoring VBI transmissions. A proxy application running in user space will be necessary if multiple applications want to read from a device at this priority.
V4L2_PRIORITY_INTERACTIVE	2	
V4L2_PRIORITY_DEFAULT	2	Medium priority, usually applications started and interactively controlled by the user. For example TV viewers, Teletext browsers, or just "panel" applications to change the channel or video controls. This is the default priority unless an application requests another.
V4L2_PRIORITY_RECORD	3	Highest priority. Only one file descriptor can have this priority, it blocks any other fd from changing device properties. Usually applications which must not be interrupted, like video recording.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### EINVAL

The requested priority value is invalid.

### EBUSY

Another application already requested higher priority.

## ioctl VIDIOC\_G\_SELECTION, VIDIOC\_S\_SELECTION

### Name

`VIDIOC_G_SELECTION` - `VIDIOC_S_SELECTION` - Get or set one of the selection rectangles

### Synopsis

#### VIDIOC\_G\_SELECTION

```
int ioctl(int fd, VIDIOC_G_SELECTION, struct v4l2_selection *argp)
```

#### VIDIOC\_S\_SELECTION

```
int ioctl(int fd, VIDIOC_S_SELECTION, struct v4l2_selection *argp)
```

## Arguments

### fd

File descriptor returned by `open()`.

### argp

Pointer to struct `v4l2_selection`.

## Description

The ioctls are used to query and configure selection rectangles.

To query the cropping (composing) rectangle set struct `v4l2_selection` type field to the respective buffer type. The next step is setting the value of struct `v4l2_selection` target field to V4L2\_SEL\_TGT\_CROP (V4L2\_SEL\_TGT\_COMPOSE). Please refer to table [Common selection definitions](#) or [Cropping, composing and scaling -- the SELECTION API](#) for additional targets. The flags and reserved fields of struct `v4l2_selection` are ignored and they must be filled with zeros. The driver fills the rest of the structure or returns EINVAL error code if incorrect buffer type or target was used. If cropping (composing) is not supported then the active rectangle is not mutable and it is always equal to the bounds rectangle. Finally, the struct `v4l2_rect` rectangle is filled with the current cropping (composing) coordinates. The coordinates are expressed in driver-dependent units. The only exception are rectangles for images in raw formats, whose coordinates are always expressed in pixels.

To change the cropping (composing) rectangle set the struct `v4l2_selection` type field to the respective buffer type. The next step is setting the value of struct `v4l2_selection` target to V4L2\_SEL\_TGT\_CROP (V4L2\_SEL\_TGT\_COMPOSE). Please refer to table [Common selection definitions](#) or [Cropping, composing and scaling -- the SELECTION API](#) for additional targets. The struct `v4l2_rect` rectangle need to be set to the desired active area. Field struct `v4l2_selection` reserved is ignored and must be filled with zeros. The driver may adjust coordinates of the requested rectangle. An application may introduce constraints to control rounding behaviour. The struct `v4l2_selection` flags field must be set to one of the following:

- 0 - The driver can adjust the rectangle size freely and shall choose a crop/compose rectangle as close as possible to the requested one.
- V4L2\_SEL\_FLAG\_GE - The driver is not allowed to shrink the rectangle. The original rectangle must lay inside the adjusted one.
- V4L2\_SEL\_FLAG\_LE - The driver is not allowed to enlarge the rectangle. The adjusted rectangle must lay inside the original one.
- V4L2\_SEL\_FLAG\_GE | V4L2\_SEL\_FLAG\_LE - The driver must choose the size exactly the same as in the requested rectangle.

Please refer to [Size adjustments with constraint flags..](#)

The driver may have to adjusts the requested dimensions against hardware limits and other parts as the pipeline, i.e. the bounds given by the capture/output window or TV display. The closest possible values of horizontal and vertical offset and sizes are chosen according to following priority:

1. Satisfy constraints from struct `v4l2_selection` flags.
2. Adjust width, height, left, and top to hardware limits and alignments.

3. Keep center of adjusted rectangle as close as possible to the original one.
4. Keep width and height as close as possible to original ones.
5. Keep horizontal and vertical offset as close as possible to original ones.

On success the struct `v4l2_rect` `r` field contains the adjusted rectangle. When the parameters are unsuitable the application may modify the cropping (composing) or image parameters and repeat the cycle until satisfactory parameters have been negotiated. If constraints flags have to be violated at then ERANGE is returned. The error indicates that *there exist no rectangle* that satisfies the constraints.

Selection targets and flags are documented in *Common selection definitions*.

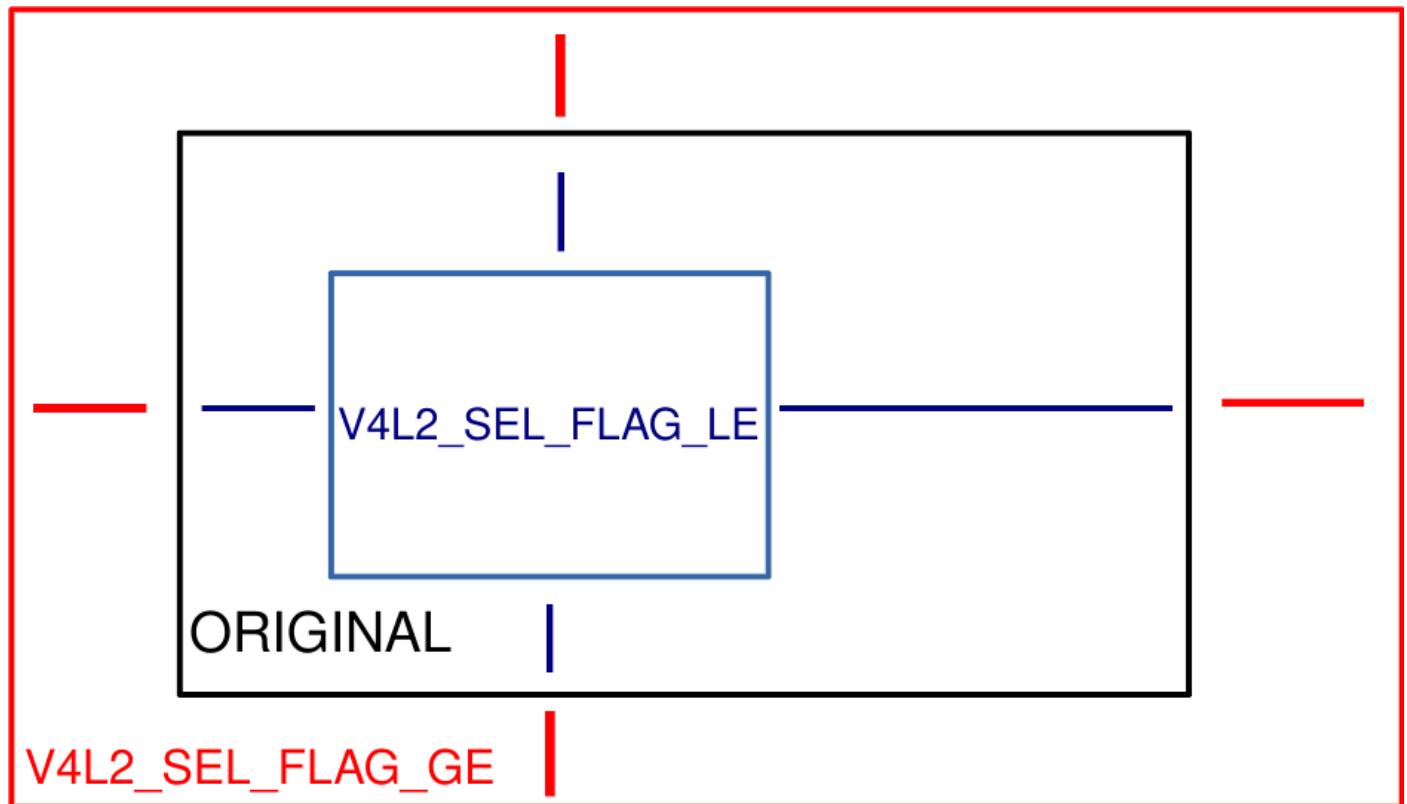


Fig. 18: Size adjustments with constraint flags.  
Behaviour of rectangle adjustment for different constraint flags.

type `v4l2_selection`

Table 243: struct `v4l2_selection`

<code>_u32</code>	<code>type</code>	Type of the buffer (from enum <code>v4l2_buf_type</code> ).
<code>_u32</code>	<code>target</code>	Used to select between <i>cropping and composing rectangles</i> .
<code>_u32</code>	<code>flags</code>	Flags controlling the selection rectangle adjustments, refer to <i>selection flags</i> .
<code>struct v4l2_rect</code>	<code>r</code>	The selection rectangle.
<code>_u32</code>	<code>reserved[9]</code>	Reserved fields for future use. Drivers and applications must zero this array.

---

**Note:** Unfortunately in the case of multiplanar buffer types (V4L2\_BUF\_TYPE\_VIDEO\_CAPTURE\_MPLANE and V4L2\_BUF\_TYPE\_VIDEO\_OUTPUT\_MPLANE) this API was messed up with regards to how the *v4l2\_selection* type field should be filled in. Some drivers only accepted the \_MPLANE buffer type while other drivers only accepted a non-multiplanar buffer type (i.e. without the \_MPLANE at the end).

Starting with kernel 4.13 both variations are allowed.

---

## Return Value

On success 0 is returned, on error -1 and the *errno* variable is set appropriately. The generic error codes are described at the *Generic Error Codes* chapter.

### EINVAL

Given buffer type *type* or the selection target *target* is not supported, or the *flags* argument is not valid.

### ERANGE

It is not possible to adjust struct *v4l2\_rect* *r* rectangle to satisfy all constraints given in the *flags* argument.

### ENODATA

Selection is not supported for this input or output.

### EBUSY

It is not possible to apply change of the selection rectangle at the moment. Usually because streaming is in progress.

## ioctl VIDIOC\_G\_SLICED\_VBI\_CAP

### Name

VIDIOC\_G\_SLICED\_VBI\_CAP - Query sliced VBI capabilities

### Synopsis

#### VIDIOC\_G\_SLICED\_VBI\_CAP

```
int ioctl(int fd, VIDIOC_G_SLICED_VBI_CAP, struct v4l2_sliced_vbi_cap *argp)
```

## Arguments

### fd

File descriptor returned by `open()`.

### argp

Pointer to struct `v4l2_sliced_vbi_cap`.

## Description

To find out which data services are supported by a sliced VBI capture or output device, applications initialize the type field of a struct `v4l2_sliced_vbi_cap`, clear the reserved array and call the `VIDIOC_G_SLICED_VBI_CAP` ioctl. The driver fills in the remaining fields or returns an `EINVAL` error code if the sliced VBI API is unsupported or type is invalid.

---

**Note:** The type field was added, and the ioctl changed from read-only to write-read, in Linux 2.6.19.

---

### type `v4l2_sliced_vbi_cap`

Table 244: struct `v4l2_sliced_vbi_cap`

<code>_u16</code>	<code>service_set</code>	A set of all data services supported by the driver. Equal to the union of all elements of the <code>service_lines</code> array.															
<code>_u16</code>	<code>service_lines[2][24]</code>	Each element of this array contains a set of data services the hardware can look for or insert into a particular scan line. Data services are defined in <i>Sliced VBI services</i> . Array indices map to ITU-R line numbers <sup>1</sup> as follows:															
		<table border="1"> <thead> <tr> <th>Element</th> <th>525 line systems</th> <th>625 line systems</th> </tr> </thead> <tbody> <tr> <td><code>service_lines[0][1]</code></td><td>1</td><td>1</td></tr> <tr> <td><code>service_lines[0][23]</code></td><td>23</td><td>23</td></tr> <tr> <td><code>service_lines[1][1]</code></td><td>264</td><td>314</td></tr> <tr> <td><code>service_lines[1][23]</code></td><td>286</td><td>336</td></tr> </tbody> </table>	Element	525 line systems	625 line systems	<code>service_lines[0][1]</code>	1	1	<code>service_lines[0][23]</code>	23	23	<code>service_lines[1][1]</code>	264	314	<code>service_lines[1][23]</code>	286	336
Element	525 line systems	625 line systems															
<code>service_lines[0][1]</code>	1	1															
<code>service_lines[0][23]</code>	23	23															
<code>service_lines[1][1]</code>	264	314															
<code>service_lines[1][23]</code>	286	336															
		The number of VBI lines the hardware can capture or output per frame, or the number of services it can identify on a given line may be limited. For example on PAL line 16 the hardware may be able to look for a VPS or Teletext signal, but not both at the same time. Applications can learn about these limits using the <code>VIDIOC_S_FMT</code> ioctl as described in <i>Sliced VBI Data Interface</i> .															
		Drivers must set <code>service_lines[0][0]</code> and <code>service_lines[1][0]</code> to zero.															
<code>_u32</code>	<code>type</code>	Type of the data stream, see <code>v4l2_buf_type</code> . Should be <code>V4L2_BUF_TYPE_SLICED_VBI_CAPTURE</code> or <code>V4L2_BUF_TYPE_SLICED_VBI_OUTPUT</code> .															
<code>_u32</code>	<code>reserved[3]</code>	This array is reserved for future extensions. Applications and drivers must set it to zero.															

<sup>1</sup> See also *Figure 4.2. ITU-R 525 line numbering (M/NTSC and M/PAL)* and *Figure 4.3. ITU-R 625 line numbering*.

Table 245: Sliced VBI services

Symbol	Value	Reference	Lines, usually	Payload
V4L2_SLICED_TELETEXT_B (Teletext System B)	0x0001	<a href="#">ETS 300 706, ITU BT.653</a>	PAL/SECAM line 7-22, 320-335 (second field 7-22)	Last 42 of the 45 byte Teletext packet, that is without clock run-in and framing code, lsb first transmitted.
V4L2_SLICED_VPS	0x0400	<a href="#">ETS 300 231</a>	PAL line 16	Byte number 3 to 15 according to Figure 9 of ETS 300 231, lsb first transmitted.
V4L2_SLICED_CAPTION_525	0x1000	<a href="#">CEA 608-E</a>	NTSC line 21, 284 (second field 21)	Two bytes in transmission order, including parity bit, lsb first transmitted.
V4L2_SLICED_WSS_625	0x4000	<a href="#">EN 300 294, ITU BT.1119</a>	PAL/SECAM line 23	See <a href="#">V4L2_SLICED_VBI_CAP_WSS_625 payload</a> below.
V4L2_SLICED_VBI_525	0x1000	Set of services applicable to 525 line systems.		
V4L2_SLICED_VBI_625	0x4401	Set of services applicable to 625 line systems.		

## V4L2\_SLICED\_VBI\_CAP\_WSS\_625 payload

The payload for V4L2\_SLICED\_WSS\_625 is:

Byte	0								1							
Bit	msb				lsb				msb				lsb			
	7	6	5	4	3	2	1	0	x	x	13	12	11	10	9	8

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## EINVAL

The value in the type field is wrong.

## ioctl VIDIOC\_G\_STD, VIDIOC\_S\_STD, VIDIOC\_SUBDEV\_G\_STD, VIDIOC\_SUBDEV\_S\_STD

### Name

`VIDIOC_G_STD` - `VIDIOC_S_STD` - `VIDIOC_SUBDEV_G_STD` - `VIDIOC_SUBDEV_S_STD` - Query or select the video standard of the current input

### Synopsis

#### VIDIOC\_G\_STD

```
int ioctl(int fd, VIDIOC_G_STD, v4l2_std_id *argp)
```

#### VIDIOC\_S\_STD

```
int ioctl(int fd, VIDIOC_S_STD, const v4l2_std_id *argp)
```

#### VIDIOC\_SUBDEV\_G\_STD

```
int ioctl(int fd, VIDIOC_SUBDEV_G_STD, v4l2_std_id *argp)
```

### **VIDIOC\_SUBDEV\_S\_STD**

```
int ioctl(int fd, VIDIOC_SUBDEV_S_STD, const v4l2_std_id *argp)
```

#### **Arguments**

##### **fd**

File descriptor returned by [open\(\)](#).

##### **argp**

Pointer to `v4l2_std_id`.

#### **Description**

To query and select the current video standard applications use the `VIDIOC_G_STD` and `VIDIOC_S_STD` ioctls which take a pointer to a `v4l2_std_id` type as argument. `VIDIOC_G_STD` can return a single flag or a set of flags as in struct `v4l2_standard` field `id`. The flags must be unambiguous such that they appear in only one enumerated struct `v4l2_standard` structure.

`VIDIOC_S_STD` accepts one or more flags, being a write-only ioctl it does not return the actual new standard as `VIDIOC_G_STD` does. When no flags are given or the current input does not support the requested standard the driver returns an `EINVAL` error code. When the standard set is ambiguous drivers may return `EINVAL` or choose any of the requested standards. If the current input or output does not support standard video timings (e.g. if `ioctl VIDIOC_ENUMINPUT` does not set the `V4L2_IN_CAP_STD` flag), then `ENODATA` error code is returned.

Calling `VIDIOC_SUBDEV_S_STD` on a subdev device node that has been registered in read-only mode is not allowed. An error is returned and the `errno` variable is set to `-EPERM`.

#### **Return Value**

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

##### **EINVAL**

The `VIDIOC_S_STD` parameter was unsuitable.

##### **ENODATA**

Standard video timings are not supported for this input or output.

##### **EPERM**

`VIDIOC_SUBDEV_S_STD` has been called on a read-only subdevice.

## ioctl VIDIOC\_G\_TUNER, VIDIOC\_S\_TUNER

### Name

VIDIOC\_G\_TUNER - VIDIOC\_S\_TUNER - Get or set tuner attributes

### Synopsis

#### VIDIOC\_G\_TUNER

```
int ioctl(int fd, VIDIOC_G_TUNER, struct v4l2_tuner *argp)
```

#### VIDIOC\_S\_TUNER

```
int ioctl(int fd, VIDIOC_S_TUNER, const struct v4l2_tuner *argp)
```

### Arguments

#### fd

File descriptor returned by [open\(\)](#).

#### argp

Pointer to struct [v4l2\\_tuner](#).

### Description

To query the attributes of a tuner applications initialize the index field and zero out the reserved array of a struct [v4l2\\_tuner](#) and call the VIDIOC\_G\_TUNER ioctl with a pointer to this structure. Drivers fill the rest of the structure or return an EINVAL error code when the index is out of bounds. To enumerate all tuners applications shall begin at index zero, incrementing by one until the driver returns EINVAL.

Tuners have two writable properties, the audio mode and the radio frequency. To change the audio mode, applications initialize the index, audmode and reserved fields and call the VIDIOC\_S\_TUNER ioctl. This will *not* change the current tuner, which is determined by the current video input. Drivers may choose a different audio mode if the requested mode is invalid or unsupported. Since this is a write-only ioctl, it does not return the actually selected audio mode.

[SDR](#) specific tuner types are V4L2\_TUNER\_SDR and V4L2\_TUNER\_RF. For SDR devices audmode field must be initialized to zero. The term 'tuner' means SDR receiver in this context.

To change the radio frequency the [VIDIOC\\_S\\_FREQUENCY](#) ioctl is available.

type [v4l2\\_tuner](#)

Table 246: struct v4l2\_tuner

<code>_u32</code>	<code>index</code>	Identifies the tuner, set by the application.
continues on next page		

Table 246 – continued from previous page

<code>_u8</code>	<code>name[32]</code>	Name of the tuner, a NUL-terminated ASCII string. This information is intended for the user.	
<code>_u32</code>	<code>type</code>	Type of the tuner, see <a href="#">v4l2_tuner_type</a> .	
<code>_u32</code>	<code>capability</code>	Tuner capability flags, see <a href="#">Tuner and Modulator Capability Flags</a> . Audio flags indicate the ability to decode audio subprograms. They will <i>not</i> change, for example with the current video standard. When the structure refers to a radio tuner the <code>V4L2_TUNER_CAP_LANG1</code> , <code>V4L2_TUNER_CAP_LANG2</code> and <code>V4L2_TUNER_CAP_NORM</code> flags can't be used. If multiple frequency bands are supported, then <code>capability</code> is the union of all <code>capability</code> fields of each struct <a href="#">v4l2_frequency_band</a> .	
<code>_u32</code>	<code>rangelow</code>	The lowest tunable frequency in units of 62.5 kHz, or if the capability flag <code>V4L2_TUNER_CAP_LOW</code> is set, in units of 62.5 Hz, or if the capability flag <code>V4L2_TUNER_CAP_1HZ</code> is set, in units of 1 Hz. If multiple frequency bands are supported, then <code>rangelow</code> is the lowest frequency of all the frequency bands.	
<code>_u32</code>	<code>rangehigh</code>	The highest tunable frequency in units of 62.5 kHz, or if the capability flag <code>V4L2_TUNER_CAP_LOW</code> is set, in units of 62.5 Hz, or if the capability flag <code>V4L2_TUNER_CAP_1HZ</code> is set, in units of 1 Hz. If multiple frequency bands are supported, then <code>rangehigh</code> is the highest frequency of all the frequency bands.	
<code>_u32</code>	<code>rxsubchans</code>	Some tuners or audio decoders can determine the received audio subprograms by analyzing audio carriers, pilot tones or other indicators. To pass this information drivers set flags defined in <a href="#">Tuner Audio Reception Flags</a> in this field. For example:	
		<code>V4L2_TUNER_SUB_MONO</code>	receiving mono audio
		<code>STEREO   SAP</code>	receiving stereo audio and a secondary audio program
		<code>MONO   STEREO</code>	receiving mono or stereo audio, the hardware cannot distinguish
		<code>LANG1   LANG2</code>	receiving bilingual audio
		<code>MONO   STEREO   LANG1   LANG2</code>	receiving mono, stereo or bilingual audio
		When the <code>V4L2_TUNER_CAP_STEREO</code> , <code>_LANG1</code> , <code>_LANG2</code> or <code>_SAP</code> flag is cleared in the <code>capability</code> field, the corresponding <code>V4L2_TUNER_SUB_</code> flag must not be set here. This field is valid only if this is the tuner of the current video input, or when the structure refers to a radio tuner.	

continues on next page

Table 246 – continued from previous page

<code>_u32</code>	<code>audmode</code>	The selected audio mode, see <a href="#">Tuner Audio Modes</a> for valid values. The audio mode does not affect audio subprogram detection, and like a <a href="#">User Controls</a> it does not automatically change unless the requested mode is invalid or unsupported. See <a href="#">Tuner Audio Matrix</a> for possible results when the selected and received audio programs do not match. Currently this is the only field of struct <code>v4l2_tuner</code> applications can change.
<code>_u32</code>	<code>signal</code>	The signal strength if known. Ranging from 0 to 65535. Higher values indicate a better signal.
<code>_s32</code>	<code>afc</code>	Automatic frequency control. When the <code>afc</code> value is negative, the frequency is too low, when positive too high.
<code>_u32</code>	<code>reserved[4]</code>	Reserved for future extensions. Drivers and applications must set the array to zero.

type `v4l2_tuner_type`Table 247: enum `v4l2_tuner_type`

<code>V4L2_TUNER_RADIO</code>	1	Tuner supports radio
<code>V4L2_TUNER_ANALOG_TV</code>	2	Tuner supports analog TV
<code>V4L2_TUNER_SDR</code>	4	Tuner controls the A/D and/or D/A block of a Software Digital Radio (SDR)
<code>V4L2_TUNER_RF</code>	5	Tuner controls the RF part of a Software Digital Radio (SDR)

Table 248: Tuner and Modulator Capability Flags

<code>V4L2_TUNER_CAP_LOW</code>	0x0001	When set, tuning frequencies are expressed in units of 62.5 Hz instead of 62.5 kHz.
<code>V4L2_TUNER_CAP_NORM</code>	0x0002	This is a multi-standard tuner; the video standard can or must be switched. (B/G PAL tuners for example are typically not considered multi-standard because the video standard is automatically determined from the frequency band.) The set of supported video standards is available from the struct <code>v4l2_input</code> pointing to this tuner, see the description of ioctl <code>VIDIOC_ENUMINPUT</code> for details. Only <code>V4L2_TUNER_ANALOG_TV</code> tuners can have this capability.
<code>V4L2_TUNER_CAP_HWSEEK_BOUNDED</code>	0x0004	If set, then this tuner supports the hardware seek functionality where the seek stops when it reaches the end of the frequency range.

continues on next page

Table 248 – continued from previous page

V4L2_TUNER_CAP_HWSEEK_WRAP	0x0008	If set, then this tuner supports the hardware seek functionality where the seek wraps around when it reaches the end of the frequency range.
V4L2_TUNER_CAP_STEREO	0x0010	Stereo audio reception is supported.
V4L2_TUNER_CAP_LANG1	0x0040	Reception of the primary language of a bilingual audio program is supported. Bilingual audio is a feature of two-channel systems, transmitting the primary language monaural on the main audio carrier and a secondary language monaural on a second carrier. Only V4L2_TUNER_ANALOG_TV tuners can have this capability.
V4L2_TUNER_CAP_LANG2	0x0020	Reception of the secondary language of a bilingual audio program is supported. Only V4L2_TUNER_ANALOG_TV tuners can have this capability.
V4L2_TUNER_CAP_SAP	0x0020	Reception of a secondary audio program is supported. This is a feature of the BTSC system which accompanies the NTSC video standard. Two audio carriers are available for mono or stereo transmissions of a primary language, and an independent third carrier for a monaural secondary language. Only V4L2_TUNER_ANALOG_TV tuners can have this capability.
		<b>Note:</b> The V4L2_TUNER_CAP_LANG2 and V4L2_TUNER_CAP_SAP flags are synonyms. V4L2_TUNER_CAP_SAP applies when the tuner supports the V4L2_STD_NTSC_M video standard.
V4L2_TUNER_CAP_RDS	0x0080	RDS capture is supported. This capability is only valid for radio tuners.
V4L2_TUNER_CAP_RDS_BLOCK_IO	0x0100	The RDS data is passed as unparsed RDS blocks.
V4L2_TUNER_CAP_RDS_CONTROLS	0x0200	The RDS data is parsed by the hardware and set via controls.
V4L2_TUNER_CAP_FREQ_BANDS	0x0400	The <a href="#"><i>ioctl VIDIOC_ENUM_FREQ_BANDS</i></a> ioctl can be used to enumerate the available frequency bands.
V4L2_TUNER_CAP_HWSEEK_PROG_LIM	0x0800	The range to search when using the hardware seek functionality is programmable, see <a href="#"><i>ioctl VIDIOC_S_HW_FREQ_SEEK</i></a> for details.

continues on next page

Table 248 – continued from previous page

V4L2_TUNER_CAP_1HZ	0x1000	When set, tuning frequencies are expressed in units of 1 Hz instead of 62.5 kHz.
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Table 249: Tuner Audio Reception Flags

V4L2_TUNER_SUB_MONO	0x0001	The tuner receives a mono audio signal.
V4L2_TUNER_SUB_STEREO	0x0002	The tuner receives a stereo audio signal.
V4L2_TUNER_SUB_LANG1	0x0008	The tuner receives the primary language of a bilingual audio signal. Drivers must clear this flag when the current video standard is V4L2_STD_NTSC_M.
V4L2_TUNER_SUB_LANG2	0x0004	The tuner receives the secondary language of a bilingual audio signal (or a second audio program).
V4L2_TUNER_SUB_SAP	0x0004	The tuner receives a Second Audio Program.  <b>Note:</b> The V4L2_TUNER_SUB_LANG2 and V4L2_TUNER_SUB_SAP flags are synonyms. The V4L2_TUNER_SUB_SAP flag applies when the current video standard is V4L2_STD_NTSC_M.
V4L2_TUNER_SUB_RDS	0x0010	The tuner receives an RDS channel.

Table 250: Tuner Audio Modes

V4L2_TUNER_MODE_MONO	0	Play mono audio. When the tuner receives a stereo signal this a down-mix of the left and right channel. When the tuner receives a bilingual or SAP signal this mode selects the primary language.
V4L2_TUNER_MODE_STEREO	1	Play stereo audio. When the tuner receives bilingual audio it may play different languages on the left and right channel or the primary language is played on both channels. Playing different languages in this mode is deprecated. New drivers should do this only in MODE_LANG1_LANG2. When the tuner receives no stereo signal or does not support stereo reception the driver shall fall back to MODE_MONO.
V4L2_TUNER_MODE_LANG1	3	Play the primary language, mono or stereo. Only V4L2_TUNER_ANALOG_TV tuners support this mode.
V4L2_TUNER_MODE_LANG2	2	Play the secondary language, mono. When the tuner receives no bilingual audio or SAP, or their reception is not supported the driver shall fall back to mono or stereo mode. Only V4L2_TUNER_ANALOG_TV tuners support this mode.
V4L2_TUNER_MODE_SAP	2	Play the Second Audio Program. When the tuner receives no bilingual audio or SAP, or their reception is not supported the driver shall fall back to mono or stereo mode. Only V4L2_TUNER_ANALOG_TV tuners support this mode.  <b>Note:</b> The V4L2_TUNER_MODE_LANG2 and V4L2_TUNER_MODE_SAP are synonyms.
V4L2_TUNER_MODE_LANG1_LANG2	4	Play the primary language on the left channel, the secondary language on the right channel. When the tuner receives no bilingual audio or SAP, it shall fall back to MODE_LANG1 or MODE_MONO. Only V4L2_TUNER_ANALOG_TV tuners support this mode.

Table 251: Tuner Audio Matrix

		Selected V4L2_TUNER_MODE_				
Received V4L2_TUNER	SUB	MONO	STEREO	LANG1	LANG2 = SAP	LANG1_LANG2 <sup>Page 673, 1</sup>
MONO	Mono	Mono/Mono	Mono	Mono	Mono	Mono/Mono
MONO   SAP	Mono	Mono/Mono	Mono	Mono	SAP	Mono/SAP (preferred) or Mono/Mono
STEREO	L+R	L/R	Stereo L/R (preferred) or Mono L+R	Stereo L/R (preferred) or Mono L+R	Stereo L/R (preferred) or Mono L+R	L/R (preferred) or L+R/L+R
STEREO   SAP	L+R	L/R	Stereo L/R (preferred) or Mono L+R	SAP	SAP	L+R/SAP (preferred) or L/R or L+R/L+R
LANG1   LANG2	Language 1	Lang1/Lang2 (deprecated <sup>2</sup> ) or Lang1/Lang1	Language 1	Language 1	Language 2	Lang1/Lang2 (preferred) or Lang1/Lang1

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## EINVAL

The struct `v4l2_tuner` index is out of bounds.

## ioctl VIDIOC\_LOG\_STATUS

### Name

`VIDIOC_LOG_STATUS` - Log driver status information

### Synopsis

#### VIDIOC\_LOG\_STATUS

```
int ioctl(int fd, VIDIOC_LOG_STATUS)
```

### Arguments

#### fd

File descriptor returned by `open()`.

<sup>1</sup> This mode has been added in Linux 2.6.17 and may not be supported by older drivers.

<sup>2</sup> Playback of both languages in MODE\_STEREO is deprecated. In the future drivers should produce only the primary language in this mode. Applications should request MODE\_LANG1\_LANG2 to record both languages or a stereo signal.

## Description

As the video/audio devices become more complicated it becomes harder to debug problems. When this ioctl is called the driver will output the current device status to the kernel log. This is particular useful when dealing with problems like no sound, no video and incorrectly tuned channels. Also many modern devices autodetect video and audio standards and this ioctl will report what the device thinks what the standard is. Mismatches may give an indication where the problem is.

This ioctl is optional and not all drivers support it. It was introduced in Linux 2.6.15.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## ioctl VIDIOC\_OVERLAY

### Name

`VIDIOC_OVERLAY` - Start or stop video overlay

### Synopsis

#### `VIDIOC_OVERLAY`

```
int ioctl(int fd, VIDIOC_OVERLAY, const int *argp)
```

### Arguments

#### `fd`

File descriptor returned by `open()`.

#### `argp`

Pointer to an integer.

## Description

This ioctl is part of the `video overlay` I/O method. Applications call `ioctl VIDIOC_OVERLAY` to start or stop the overlay. It takes a pointer to an integer which must be set to zero by the application to stop overlay, to one to start.

Drivers do not support `ioctl VIDIOC_STREAMON`, `VIDIOC_STREAMOFF` or `VIDIOC_STREAMOFF` with `V4L2_BUF_TYPE_VIDEO_OVERLAY`.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### EINVAL

The overlay parameters have not been set up. See [Video Overlay Interface](#) for the necessary steps.

## `ioctl VIDIOC_PREPARE_BUF`

### Name

`VIDIOC_PREPARE_BUF` - Prepare a buffer for I/O

### Synopsis

#### `VIDIOC_PREPARE_BUF`

```
int ioctl(int fd, VIDIOC_PREPARE_BUF, struct v4l2_buffer *argp)
```

### Arguments

#### `fd`

File descriptor returned by [open\(\)](#).

#### `argp`

Pointer to struct [`v4l2\_buffer`](#).

### Description

Applications can optionally call the `ioctl VIDIOC_PREPARE_BUF` ioctl to pass ownership of the buffer to the driver before actually enqueueing it, using the `VIDIOC_QBUF` ioctl, and to prepare it for future I/O. Such preparations may include cache invalidation or cleaning. Performing them in advance saves time during the actual I/O.

The struct `v4l2_buffer` structure is specified in [Buffers](#).

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### EBUSY

File I/O is in progress.

### EINVAL

The buffer type is not supported, or the index is out of bounds, or no buffers have been allocated yet, or the userptr or length are invalid.

### ioctl VIDIOC\_QBUF, VIDIOC\_DQBUF

#### Name

VIDIOC\_QBUF - VIDIOC\_DQBUF - Exchange a buffer with the driver

#### Synopsis

##### VIDIOC\_QBUF

```
int ioctl(int fd, VIDIOC_QBUF, struct v4l2_buffer *argp)
```

##### VIDIOC\_DQBUF

```
int ioctl(int fd, VIDIOC_DQBUF, struct v4l2_buffer *argp)
```

#### Arguments

##### fd

File descriptor returned by [open\(\)](#).

##### argp

Pointer to struct [v4l2\\_buffer](#).

#### Description

Applications call the VIDIOC\_QBUF ioctl to enqueue an empty (capturing) or filled (output) buffer in the driver's incoming queue. The semantics depend on the selected I/O method.

To enqueue a buffer applications set the `type` field of a struct [v4l2\\_buffer](#) to the same buffer type as was previously used with struct [v4l2\\_format](#) type and struct [v4l2\\_requestbuffers](#) type. Applications must also set the `index` field. Valid index numbers range from zero to the number of buffers allocated with [ioctl VIDIOC\\_REQBUFS](#) (struct [v4l2\\_requestbuffers](#) `count`) minus one. The contents of the struct [v4l2\\_buffer](#) returned by a [ioctl VIDIOC\\_QUERYBUF](#) ioctl will do as well. When the buffer is intended for output (`type` is `V4L2_BUF_TYPE_VIDEO_OUTPUT`, `V4L2_BUF_TYPE_VIDEO_OUTPUT_MPLANE`, or `V4L2_BUF_TYPE_VBI_OUTPUT`) applications must also initialize the `bytesused`, `field` and `timestamp` fields, see [Buffers](#) for details. Applications must also set `flags` to 0. The `reserved2` and `reserved` fields must be set to 0. When using the [multi-planar API](#), the `m.planes` field must contain a userspace pointer to a filled-in array of struct [v4l2\\_plane](#) and the `length` field must be set to the number of elements in that array.

To enqueue a [memory mapped](#) buffer applications set the `memory` field to `V4L2_MEMORY_MMAP`. When VIDIOC\_QBUF is called with a pointer to this structure the driver sets the `V4L2_BUF_FLAG_MAPPED` and `V4L2_BUF_FLAG_QUEUED` flags and clears the `V4L2_BUF_FLAG_DONE` flag in the `flags` field, or it returns an `EINVAL` error code.

To enqueue a [user pointer](#) buffer applications set the `memory` field to `V4L2_MEMORY_USERPTR`, the `m.userptr` field to the address of the buffer and `length` to its size. When the multi-planar API is used, `m.userptr` and `length` members of the passed array of struct [v4l2\\_plane](#) have to be used instead. When VIDIOC\_QBUF is called with a pointer to this structure the driver sets the `V4L2_BUF_FLAG_QUEUED` flag and clears the `V4L2_BUF_FLAG_MAPPED` and `V4L2_BUF_FLAG_DONE`

flags in the flags field, or it returns an error code. This ioctl locks the memory pages of the buffer in physical memory, they cannot be swapped out to disk. Buffers remain locked until dequeued, until the `VIDIOC_STREAMOFF` or `ioctl VIDIOC_REQBUFS` ioctl is called, or until the device is closed.

To enqueue a `DMABUF` buffer applications set the `memory` field to `V4L2_MEMORY_DMABUF` and the `m.fd` field to a file descriptor associated with a `DMABUF` buffer. When the multi-planar API is used the `m.fd` fields of the passed array of struct `v4l2_plane` have to be used instead. When `VIDIOC_QBUF` is called with a pointer to this structure the driver sets the `V4L2_BUF_FLAG_QUEUED` flag and clears the `V4L2_BUF_FLAG_MAPPED` and `V4L2_BUF_FLAG_DONE` flags in the `flags` field, or it returns an error code. This ioctl locks the buffer. Locking a buffer means passing it to a driver for a hardware access (usually DMA). If an application accesses (reads/writes) a locked buffer then the result is undefined. Buffers remain locked until dequeued, until the `VIDIOC_STREAMOFF` or `ioctl VIDIOC_REQBUFS` ioctl is called, or until the device is closed.

The `request_fd` field can be used with the `VIDIOC_QBUF` ioctl to specify the file descriptor of a `request`, if requests are in use. Setting it means that the buffer will not be passed to the driver until the request itself is queued. Also, the driver will apply any settings associated with the request for this buffer. This field will be ignored unless the `V4L2_BUF_FLAG_REQUEST_FD` flag is set. If the device does not support requests, then `EBADR` will be returned. If requests are supported but an invalid request file descriptor is given, then `EINVAL` will be returned.

**Caution:** It is not allowed to mix queuing requests with queuing buffers directly. `EBUSY` will be returned if the first buffer was queued directly and then the application tries to queue a request, or vice versa. After closing the file descriptor, calling `VIDIOC_STREAMOFF` or calling `ioctl VIDIOC_REQBUFS` the check for this will be reset.

For `memory-to-memory devices` you can specify the `request_fd` only for output buffers, not for capture buffers. Attempting to specify this for a capture buffer will result in an `EBADR` error.

Applications call the `VIDIOC_DQBUF` ioctl to dequeue a filled (capturing) or displayed (output) buffer from the driver's outgoing queue. They just set the type, `memory` and `reserved` fields of a struct `v4l2_buffer` as above, when `VIDIOC_DQBUF` is called with a pointer to this structure the driver fills all remaining fields or returns an error code. The driver may also set `V4L2_BUF_FLAG_ERROR` in the `flags` field. It indicates a non-critical (recoverable) streaming error. In such case the application may continue as normal, but should be aware that data in the dequeued buffer might be corrupted. When using the multi-planar API, the `planes` array must be passed in as well.

If the application sets the `memory` field to `V4L2_MEMORY_DMABUF` to dequeue a `DMABUF` buffer, the driver fills the `m.fd` field with a file descriptor numerically the same as the one given to `VIDIOC_QBUF` when the buffer was enqueued. No new file descriptor is created at dequeue time and the value is only for the application convenience. When the multi-planar API is used the `m.fd` fields of the passed array of struct `v4l2_plane` are filled instead.

By default `VIDIOC_DQBUF` blocks when no buffer is in the outgoing queue. When the `O_NONBLOCK` flag was given to the `open()` function, `VIDIOC_DQBUF` returns immediately with an `EAGAIN` error code when no buffer is available.

The struct `v4l2_buffer` structure is specified in *Buffers*.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### EAGAIN

Non-blocking I/O has been selected using `O_NONBLOCK` and no buffer was in the outgoing queue.

### EINVAL

The buffer type is not supported, or the `index` is out of bounds, or no buffers have been allocated yet, or the `userptr` or `length` are invalid, or the `V4L2_BUF_FLAG_REQUEST_FD` flag was set but the given `request_fd` was invalid, or `m.fd` was an invalid DMABUF file descriptor.

### EIO

`VIDIOC_DQBUF` failed due to an internal error. Can also indicate temporary problems like signal loss.

---

**Note:** The driver might dequeue an (empty) buffer despite returning an error, or even stop capturing. Reusing such buffer may be unsafe though and its details (e.g. `index`) may not be returned either. It is recommended that drivers indicate recoverable errors by setting the `V4L2_BUF_FLAG_ERROR` and returning 0 instead. In that case the application should be able to safely reuse the buffer and continue streaming.

---

### EPIPE

`VIDIOC_DQBUF` returns this on an empty capture queue for mem2mem codecs if a buffer with the `V4L2_BUF_FLAG_LAST` was already dequeued and no new buffers are expected to become available.

### EBADR

The `V4L2_BUF_FLAG_REQUEST_FD` flag was set but the device does not support requests for the given buffer type, or the `V4L2_BUF_FLAG_REQUEST_FD` flag was not set but the device requires that the buffer is part of a request.

### EBUSY

The first buffer was queued via a request, but the application now tries to queue it directly, or vice versa (it is not permitted to mix the two APIs).

## ioctl VIDIOC\_QUERYBUF

### Name

`VIDIOC_QUERYBUF` - Query the status of a buffer

## Synopsis

### **VIDIOC\_QUERYBUF**

```
int ioctl(int fd, VIDIOC_QUERYBUF, struct v4l2_buffer *argp)
```

## Arguments

### **fd**

File descriptor returned by [open\(\)](#).

### **argp**

Pointer to struct [v4l2\\_buffer](#).

## Description

This ioctl is part of the [streaming](#) I/O method. It can be used to query the status of a buffer at any time after buffers have been allocated with the [ioctl VIDIOC\\_REQBUFS](#) ioctl.

Applications set the `type` field of a struct [v4l2\\_buffer](#) to the same buffer type as was previously used with struct [v4l2\\_format](#) type and struct [v4l2\\_requestbuffers](#) type, and the `index` field. Valid index numbers range from zero to the number of buffers allocated with [ioctl VIDIOC\\_REQBUFS](#) (struct [v4l2\\_requestbuffers](#) `count`) minus one. The `reserved` and `reserved2` fields must be set to 0. When using the [multi-planar API](#), the `m.planes` field must contain a userspace pointer to an array of struct [v4l2\\_plane](#) and the `length` field has to be set to the number of elements in that array. After calling [ioctl VIDIOC\\_QUERYBUF](#) with a pointer to this structure drivers return an error code or fill the rest of the structure.

In the `flags` field the `V4L2_BUF_FLAG_MAPPED`, `V4L2_BUF_FLAG_PREPARED`, `V4L2_BUF_FLAG_QUEUED` and `V4L2_BUF_FLAG_DONE` flags will be valid. The `memory` field will be set to the current I/O method. For the single-planar API, the `m.offset` contains the offset of the buffer from the start of the device memory, the `length` field its size. For the multi-planar API, fields `m.mem_offset` and `length` in the `m.planes` array elements will be used instead and the `length` field of struct [v4l2\\_buffer](#) is set to the number of filled-in array elements. The driver may or may not set the remaining fields and flags, they are meaningless in this context.

The struct [v4l2\\_buffer](#) structure is specified in [Buffers](#).

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### **EINVAL**

The buffer type is not supported, or the index is out of bounds.

**ioctl VIDIOC\_QUERYCAP****Name**

VIDIOC\_QUERYCAP - Query device capabilities

**Synopsis****VIDIOC\_QUERYCAP**

```
int ioctl(int fd, VIDIOC_QUERYCAP, struct v4l2_capability *argp)
```

**Arguments****fd**

File descriptor returned by [open\(\)](#).

**argp**

Pointer to struct [v4l2\\_capability](#).

**Description**

All V4L2 devices support the VIDIOC\_QUERYCAP ioctl. It is used to identify kernel devices compatible with this specification and to obtain information about driver and hardware capabilities. The ioctl takes a pointer to a struct [v4l2\\_capability](#) which is filled by the driver. When the driver is not compatible with this specification the ioctl returns an EINVAL error code.

**type v4l2\_capability**

Table 252: struct v4l2\_capability

<code>_u8</code>	<code>driver[16]</code>	Name of the driver, a unique NUL-terminated ASCII string. For example: "bttv". Driver specific applications can use this information to verify the driver identity. It is also useful to work around known bugs, or to identify drivers in error reports. Storing strings in fixed sized arrays is bad practice but unavoidable here. Drivers and applications should take precautions to never read or write beyond the end of the array and to make sure the strings are properly NUL-terminated.
<code>_u8</code>	<code>card[32]</code>	Name of the device, a NUL-terminated UTF-8 string. For example: "Yoyodyne TV/FM". One driver may support different brands or models of video hardware. This information is intended for users, for example in a menu of available devices. Since multiple TV cards of the same brand may be installed which are supported by the same driver, this name should be combined with the character device file name (e. g. <code>/dev/video2</code> ) or the <code>bus_info</code> string to avoid ambiguities.

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__u8	bus_info[32]	Location of the device in the system, a NUL-terminated ASCII string. For example: "PCI:0000:05:06.0". This information is intended for users, to distinguish multiple identical devices. If no such information is available the field must simply count the devices controlled by the driver ("platform:vivid-000"). The bus_info must start with "PCI:" for PCI boards, "PCIe:" for PCI Express boards, "usb-" for USB devices, "I2C:" for i2c devices, "ISA:" for ISA devices, "parallel" for parallel port devices and "platform:" for platform devices.
__u32	version	Version number of the driver. Starting with kernel 3.1, the version reported is provided by the V4L2 subsystem following the kernel numbering scheme. However, it may not always return the same version as the kernel if, for example, a stable or distribution-modified kernel uses the V4L2 stack from a newer kernel. The version number is formatted using the KERNEL_VERSION() macro. For example if the media stack corresponds to the V4L2 version shipped with Kernel 4.14, it would be equivalent to:
<pre>#define KERNEL_VERSION(a,b,c) (((a) &lt;&lt; 16) + ((b) &lt;&lt; 8) + (c)) __u32 version = KERNEL_VERSION(4, 14, 0); printf ("Version: %u.%u.%u\n", (version &gt;&gt; 16) &amp; 0xFF, (version &gt;&gt; 8) &amp; 0xFF, version &amp; 0xFF);</pre>		
__u32	capabilities	Available capabilities of the physical device as a whole, see <a href="#">Device Capabilities Flags</a> . The same physical device can export multiple devices in /dev (e.g. /dev/videoX, /dev/vbiY and /dev/radioZ). The capabilities field should contain a union of all capabilities available around the several V4L2 devices exported to userspace. For all those devices the capabilities field returns the same set of capabilities. This allows applications to open just one of the devices (typically the video device) and discover whether video, vbi and/or radio are also supported.
__u32	device_caps	Device capabilities of the opened device, see <a href="#">Device Capabilities Flags</a> . Should contain the available capabilities of that specific device node. So, for example, device_caps of a radio device will only contain radio related capabilities and no video or vbi capabilities. This field is only set if the capabilities field contains the V4L2_CAP_DEVICE_CAPS capability. Only the capabilities field can have the V4L2_CAP_DEVICE_CAPS capability, device_caps will never set V4L2_CAP_DEVICE_CAPS.
__u32	reserved[3]	Reserved for future extensions. Drivers must set this array to zero.

Table 253: Device Capabilities Flags

V4L2_CAP_VIDEO_CAPTURE	0x00000001	The device supports the single-planar API through the <a href="#">Video Capture</a> interface.
V4L2_CAP_VIDEO_CAPTURE_MPLANE	0x00001000	The device supports the <a href="#">multi-planar API</a> through the <a href="#">Video Capture</a> interface.

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Table 253 – continued from previous page

V4L2_CAP_VIDEO_OUTPUT	0x00000002	The device supports the single-planar API through the <a href="#">Video Output</a> interface.
V4L2_CAP_VIDEO_OUTPUT_MPLANE	0x00002000	The device supports the <a href="#">multi-planar API</a> through the <a href="#">Video Output</a> interface.
V4L2_CAP_VIDEO_M2M	0x00008000	The device supports the single-planar API through the Video Memory-To-Memory interface.
V4L2_CAP_VIDEO_M2M_MPLANE	0x00004000	The device supports the <a href="#">multi-planar API</a> through the Video Memory-To-Memory interface.
V4L2_CAP_VIDEO_OVERLAY	0x00000004	The device supports the <a href="#">Video Overlay</a> interface. A video overlay device typically stores captured images directly in the video memory of a graphics card, with hardware clipping and scaling.
V4L2_CAP_VBI_CAPTURE	0x00000010	The device supports the <a href="#">Raw VBI Capture</a> interface, providing Teletext and Closed Caption data.
V4L2_CAP_VBI_OUTPUT	0x00000020	The device supports the <a href="#">Raw VBI Output</a> interface.
V4L2_CAP_SLICED_VBI_CAPTURE	0x00000040	The device supports the <a href="#">Sliced VBI Capture</a> interface.
V4L2_CAP_SLICED_VBI_OUTPUT	0x00000080	The device supports the <a href="#">Sliced VBI Output</a> interface.
V4L2_CAP_RDS_CAPTURE	0x00000100	The device supports the <a href="#">RDS</a> capture interface.
V4L2_CAP_VIDEO_OUTPUT_OVERLAY	0x00000200	The device supports the <a href="#">Video Output Overlay</a> (OSD) interface. Unlike the <a href="#">Video Overlay</a> interface, this is a secondary function of video output devices and overlays an image onto an outgoing video signal. When the driver sets this flag, it must clear the V4L2_CAP_VIDEO_OVERLAY flag and vice versa. <sup>1</sup>
V4L2_CAP_HW_FREQ_SEEK	0x00000400	The device supports the <a href="#">ioctl VIDIOC_S_HW_FREQ_SEEK</a> ioctl for hardware frequency seeking.
V4L2_CAP_RDS_OUTPUT	0x00000800	The device supports the <a href="#">RDS</a> output interface.
V4L2_CAP_TUNER	0x00010000	The device has some sort of tuner to receive RF-modulated video signals. For more information about tuner programming see <a href="#">Tuners and Modulators</a> .

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V4L2_CAP_AUDIO	0x00020000	The device has audio inputs or outputs. It may or may not support audio recording or playback, in PCM or compressed formats. PCM audio support must be implemented as ALSA or OSS interface. For more information on audio inputs and outputs see <a href="#">Audio Inputs and Outputs</a> .
V4L2_CAP_RADIO	0x00040000	This is a radio receiver.
V4L2_CAP_MODULATOR	0x00080000	The device has some sort of modulator to emit RF-modulated video/audio signals. For more information about modulator programming see <a href="#">Tuners and Modulators</a> .
V4L2_CAP_SDR_CAPTURE	0x00100000	The device supports the <a href="#">SDR Capture</a> interface.
V4L2_CAP_EXT_PIX_FORMAT	0x00200000	The device supports the struct <a href="#">v4l2_pix_format</a> extended fields.
V4L2_CAP_SDR_OUTPUT	0x00400000	The device supports the <a href="#">SDR Output</a> interface.
V4L2_CAP_META_CAPTURE	0x00800000	The device supports the <a href="#">Metadata Interface</a> capture interface.
V4L2_CAP_READWRITE	0x01000000	The device supports the <a href="#">read()</a> and/or <a href="#">write()</a> I/O methods.
V4L2_CAP_STREAMING	0x04000000	The device supports the <a href="#">streaming</a> I/O method.
V4L2_CAP_META_OUTPUT	0x08000000	The device supports the <a href="#">Metadata Interface</a> output interface.
V4L2_CAP_TOUCH	0x10000000	This is a touch device.
V4L2_CAP_IO_MC	0x20000000	There is only one input and/or output seen from userspace. The whole video topology configuration, including which I/O entity is routed to the input/output, is configured by userspace via the Media Controller. See <a href="#">Part IV - Media Controller API</a> .
V4L2_CAP_DEVICE_CAPS	0x80000000	The driver fills the <code>device_caps</code> field. This capability can only appear in the <code>capabilities</code> field and never in the <code>device_caps</code> field.

<sup>1</sup> The struct `v4l2_framebuffer` lacks an enum `v4l2_buf_type` field, therefore the type of overlay is implied by the driver capabilities.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## ioctls VIDIOC\_QUERYCTRL, VIDIOC\_QUERY\_EXT\_CTRL and VIDIOC\_QUERYMENU

### Name

`VIDIOC_QUERYCTRL` - `VIDIOC_QUERY_EXT_CTRL` - `VIDIOC_QUERYMENU` - Enumerate controls and menu control items

### Synopsis

```
int ioctl(int fd, int VIDIOC_QUERYCTRL, struct v4l2_queryctrl *argp)
VIDIOC_QUERY_EXT_CTRL
int ioctl(int fd, VIDIOC_QUERY_EXT_CTRL, struct v4l2_query_ext_ctrl *argp)
VIDIOC_QUERYMENU
int ioctl(int fd, VIDIOC_QUERYMENU, struct v4l2_querymenu *argp)
```

### Arguments

#### fd

File descriptor returned by [`open\(\)`](#).

#### argp

Pointer to struct `v4l2_queryctrl`, `v4l2_query_ext_ctrl` or `v4l2_querymenu` (depending on the ioctl).

### Description

To query the attributes of a control applications set the `id` field of a struct `v4l2_queryctrl` and call the `VIDIOC_QUERYCTRL` ioctl with a pointer to this structure. The driver fills the rest of the structure or returns an `EINVAL` error code when the `id` is invalid.

It is possible to enumerate controls by calling `VIDIOC_QUERYCTRL` with successive `id` values starting from `V4L2_CID_BASE` up to and exclusive `V4L2_CID_LASTP1`. Drivers may return `EINVAL` if a control in this range is not supported. Further applications can enumerate private controls, which are not defined in this specification, by starting at `V4L2_CID_PRIVATE_BASE` and incrementing `id` until the driver returns `EINVAL`.

In both cases, when the driver sets the `V4L2_CTRL_FLAG_DISABLED` flag in the `flags` field this control is permanently disabled and should be ignored by the application.<sup>1</sup>

<sup>1</sup> `V4L2_CTRL_FLAG_DISABLED` was intended for two purposes: Drivers can skip predefined controls not supported by the hardware (although returning `EINVAL` would do as well), or disable predefined and private controls after hardware detection without the trouble of reordering control arrays and indices (`EINVAL` cannot be used to skip private controls because it would prematurely end the enumeration).

When the application ORs `id` with `V4L2_CTRL_FLAG_NEXT_CTRL` the driver returns the next supported non-compound control, or `EINVAL` if there is none. In addition, the `V4L2_CTRL_FLAG_NEXT_COMPOUND` flag can be specified to enumerate all compound controls (i.e. controls with type  $\geq V4L2_CTRL_COMPOUND_TYPES$  and/or array control, in other words controls that contain more than one value). Specify both `V4L2_CTRL_FLAG_NEXT_CTRL` and `V4L2_CTRL_FLAG_NEXT_COMPOUND` in order to enumerate all controls, compound or not. Drivers which do not support these flags yet always return `EINVAL`.

The `VIDIOC_QUERY_EXT_CTRL` ioctl was introduced in order to better support controls that can use compound types, and to expose additional control information that cannot be returned in struct `v4l2_queryctrl` since that structure is full.

`VIDIOC_QUERY_EXT_CTRL` is used in the same way as `VIDIOC_QUERYCTRL`, except that the reserved array must be zeroed as well.

Additional information is required for menu controls: the names of the menu items. To query them applications set the `id` and `index` fields of struct `v4l2_querymenu` and call the `VIDIOC_QUERYMENU` ioctl with a pointer to this structure. The driver fills the rest of the structure or returns an `EINVAL` error code when the `id` or `index` is invalid. Menu items are enumerated by calling `VIDIOC_QUERYMENU` with successive `index` values from struct `v4l2_queryctrl` minimum to maximum, inclusive.

---

**Note:** It is possible for `VIDIOC_QUERYMENU` to return an `EINVAL` error code for some indices between `minimum` and `maximum`. In that case that particular menu item is not supported by this driver. Also note that the `minimum` value is not necessarily 0.

---

See also the examples in [User Controls](#).

Table 254: struct `v4l2_queryctrl`

<code>_u32</code>	<code>id</code>	Identifies the control, set by the application. See <a href="#">Control IDs</a> for predefined IDs. When the ID is ORed with <code>V4L2_CTRL_FLAG_NEXT_CTRL</code> the driver clears the flag and returns the first control with a higher ID. Drivers which do not support this flag yet always return an <code>EINVAL</code> error code.
<code>_u32</code>	<code>type</code>	Type of control, see <a href="#">v4l2_ctrl_type</a> .
<code>_u8</code>	<code>name[32]</code>	Name of the control, a NUL-terminated ASCII string. This information is intended for the user.
<code>_s32</code>	<code>minimum</code>	Minimum value, inclusive. This field gives a lower bound for the control. See enum <a href="#">v4l2_ctrl_type</a> how the minimum value is to be used for each possible control type. Note that this is a signed 32-bit value.
<code>_s32</code>	<code>maximum</code>	Maximum value, inclusive. This field gives an upper bound for the control. See enum <a href="#">v4l2_ctrl_type</a> how the maximum value is to be used for each possible control type. Note that this is a signed 32-bit value.

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<code>_s32</code>	<code>step</code>	This field gives a step size for the control. See enum <code>v4l2_ctrl_type</code> how the step value is to be used for each possible control type. Note that this is an unsigned 32-bit value. Generally drivers should not scale hardware control values. It may be necessary for example when the name or id imply a particular unit and the hardware actually accepts only multiples of said unit. If so, drivers must take care values are properly rounded when scaling, such that errors will not accumulate on repeated read-write cycles. This field gives the smallest change of an integer control actually affecting hardware. Often the information is needed when the user can change controls by keyboard or GUI buttons, rather than a slider. When for example a hardware register accepts values 0-511 and the driver reports 0-65535, step should be 128. Note that although signed, the step value is supposed to be always positive.
<code>_s32</code>	<code>default_value</code>	The default value of a <code>V4L2_CTRL_TYPE_INTEGER</code> , <code>_BOOLEAN</code> , <code>_BITMASK</code> , <code>_MENU</code> or <code>_INTEGER_MENU</code> control. Not valid for other types of controls.  <b>Note:</b> Drivers reset controls to their default value only when the driver is first loaded, never afterwards.
<code>_u32</code>	<code>flags</code>	Control flags, see <i>Control Flags</i> .
<code>_u32</code>	<code>reserved[2]</code>	Reserved for future extensions. Drivers must set the array to zero.

Table 255: struct `v4l2_query_ext_ctrl`

<code>_u32</code>	<code>id</code>	Identifies the control, set by the application. See <i>Control IDs</i> for predefined IDs. When the ID is ORed with <code>V4L2_CTRL_FLAG_NEXT_CTRL</code> the driver clears the flag and returns the first non-compound control with a higher ID. When the ID is ORed with <code>V4L2_CTRL_FLAG_NEXT_COMPOUND</code> the driver clears the flag and returns the first compound control with a higher ID. Set both to get the first control (compound or not) with a higher ID.
<code>_u32</code>	<code>type</code>	Type of control, see <code>v4l2_ctrl_type</code> .
<code>char</code>	<code>name[32]</code>	Name of the control, a NUL-terminated ASCII string. This information is intended for the user.
<code>_s64</code>	<code>minimum</code>	Minimum value, inclusive. This field gives a lower bound for the control. See enum <code>v4l2_ctrl_type</code> how the minimum value is to be used for each possible control type. Note that this is a signed 64-bit value.

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<code>_s64</code>	<code>maximum</code>	Maximum value, inclusive. This field gives an upper bound for the control. See enum <code>v4l2_ctrl_type</code> how the maximum value is to be used for each possible control type. Note that this is a signed 64-bit value.
<code>_u64</code>	<code>step</code>	<p>This field gives a step size for the control. See enum <code>v4l2_ctrl_type</code> how the step value is to be used for each possible control type. Note that this is an unsigned 64-bit value.</p> <p>Generally drivers should not scale hardware control values. It may be necessary for example when the name or id imply a particular unit and the hardware actually accepts only multiples of said unit. If so, drivers must take care values are properly rounded when scaling, such that errors will not accumulate on repeated read-write cycles.</p> <p>This field gives the smallest change of an integer control actually affecting hardware. Often the information is needed when the user can change controls by keyboard or GUI buttons, rather than a slider. When for example a hardware register accepts values 0-511 and the driver reports 0-65535, step should be 128.</p>
<code>_s64</code>	<code>default_value</code>	<p>The default value of a <code>V4L2_CTRL_TYPE_INTEGER</code>, <code>_INTEGER64</code>, <code>_BOOLEAN</code>, <code>_BITMASK</code>, <code>_MENU</code>, <code>_INTEGER_MENU</code>, <code>_U8</code> or <code>_U16</code> control. Not valid for other types of controls.</p> <p><b>Note:</b> Drivers reset controls to their default value only when the driver is first loaded, never afterwards.</p>
<code>_u32</code>	<code>flags</code>	Control flags, see <a href="#">Control Flags</a> .
<code>_u32</code>	<code>elem_size</code>	The size in bytes of a single element of the array. Given a char pointer <code>p</code> to a 3-dimensional array you can find the position of cell ( <code>z</code> , <code>y</code> , <code>x</code> ) as follows: <code>p + ((z * dims[1] + y) * dims[0] + x) * elem_size</code> . <code>elem_size</code> is always valid, also when the control isn't an array. For string controls <code>elem_size</code> is equal to <code>maximum + 1</code> .
<code>_u32</code>	<code>elems</code>	The number of elements in the N-dimensional array. If this control is not an array, then <code>elems</code> is 1. The <code>elems</code> field can never be 0.
<code>_u32</code>	<code>nr_of_dims</code>	The number of dimension in the N-dimensional array. If this control is not an array, then this field is 0.
<code>_u32</code>	<code>dims[V4L2_CTRL_MAX_DIMS]</code>	The size of each dimension. The first <code>nr_of_dims</code> elements of this array must be non-zero, all remaining elements must be zero.
<code>_u32</code>	<code>reserved[32]</code>	Reserved for future extensions. Applications and drivers must set the array to zero.

Table 256: struct v4l2\_querymenu

<code>_u32</code>	<code>id</code>	Identifies the control, set by the application from the respective struct <code>v4l2_queryctrl</code> id.
<code>_u32</code>	<code>index</code>	Index of the menu item, starting at zero, set by the application.
union {	(anonymous)	
<code>_u8</code>	<code>name[32]</code>	Name of the menu item, a NUL-terminated ASCII string. This information is intended for the user. This field is valid for <code>V4L2_CTRL_TYPE_MENU</code> type controls.
<code>_s64</code>	<code>value</code>	Value of the integer menu item. This field is valid for <code>V4L2_CTRL_TYPE_INTEGER_MENU</code> type controls.
}		
<code>_u32</code>	<code>reserved</code>	Reserved for future extensions. Drivers must set the array to zero.

type `v4l2_ctrl_type`

Table 257: enum v4l2\_ctrl\_type

Type	minimum	step	maximum	Description
<code>V4L2_CTRL_TYPE_INTEGER</code>	any	any	any	An integer-valued control ranging from minimum to maximum inclusive. The step value indicates the increment between values.
<code>V4L2_CTRL_TYPE_BOOLEAN</code>	0	1	1	A boolean-valued control. Zero corresponds to "disabled", and one means "enabled".
<code>V4L2_CTRL_TYPE_MENU</code>	$\geq 0$	1	N-1	The control has a menu of N choices. The names of the menu items can be enumerated with the <code>VIDIOC_QUERYMENU</code> ioctl.
<code>V4L2_CTRL_TYPE_INTEGER_MENU</code>	$\geq 0$	1	N-1	The control has a menu of N choices. The values of the menu items can be enumerated with the <code>VIDIOC_QUERYMENU</code> ioctl. This is similar to <code>V4L2_CTRL_TYPE_MENU</code> except that instead of strings, the menu items are signed 64-bit integers.
<code>V4L2_CTRL_TYPE_BITMASK</code>	0	n/a	any	A bitmask field. The maximum value is the set of bits that can be used, all other bits are to be 0. The maximum value is interpreted as a <code>_u32</code> , allowing the use of bit 31 in the bitmask.
<code>V4L2_CTRL_TYPE_BUTTON</code>	0	0	0	A control which performs an action when set. Drivers must ignore the value passed with <code>VIDIOC_S_CTRL</code> and return an <code>EACCES</code> error code on a <code>VIDIOC_G_CTRL</code> attempt.
<code>V4L2_CTRL_TYPE_INTEGER64</code>	any	any	any	A 64-bit integer valued control. Minimum, maximum and step size cannot be queried using <code>VIDIOC_QUERYCTRL</code> . Only <code>VIDIOC_QUERY_EXT_CTRL</code> can retrieve the 64-bit min/max/step values, they should be interpreted as n/a when using <code>VIDIOC_QUERYCTRL</code> .

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Type	minimum	step	maximum	Description
V4L2_CTRL_TYPE_STRING	$\geq 0$	$\geq 1$	$\geq 0$	The minimum and maximum string lengths. The step size means that the string must be (minimum + N * step) characters long for $N \geq 0$ . These lengths do not include the terminating zero, so in order to pass a string of length 8 to <a href="#">VIDIOC_S_EXT_CTRLS</a> you need to set the size field of struct <a href="#">v4l2_ext_control</a> to 9. For <a href="#">VIDIOC_G_EXT_CTRLS</a> you can set the size field to maximum + 1. Which character encoding is used will depend on the string control itself and should be part of the control documentation.
V4L2_CTRL_TYPE_CTRL_CLASS	n/a	n/a	n/a	This is not a control. When VIDIOC_QUERYCTRL is called with a control ID equal to a control class code (see <a href="#">Control classes</a> ) + 1, the ioctl returns the name of the control class and this control type. Older drivers which do not support this feature return an EINVAL error code.
V4L2_CTRL_TYPE_U8	any	any	any	An unsigned 8-bit valued control ranging from minimum to maximum inclusive. The step value indicates the increment between values.
V4L2_CTRL_TYPE_U16	any	any	any	An unsigned 16-bit valued control ranging from minimum to maximum inclusive. The step value indicates the increment between values.
V4L2_CTRL_TYPE_U32	any	any	any	An unsigned 32-bit valued control ranging from minimum to maximum inclusive. The step value indicates the increment between values.
V4L2_CTRL_TYPE_MPEG2_QUANTISATION	n/a	n/a	n/a	A struct <a href="#">v4l2_ctrl_mpeg2_quantisation</a> , containing MPEG-2 quantisation matrices for stateless video decoders.
V4L2_CTRL_TYPE_MPEG2_SEQUENCE	n/a	n/a	n/a	A struct <a href="#">v4l2_ctrl_mpeg2_sequence</a> , containing MPEG-2 sequence parameters for stateless video decoders.
V4L2_CTRL_TYPE_MPEG2_PICTURE	n/a	n/a	n/a	A struct <a href="#">v4l2_ctrl_mpeg2_picture</a> , containing MPEG-2 picture parameters for stateless video decoders.
V4L2_CTRL_TYPE_AREA	n/a	n/a	n/a	A struct <a href="#">v4l2_area</a> , containing the width and the height of a rectangular area. Units depend on the use case.
V4L2_CTRL_TYPE_H264_SPS	n/a	n/a	n/a	A struct <a href="#">v4l2_ctrl_h264_sps</a> , containing H264 sequence parameters for stateless video decoders.
V4L2_CTRL_TYPE_H264_PPS	n/a	n/a	n/a	A struct <a href="#">v4l2_ctrl_h264_pps</a> , containing H264 picture parameters for stateless video decoders.
V4L2_CTRL_TYPE_H264_SCALING_MATRIX	n/a	n/a	n/a	A struct <a href="#">v4l2_ctrl_h264_scaling_matrix</a> , containing H264 scaling matrices for stateless video decoders.
V4L2_CTRL_TYPE_H264_SLICE_PARAMS	n/a	n/a	n/a	A struct <a href="#">v4l2_ctrl_h264_slice_params</a> , containing H264 slice parameters for stateless video decoders.
V4L2_CTRL_TYPE_H264_DECODE_PARAMS	n/a	n/a	n/a	A struct <a href="#">v4l2_ctrl_h264_decode_params</a> , containing H264 decode parameters for stateless video decoders.

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Type	minimum	step	maximum	Description
V4L2_CTRL_TYPE_FWHT_PARAMS	n/a	n/a	n/a	A struct <code>v4l2_ctrl_fwht_params</code> , containing FWHT parameters for stateless video decoders.
V4L2_CTRL_TYPE_HEVC_SPS	n/a	n/a	n/a	A struct <code>v4l2_ctrl_hevc_sps</code> , containing HEVC Sequence Parameter Set for stateless video decoders.
V4L2_CTRL_TYPE_HEVC_PPS	n/a	n/a	n/a	A struct <code>v4l2_ctrl_hevc_pps</code> , containing HEVC Picture Parameter Set for stateless video decoders.
V4L2_CTRL_TYPE_HEVC_SLICE_PARAMS	n/a	n/a	n/a	A struct <code>v4l2_ctrl_hevc_slice_params</code> , containing HEVC slice parameters for stateless video decoders.
V4L2_CTRL_TYPE_HEVC_SCALING_MATRIX	n/a	n/a	n/a	A struct <code>v4l2_ctrl_hevc_scaling_matrix</code> , containing HEVC scaling matrix for stateless video decoders.
V4L2_CTRL_TYPE_VP8_FRAME	n/a	n/a	n/a	A struct <code>v4l2_ctrl_vp8_frame</code> , containing VP8 frame parameters for stateless video decoders.
V4L2_CTRL_TYPE_HEVC_DECODE_PARAMS	n/a	n/a	n/a	A struct <code>v4l2_ctrl_hevc_decode_params</code> , containing HEVC decoding parameters for stateless video decoders.
V4L2_CTRL_TYPE_VP9_COMPRESSED_HDR	n/a	n/a	n/a	A struct <code>v4l2_ctrl_vp9_compressed_hdr</code> , containing VP9 probabilities updates for stateless video decoders.
V4L2_CTRL_TYPE_VP9_FRAME	n/a	n/a	n/a	A struct <code>v4l2_ctrl_vp9_frame</code> , containing VP9 frame decode parameters for stateless video decoders.
V4L2_CTRL_TYPE_AV1_SEQUENCE	n/a	n/a	n/a	A struct <code>v4l2_ctrl_av1_sequence</code> , containing AV1 Sequence OBU decoding parameters for stateless video decoders.
V4L2_CTRL_TYPE_AV1_TILE_GROUP_ENTRY	n/a	n/a	n/a	A struct <code>v4l2_ctrl_av1_tile_group_entry</code> , containing AV1 Tile Group OBU decoding parameters for stateless video decoders.
V4L2_CTRL_TYPE_AV1_FRAME	n/a	n/a	n/a	A struct <code>v4l2_ctrl_av1_frame</code> , containing AV1 Frame/Frame Header OBU decoding parameters for stateless video decoders.
V4L2_CTRL_TYPE_AV1_FILM_GRAIN	n/a	n/a	n/a	A struct <code>v4l2_ctrl_av1_film_grain</code> , containing AV1 Film Grain parameters for stateless video decoders.

Table 258: Control Flags

V4L2_CTRL_FLAG_DISABLED	0x0001	This control is permanently disabled and should be ignored by the application. Any attempt to change the control will result in an EINVAL error code.
V4L2_CTRL_FLAG_GRABBED	0x0002	This control is temporarily unchangeable, for example because another application took over control of the respective resource. Such controls may be displayed specially in a user interface. Attempts to change the control may result in an EBUSY error code.

continues on next page

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V4L2_CTRL_FLAG_READ_ONLY	0x0004	This control is permanently readable only. Any attempt to change the control will result in an <code>EINVAL</code> error code.
V4L2_CTRL_FLAG_UPDATE	0x0008	A hint that changing this control may affect the value of other controls within the same control class. Applications should update their user interface accordingly.
V4L2_CTRL_FLAG_INACTIVE	0x0010	This control is not applicable to the current configuration and should be displayed accordingly in a user interface. For example the flag may be set on a MPEG audio level 2 bitrate control when MPEG audio encoding level 1 was selected with another control.
V4L2_CTRL_FLAG_SLIDER	0x0020	A hint that this control is best represented as a slider-like element in a user interface.
V4L2_CTRL_FLAG_WRITE_ONLY	0x0040	This control is permanently writable only. Any attempt to read the control will result in an <code>EACCES</code> error code error code. This flag is typically present for relative controls or action controls where writing a value will cause the device to carry out a given action (e. g. motor control) but no meaningful value can be returned.
V4L2_CTRL_FLAG_VOLATILE	0x0080	<p>This control is volatile, which means that the value of the control changes continuously. A typical example would be the current gain value if the device is in auto-gain mode. In such a case the hardware calculates the gain value based on the lighting conditions which can change over time.</p> <p><b>Note:</b> Setting a new value for a volatile control will be ignored unless <code>V4L2_CTRL_FLAG_EXECUTE_ON_WRITE</code> is also set. Setting a new value for a volatile control will <i>never</i> trigger a <code>V4L2_EVENT_CTRL_CH_VALUE</code> event.</p>
V4L2_CTRL_FLAG_HAS_PAYLOAD	0x0100	This control has a pointer type, so its value has to be accessed using one of the pointer fields of struct <code>v4l2_ext_control</code> . This flag is set for controls that are an array, string, or have a compound type. In all cases you have to set a pointer to memory containing the payload of the control.

continues on next page

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V4L2_CTRL_FLAG_EXECUTE_ON_WRITE	0x0200	The value provided to the control will be propagated to the driver even if it remains constant. This is required when the control represents an action on the hardware. For example: clearing an error flag or triggering the flash. All the controls of the type V4L2_CTRL_TYPE_BUTTON have this flag set.
V4L2_CTRL_FLAG MODIFY_LAYOUT	0x0400	Changing this control value may modify the layout of the buffer (for video devices) or the media bus format (for sub-devices). A typical example would be the V4L2_CID_ROTATE control. Note that typically controls with this flag will also set the V4L2_CTRL_FLAG_GRABBED flag when buffers are allocated or streaming is in progress since most drivers do not support changing the format in that case.
V4L2_CTRL_FLAG_DYNAMIC_ARRAY	0x0800	This control is a dynamically sized 1-dimensional array. It behaves the same as a regular array, except that the number of elements as reported by the <code>elems</code> field is between 1 and <code>dims[0]</code> . So setting the control with a differently sized array will change the <code>elems</code> field when the control is queried afterwards.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### EINVAL

The struct `v4l2_queryctrl` id is invalid. The struct `v4l2_querymenu` id is invalid or `index` is out of range (less than `minimum` or greater than `maximum`) or this particular menu item is not supported by the driver.

### EACCES

An attempt was made to read a write-only control.

## ioctl VIDIOC\_QUERY\_DV\_TIMINGS

### Name

VIDIOC\_QUERY\_DV\_TIMINGS - VIDIOC\_SUBDEV\_QUERY\_DV\_TIMINGS - Sense the DV preset received by the current input

### Synopsis

#### **VIDIOC\_QUERY\_DV\_TIMINGS**

```
int ioctl(int fd, VIDIOC_QUERY_DV_TIMINGS, struct v4l2_dv_timings *argp)
```

#### **VIDIOC\_SUBDEV\_QUERY\_DV\_TIMINGS**

```
int ioctl(int fd, VIDIOC_SUBDEV_QUERY_DV_TIMINGS, struct v4l2_dv_timings *argp)
```

### Arguments

#### **fd**

File descriptor returned by [open\(\)](#).

#### **argp**

Pointer to struct [\*v4l2\\_dv\\_timings\*](#).

### Description

The hardware may be able to detect the current DV timings automatically, similar to sensing the video standard. To do so, applications call [\*ioctl VIDIOC\\_QUERY\\_DV\\_TIMINGS\*](#) with a pointer to a struct [\*v4l2\\_dv\\_timings\*](#). Once the hardware detects the timings, it will fill in the timings structure.

---

**Note:** Drivers shall *not* switch timings automatically if new timings are detected. Instead, drivers should send the V4L2\_EVENT\_SOURCE\_CHANGE event (if they support this) and expect that userspace will take action by calling [\*ioctl VIDIOC\\_QUERY\\_DV\\_TIMINGS\*](#). The reason is that new timings usually mean different buffer sizes as well, and you cannot change buffer sizes on the fly. In general, applications that receive the Source Change event will have to call [\*ioctl VIDIOC\\_QUERY\\_DV\\_TIMINGS\*](#), and if the detected timings are valid they will have to stop streaming, set the new timings, allocate new buffers and start streaming again.

If the timings could not be detected because there was no signal, then ENOLINK is returned. If a signal was detected, but it was unstable and the receiver could not lock to the signal, then ENOLCK is returned. If the receiver could lock to the signal, but the format is unsupported (e.g. because the pixelclock is out of range of the hardware capabilities), then the driver fills in whatever timings it could find and returns ERANGE. In that case the application can call [\*ioctl VIDIOC\\_DV\\_TIMINGS\\_CAP\*](#), [\*VIDIOC\\_SUBDEV\\_DV\\_TIMINGS\\_CAP\*](#) to compare the found timings with the hardware's capabilities in order to give more precise feedback to the user.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### **ENODATA**

Digital video timings are not supported for this input or output.

### **ENOLINK**

No timings could be detected because no signal was found.

### **ENOLCK**

The signal was unstable and the hardware could not lock on to it.

### **ERANGE**

Timings were found, but they are out of range of the hardware capabilities.

## **ioctl VIDIOC\_QUERYSTD, VIDIOC\_SUBDEV\_QUERYSTD**

### Name

`VIDIOC_QUERYSTD` - `VIDIOC_SUBDEV_QUERYSTD` - Sense the video standard received by the current input

### Synopsis

#### **VIDIOC\_QUERYSTD**

```
int ioctl(int fd, VIDIOC_QUERYSTD, v4l2_std_id *argp)
```

#### **VIDIOC\_SUBDEV\_QUERYSTD**

```
int ioctl(int fd, VIDIOC_SUBDEV_QUERYSTD, v4l2_std_id *argp)
```

### Arguments

#### **fd**

File descriptor returned by [`open\(\)`](#).

#### **argp**

Pointer to `v4l2_std_id`.

## Description

The hardware may be able to detect the current video standard automatically. To do so, applications call `ioctl VIDIOC_QUERYSTD`, `VIDIOC_SUBDEV_QUERYSTD` with a pointer to a `v4l2_std_id` type. The driver stores here a set of candidates, this can be a single flag or a set of supported standards if for example the hardware can only distinguish between 50 and 60 Hz systems. If no signal was detected, then the driver will return `V4L2_STD_UNKNOWN`. When detection is not possible or fails, the set must contain all standards supported by the current video input or output.

---

**Note:** Drivers shall *not* switch the video standard automatically if a new video standard is detected. Instead, drivers should send the `V4L2_EVENT_SOURCE_CHANGE` event (if they support this) and expect that userspace will take action by calling `ioctl VIDIOC_QUERYSTD`, `VIDIOC_SUBDEV_QUERYSTD`. The reason is that a new video standard can mean different buffer sizes as well, and you cannot change buffer sizes on the fly. In general, applications that receive the Source Change event will have to call `ioctl VIDIOC_QUERYSTD`, `VIDIOC_SUBDEV_QUERYSTD`, and if the detected video standard is valid they will have to stop streaming, set the new standard, allocate new buffers and start streaming again.

---

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### ENODATA

Standard video timings are not supported for this input or output.

## ioctl VIDIOC\_REQBUFS

### Name

`VIDIOC_REQBUFS` - Initiate Memory Mapping, User Pointer I/O or DMA buffer I/O

### Synopsis

#### `VIDIOC_REQBUFS`

```
int ioctl(int fd, VIDIOC_REQBUFS, struct v4l2_requestbuffers *argp)
```

### Arguments

#### fd

File descriptor returned by `open()`.

#### argp

Pointer to struct `v4l2_requestbuffers`.

### Description

This ioctl is used to initiate *memory mapped*, *user pointer* or *DMABUF* based I/O. Memory mapped buffers are located in device memory and must be allocated with this ioctl before they can be mapped into the application's address space. User buffers are allocated by applications themselves, and this ioctl is merely used to switch the driver into user pointer I/O mode and to setup some internal structures. Similarly, DMABUF buffers are allocated by applications through a device driver, and this ioctl only configures the driver into DMABUF I/O mode without performing any direct allocation.

To allocate device buffers applications initialize all fields of the struct `v4l2_requestbuffers` structure. They set the type field to the respective stream or buffer type, the count field to the desired number of buffers, memory must be set to the requested I/O method and the reserved array must be zeroed. When the ioctl is called with a pointer to this structure the driver will attempt to allocate the requested number of buffers and it stores the actual number allocated in the count field. It can be smaller than the number requested, even zero, when the driver runs out of free memory. A larger number is also possible when the driver requires more buffers to function correctly. For example video output requires at least two buffers, one displayed and one filled by the application.

When the I/O method is not supported the ioctl returns an `EINVAL` error code.

Applications can call `ioctl VIDIOC_REQBUFS` again to change the number of buffers. Note that if any buffers are still mapped or exported via DMABUF, then `ioctl VIDIOC_REQBUFS` can only succeed if the `V4L2_BUF_CAP_SUPPORTS_ORPHANED_BUFS` capability is set. Otherwise `ioctl VIDIOC_REQBUFS` will return the `EBUSY` error code. If `V4L2_BUF_CAP_SUPPORTS_ORPHANED_BUFS` is set, then these buffers are orphaned and will be freed when they are unmapped or when the exported DMABUF fds are closed. A count value of zero frees or orphans all buffers, after aborting or finishing any DMA in progress, an implicit `VIDIOC_STREAMOFF`.

type `v4l2_requestbuffers`

Table 259: struct v4l2\_requestbuffers

<code>_u32</code>	<code>count</code>	The number of buffers requested or granted.
<code>_u32</code>	<code>type</code>	Type of the stream or buffers, this is the same as the struct <code>v4l2_format</code> type field. See <code>v4l2_buf_type</code> for valid values.
<code>_u32</code>	<code>memory</code>	Applications set this field to <code>V4L2_MEMORY_MMAP</code> , <code>V4L2_MEMORY_DMABUF</code> or <code>V4L2_MEMORY_USERPTR</code> . See <code>v4l2_memory</code> .
<code>_u32</code>	<code>capabilities</code>	Set by the driver. If 0, then the driver doesn't support capabilities. In that case all you know is that the driver is guaranteed to support <code>V4L2_MEMORY_MMAP</code> and <i>might</i> support other <code>v4l2_memory</code> types. It will not support any other capabilities. If you want to query the capabilities with a minimum of side-effects, then this can be called with <code>count</code> set to 0, <code>memory</code> set to <code>V4L2_MEMORY_MMAP</code> and <code>type</code> set to the buffer type. This will free any previously allocated buffers, so this is typically something that will be done at the start of the application.
<code>_u8</code>	<code>flags</code>	Specifies additional buffer management attributes. See <code>Memory Consistency Flags</code> .
<code>_u8</code>	<code>reserved[3]</code>	Reserved for future extensions.

Table 260: V4L2 Buffer Capabilities Flags

<code>V4L2_BUF_CAP_SUPPORTS_MMAP</code>	0x00000001	This buffer type supports the <code>V4L2_MEMORY_MMAP</code> streaming mode.
<code>V4L2_BUF_CAP_SUPPORTS_USERPTR</code>	0x00000002	This buffer type supports the <code>V4L2_MEMORY_USERPTR</code> streaming mode.
<code>V4L2_BUF_CAP_SUPPORTS_DMABUF</code>	0x00000004	This buffer type supports the <code>V4L2_MEMORY_DMABUF</code> streaming mode.
<code>V4L2_BUF_CAP_SUPPORTS_REQUESTS</code>	0x00000008	This buffer type supports <i>requests</i> .
<code>V4L2_BUF_CAP_SUPPORTS_ORPHANED_BUFS</code>	0x00000010	The kernel allows calling <code>ioctl VIDIOC_REQBUFS</code> while buffers are still mapped or exported via DMABUF. These orphaned buffers will be freed when they are unmapped or when the exported DMABUF fds are closed.
<code>V4L2_BUF_CAP_SUPPORTS_M2M_HOLD_CAPTURE_BUF</code>	0x00000020	Only valid for stateless decoders. If set, then userspace can set the <code>V4L2_BUF_FLAG_M2M_HOLD_CAPTURE_BUF</code> flag to hold off on returning the capture buffer until the OUTPUT timestamp changes.

continues on next page

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V4L2_BUF_CAP_SUPPORTS_MMAP_CACHE_HINTS	0x00000040	This capability is set by the driver to indicate that the queue supports cache and memory management hints. However, it's only valid when the queue is used for <i>memory mapping</i> streaming I/O. See <a href="#">V4L2_BUF_FLAG_NO_CACHE_INVALIDATE</a> , <a href="#">V4L2_BUF_FLAG_NO_CACHE_CLEAN</a> and <a href="#">V4L2_MEMORY_FLAG_NON_COHERENT</a> .
--	------------	---

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### EINVAL

The buffer type (type field) or the requested I/O method (memory) is not supported.

## ioctl VIDIOC\_S\_HW\_FREQ\_SEEK

### Name

`VIDIOC_S_HW_FREQ_SEEK` - Perform a hardware frequency seek

### Synopsis

#### `VIDIOC_S_HW_FREQ_SEEK`

```
int ioctl(int fd, VIDIOC_S_HW_FREQ_SEEK, struct v4l2_hw_freq_seek *argp)
```

### Arguments

#### `fd`

File descriptor returned by `open()`.

#### `argp`

Pointer to struct `v4l2_hw_freq_seek`.

### Description

Start a hardware frequency seek from the current frequency. To do this applications initialize the tuner, type, seek\_upward, wrap\_around, spacing, rangelow and rangehigh fields, and zero out the reserved array of a struct `v4l2_hw_freq_seek` and call the `VIDIOC_S_HW_FREQ_SEEK` ioctl with a pointer to this structure.

The rangelow and rangehigh fields can be set to a non-zero value to tell the driver to search a specific band. If the struct `v4l2_tuner` capability field has the V4L2\_TUNER\_CAP\_HWSEEK\_PROG\_LIM flag set, these values must fall within one of the bands returned by `ioctl VIDIOC_ENUM_FREQ_BANDS`. If the V4L2\_TUNER\_CAP\_HWSEEK\_PROG\_LIM flag is not set, then these values must exactly match those of one of the bands returned by `ioctl`

`VIDIOC_ENUM_FREQ_BANDS`. If the current frequency of the tuner does not fall within the selected band it will be clamped to fit in the band before the seek is started.

If an error is returned, then the original frequency will be restored.

This ioctl is supported if the `V4L2_CAP_HW_FREQ_SEEK` capability is set.

If this ioctl is called from a non-blocking filehandle, then `EAGAIN` error code is returned and no seek takes place.

type `v4l2_hw_freq_seek`

Table 261: struct `v4l2_hw_freq_seek`

<code>_u32</code>	<code>tuner</code>	The tuner index number. This is the same value as in the struct <code>v4l2_input</code> tuner field and the struct <code>v4l2_tuner</code> index field.
<code>_u32</code>	<code>type</code>	The tuner type. This is the same value as in the struct <code>v4l2_tuner</code> type field. See <code>v4l2_tuner_type</code>
<code>_u32</code>	<code>seek_upward</code>	If non-zero, seek upward from the current frequency, else seek downward.
<code>_u32</code>	<code>wrap_around</code>	If non-zero, wrap around when at the end of the frequency range, else stop seeking. The struct <code>v4l2_tuner</code> capability field will tell you what the hardware supports.
<code>_u32</code>	<code>spacing</code>	If non-zero, defines the hardware seek resolution in Hz. The driver selects the nearest value that is supported by the device. If spacing is zero a reasonable default value is used.
<code>_u32</code>	<code>rangelow</code>	If non-zero, the lowest tunable frequency of the band to search in units of 62.5 kHz, or if the struct <code>v4l2_tuner</code> capability field has the <code>V4L2_TUNER_CAP_LOW</code> flag set, in units of 62.5 Hz or if the struct <code>v4l2_tuner</code> capability field has the <code>V4L2_TUNER_CAP_1HZ</code> flag set, in units of 1 Hz. If <code>rangelow</code> is zero a reasonable default value is used.
<code>_u32</code>	<code>rangehigh</code>	If non-zero, the highest tunable frequency of the band to search in units of 62.5 kHz, or if the struct <code>v4l2_tuner</code> capability field has the <code>V4L2_TUNER_CAP_LOW</code> flag set, in units of 62.5 Hz or if the struct <code>v4l2_tuner</code> capability field has the <code>V4L2_TUNER_CAP_1HZ</code> flag set, in units of 1 Hz. If <code>rangehigh</code> is zero a reasonable default value is used.
<code>_u32</code>	<code>reserved[5]</code>	Reserved for future extensions. Applications must set the array to zero.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### EINVAL

The tuner index is out of bounds, the `wrap_around` value is not supported or one of the values in the `type`, `rangelow` or `rangehigh` fields is wrong.

### EAGAIN

Attempted to call `VIDIOC_S_HW_FREQ_SEEK` with the filehandle in non-blocking mode.

### ENODATA

The hardware seek found no channels.

### EBUSY

Another hardware seek is already in progress.

## ioctl VIDIOC\_STREAMON, VIDIOC\_STREAMOFF

### Name

`VIDIOC_STREAMON` - `VIDIOC_STREAMOFF` - Start or stop streaming I/O

### Synopsis

#### `VIDIOC_STREAMON`

```
int ioctl(int fd, VIDIOC_STREAMON, const int *argp)
```

#### `VIDIOC_STREAMOFF`

```
int ioctl(int fd, VIDIOC_STREAMOFF, const int *argp)
```

### Arguments

#### `fd`

File descriptor returned by [`open\(\)`](#).

#### `argp`

Pointer to an integer.

## Description

The VIDIOC\_STREAMON and VIDIOC\_STREAMOFF ioctl start and stop the capture or output process during streaming (*memory mapping*, *user pointer* or *DMABUF*) I/O.

Capture hardware is disabled and no input buffers are filled (if there are any empty buffers in the incoming queue) until VIDIOC\_STREAMON has been called. Output hardware is disabled and no video signal is produced until VIDIOC\_STREAMON has been called.

Memory-to-memory devices will not start until VIDIOC\_STREAMON has been called for both the capture and output stream types.

If VIDIOC\_STREAMON fails then any already queued buffers will remain queued.

The VIDIOC\_STREAMOFF ioctl, apart of aborting or finishing any DMA in progress, unlocks any user pointer buffers locked in physical memory, and it removes all buffers from the incoming and outgoing queues. That means all images captured but not dequeued yet will be lost, likewise all images enqueued for output but not transmitted yet. I/O returns to the same state as after calling *ioctl VIDIOC\_REQBUFS* and can be restarted accordingly.

If buffers have been queued with *ioctl VIDIOC\_QBUF*, *VIDIOC\_DQBUF* and VIDIOC\_STREAMOFF is called without ever having called VIDIOC\_STREAMON, then those queued buffers will also be removed from the incoming queue and all are returned to the same state as after calling *ioctl VIDIOC\_REQBUFS* and can be restarted accordingly.

Both ioctls take a pointer to an integer, the desired buffer or stream type. This is the same as struct *v4l2\_requestbuffers* type.

If VIDIOC\_STREAMON is called when streaming is already in progress, or if VIDIOC\_STREAMOFF is called when streaming is already stopped, then 0 is returned. Nothing happens in the case of VIDIOC\_STREAMON, but VIDIOC\_STREAMOFF will return queued buffers to their starting state as mentioned above.

---

**Note:** Applications can be preempted for unknown periods right before or after the VIDIOC\_STREAMON or VIDIOC\_STREAMOFF calls, there is no notion of starting or stopping "now". Buffer timestamps can be used to synchronize with other events.

---

## Return Value

On success 0 is returned, on error -1 and the *errno* variable is set appropriately. The generic error codes are described at the *Generic Error Codes* chapter.

### EINVAL

The buffer type is not supported, or no buffers have been allocated (memory mapping) or enqueued (output) yet.

### EPIPE

The driver implements *pad-level format configuration* and the pipeline configuration is invalid.

### ENOLINK

The driver implements Media Controller interface and the pipeline link configuration is invalid.

## ioctl VIDIOC\_SUBDEV\_ENUM\_FRAME\_INTERVAL

### Name

VIDIOC\_SUBDEV\_ENUM\_FRAME\_INTERVAL - Enumerate frame intervals

### Synopsis

#### VIDIOC\_SUBDEV\_ENUM\_FRAME\_INTERVAL

```
int ioctl(int fd, VIDIOC_SUBDEV_ENUM_FRAME_INTERVAL, struct  
v4l2_subdev_frame_interval_enum * argp)
```

### Arguments

#### fd

File descriptor returned by [open\(\)](#).

#### argp

Pointer to struct [`v4l2\_subdev\_frame\_interval\_enum`](#).

### Description

This ioctl lets applications enumerate available frame intervals on a given sub-device pad. Frame intervals only makes sense for sub-devices that can control the frame period on their own. This includes, for instance, image sensors and TV tuners.

For the common use case of image sensors, the frame intervals available on the sub-device output pad depend on the frame format and size on the same pad. Applications must thus specify the desired format and size when enumerating frame intervals.

To enumerate frame intervals applications initialize the index, pad, which, code, width and height fields of struct [`v4l2\_subdev\_frame\_interval\_enum`](#) and call the [ioctl VIDIOC\\_SUBDEV\\_ENUM\\_FRAME\\_INTERVAL](#) ioctl with a pointer to this structure. Drivers fill the rest of the structure or return an EINVAL error code if one of the input fields is invalid. All frame intervals are enumerable by beginning at index zero and incrementing by one until EINVAL is returned.

Available frame intervals may depend on the current 'try' formats at other pads of the sub-device, as well as on the current active links. See [ioctl VIDIOC\\_SUBDEV\\_G\\_FMT](#), [VIDIOC\\_SUBDEV\\_S\\_FMT](#) for more information about the try formats.

Sub-devices that support the frame interval enumeration ioctl should implemented it on a single pad only. Its behaviour when supported on multiple pads of the same sub-device is not defined.

type [`v4l2\_subdev\_frame\_interval\_enum`](#)

Table 262: struct v4l2\_subdev\_frame\_interval\_enum

<code>_u32</code>	<code>index</code>	Number of the format in the enumeration, set by the application.
<code>_u32</code>	<code>pad</code>	Pad number as reported by the media controller API.
<code>_u32</code>	<code>code</code>	The media bus format code, as defined in <a href="#">Media Bus Formats</a> .
<code>_u32</code>	<code>width</code>	Frame width, in pixels.
<code>_u32</code>	<code>height</code>	Frame height, in pixels.
struct <code>v4l2_fract</code>	<code>interval</code>	Period, in seconds, between consecutive video frames.
<code>_u32</code>	<code>which</code>	Frame intervals to be enumerated, from enum <code>v4l2_subdev_format whence</code> .
<code>_u32</code>	<code>stream</code>	Stream identifier.
<code>_u32</code>	<code>reserved[7]</code>	Reserved for future extensions. Applications and drivers must set the array to zero.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## EINVAL

The struct `v4l2_subdev_frame_interval_enum` pad references a non-existing pad, the `which` field has an unsupported value, one of the `code`, `width` or `height` fields are invalid for the given pad, or the `index` field is out of bounds.

## ioctl VIDIOC\_SUBDEV\_ENUM\_FRAME\_SIZE

### Name

`VIDIOC_SUBDEV_ENUM_FRAME_SIZE` - Enumerate media bus frame sizes

### Synopsis

#### `VIDIOC_SUBDEV_ENUM_FRAME_SIZE`

```
int ioctl(int fd, VIDIOC_SUBDEV_ENUM_FRAME_SIZE, struct v4l2_subdev_frame_size_enum
* argp)
```

## Arguments

### fd

File descriptor returned by `open()`.

### argp

Pointer to struct `v4l2_subdev_frame_size_enum`.

## Description

This ioctl allows applications to access the enumeration of frame sizes supported by a sub-device on the specified pad for the specified media bus format. Supported formats can be retrieved with the `ioctl VIDIOC_SUBDEV_ENUM_MBUS_CODE` ioctl.

The enumerations are defined by the driver, and indexed using the `index` field of the struct `v4l2_subdev_frame_size_enum`. Each pair of pad and code correspond to a separate enumeration. Each enumeration starts with the `index` of 0, and the lowest invalid index marks the end of the enumeration.

Therefore, to enumerate frame sizes allowed on the specified pad and using the specified mbus format, initialize the pad, which, and code fields to desired values, and set `index` to 0. Then call the `ioctl VIDIOC_SUBDEV_ENUM_FRAME_SIZE` ioctl with a pointer to the structure.

A successful call will return with minimum and maximum frame sizes filled in. Repeat with increasing `index` until `EINVAL` is received. `EINVAL` means that either no more entries are available in the enumeration, or that an input parameter was invalid.

Sub-devices that only support discrete frame sizes (such as most sensors) will return one or more frame sizes with identical minimum and maximum values.

Not all possible sizes in given [minimum, maximum] ranges need to be supported. For instance, a scaler that uses a fixed-point scaling ratio might not be able to produce every frame size between the minimum and maximum values. Applications must use the `VIDIOC_SUBDEV_S_FMT` ioctl to try the sub-device for an exact supported frame size.

Available frame sizes may depend on the current 'try' formats at other pads of the sub-device, as well as on the current active links and the current values of V4L2 controls. See `ioctl VIDIOC_SUBDEV_G_FMT`, `VIDIOC_SUBDEV_S_FMT` for more information about try formats.

type `v4l2_subdev_frame_size_enum`

Table 263: struct v4l2\_subdev\_frame\_size\_enum

<code>_u32</code>	<code>index</code>	Index of the frame size in the enumeration belonging to the given pad and format. Filled in by the application.
<code>_u32</code>	<code>pad</code>	Pad number as reported by the media controller API. Filled in by the application.
<code>_u32</code>	<code>code</code>	The media bus format code, as defined in <a href="#">Media Bus Formats</a> . Filled in by the application.
<code>_u32</code>	<code>min_width</code>	Minimum frame width, in pixels. Filled in by the driver.
<code>_u32</code>	<code>max_width</code>	Maximum frame width, in pixels. Filled in by the driver.
<code>_u32</code>	<code>min_height</code>	Minimum frame height, in pixels. Filled in by the driver.
<code>_u32</code>	<code>max_height</code>	Maximum frame height, in pixels. Filled in by the driver.
<code>_u32</code>	<code>which</code>	Frame sizes to be enumerated, from enum <a href="#"><code>v4l2_subdev_format whence</code></a> .
<code>_u32</code>	<code>stream</code>	Stream identifier.
<code>_u32</code>	<code>reserved[7]</code>	Reserved for future extensions. Applications and drivers must set the array to zero.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## EINVAL

The struct `v4l2_subdev_frame_size_enum` pad references a non-existing pad, the `which` field has an unsupported value, the `code` is invalid for the given pad, or the `index` field is out of bounds.

## ioctl VIDIOC\_SUBDEV\_ENUM\_MBUS\_CODE

### Name

`VIDIOC_SUBDEV_ENUM_MBUS_CODE` - Enumerate media bus formats

## Synopsis

### **VIDIOC\_SUBDEV\_ENUM\_MBUS\_CODE**

```
int ioctl(int fd, VIDIOC_SUBDEV_ENUM_MBUS_CODE, struct v4l2_subdev_mbus_code_enum
* argp)
```

## Arguments

### **fd**

File descriptor returned by [open\(\)](#).

### **argp**

Pointer to struct [`v4l2\_subdev\_mbus\_code\_enum`](#).

## Description

This call is used by the application to access the enumeration of media bus formats for the selected pad.

The enumerations are defined by the driver, and indexed using the `index` field of struct [`v4l2\_subdev\_mbus\_code\_enum`](#). Each enumeration starts with the `index` of 0, and the lowest invalid index marks the end of enumeration.

Therefore, to enumerate media bus formats available at a given sub-device pad, initialize the `pad`, and which fields to desired values, and set `index` to 0. Then call the [`ioctl VIDIOC\_SUBDEV\_ENUM\_MBUS\_CODE`](#) ioctl with a pointer to this structure.

A successful call will return with the `code` field filled in with a mbus code value. Repeat with increasing `index` until EINVAL is received. EINVAL means that either pad is invalid, or that there are no more codes available at this pad.

The driver must not return the same value of `code` for different indices at the same pad.

Available media bus formats may depend on the current 'try' formats at other pads of the sub-device, as well as on the current active links. See [`ioctl VIDIOC\_SUBDEV\_G\_FMT`](#), [`VIDIOC\_SUBDEV\_S\_FMT`](#) for more information about the try formats.

type [`v4l2\_subdev\_mbus\_code\_enum`](#)

Table 264: struct v4l2\_subdev\_mbus\_code\_enum

<code>_u32</code>	<code>pad</code>	Pad number as reported by the media controller API. Filled in by the application.
<code>_u32</code>	<code>index</code>	Index of the mbus code in the enumeration belonging to the given pad. Filled in by the application.
<code>_u32</code>	<code>code</code>	The media bus format code, as defined in <a href="#">Media Bus Formats</a> . Filled in by the driver.
<code>_u32</code>	<code>which</code>	Media bus format codes to be enumerated, from enum <a href="#"><code>v4l2_subdev_format_whence</code></a> .
<code>_u32</code>	<code>flags</code>	See <a href="#">Subdev Media Bus Code Enumerate Flags</a>
<code>_u32</code>	<code>stream</code>	Stream identifier.
<code>_u32</code>	<code>reserved[6]</code>	Reserved for future extensions. Applications and drivers must set the array to zero.

Table 265: Subdev Media Bus Code Enumerate Flags

V4L2_SUBDEV_MBUS_CODE_CSC_COLORSPACE	0x00000001	The driver allows the application to try to change the default colorspace encoding. The application can ask to configure the colorspace of the subdevice when calling the <code>VIDIOC_SUBDEV_S_FMT</code> ioctl with <code>V4L2_MBUS_FRAMEFMT_SET_CSC</code> set. See <i>Media Bus Formats</i> on how to do this.
V4L2_SUBDEV_MBUS_CODE_CSC_XFER_FUNC	0x00000002	The driver allows the application to try to change the default transform function. The application can ask to configure the transform function of the subdevice when calling the <code>VIDIOC_SUBDEV_S_FMT</code> ioctl with <code>V4L2_MBUS_FRAMEFMT_SET_CSC</code> set. See <i>Media Bus Formats</i> on how to do this.
V4L2_SUBDEV_MBUS_CODE_CSC_YCBCR_ENC	0x00000004	The driver allows the application to try to change the default Y'CbCr encoding. The application can ask to configure the Y'CbCr encoding of the subdevice when calling the <code>VIDIOC_SUBDEV_S_FMT</code> ioctl with <code>V4L2_MBUS_FRAMEFMT_SET_CSC</code> set. See <i>Media Bus Formats</i> on how to do this.
V4L2_SUBDEV_MBUS_CODE_CSC_HSV_ENC	0x00000004	The driver allows the application to try to change the default HSV encoding. The application can ask to configure the HSV encoding of the subdevice when calling the <code>VIDIOC_SUBDEV_S_FMT</code> ioctl with <code>V4L2_MBUS_FRAMEFMT_SET_CSC</code> set. See <i>Media Bus Formats</i> on how to do this.
V4L2_SUBDEV_MBUS_CODE_CSC_QUANTIZATION	0x00000008	The driver allows the application to try to change the default quantization. The application can ask to configure the quantization of the subdevice when calling the <code>VIDIOC_SUBDEV_S_FMT</code> ioctl with <code>V4L2_MBUS_FRAMEFMT_SET_CSC</code> set. See <i>Media Bus Formats</i> on how to do this.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the *Generic Error Codes* chapter.

## EINVAL

The struct `v4l2_subdev_mbus_code_enum` pad references a non-existing pad, the `which` field has an unsupported value, or the `index` field is out of bounds.

## ioctl VIDIOC\_SUBDEV\_G\_CROP, VIDIOC\_SUBDEV\_S\_CROP

### Name

VIDIOC\_SUBDEV\_G\_CROP - VIDIOC\_SUBDEV\_S\_CROP - Get or set the crop rectangle on a subdev pad

### Synopsis

#### **VIDIOC\_SUBDEV\_G\_CROP**

```
int ioctl(int fd, VIDIOC_SUBDEV_G_CROP, struct v4l2_subdev_crop *argp)
```

#### **VIDIOC\_SUBDEV\_S\_CROP**

```
int ioctl(int fd, VIDIOC_SUBDEV_S_CROP, const struct v4l2_subdev_crop *argp)
```

### Arguments

#### **fd**

File descriptor returned by [open\(\)](#).

#### **argp**

Pointer to struct [`v4l2\_subdev\_crop`](#).

### Description

---

**Note:** This is an *Obsolete API Elements* interface and may be removed in the future. It is superseded by [the selection API](#).

---

To retrieve the current crop rectangle applications set the pad field of a struct [`v4l2\_subdev\_crop`](#) to the desired pad number as reported by the media API and the which field to V4L2\_SUBDEV\_FORMAT\_ACTIVE. They then call the VIDIOC\_SUBDEV\_G\_CROP ioctl with a pointer to this structure. The driver fills the members of the rect field or returns EINVAL error code if the input arguments are invalid, or if cropping is not supported on the given pad.

To change the current crop rectangle applications set both the pad and which fields and all members of the rect field. They then call the VIDIOC\_SUBDEV\_S\_CROP ioctl with a pointer to this structure. The driver verifies the requested crop rectangle, adjusts it based on the hardware capabilities and configures the device. Upon return the struct [`v4l2\_subdev\_crop`](#) contains the current format as would be returned by a VIDIOC\_SUBDEV\_G\_CROP call.

Applications can query the device capabilities by setting the which to V4L2\_SUBDEV\_FORMAT\_TRY. When set, 'try' crop rectangles are not applied to the device by the driver, but are mangled exactly as active crop rectangles and stored in the sub-device file handle. Two applications querying the same sub-device would thus not interact with each other.

If the subdev device node has been registered in read-only mode, calls to VIDIOC\_SUBDEV\_S\_CROP are only valid if the which field is set to V4L2\_SUBDEV\_FORMAT\_TRY, otherwise an error is returned and the errno variable is set to -EPERM.

Drivers must not return an error solely because the requested crop rectangle doesn't match the device capabilities. They must instead modify the rectangle to match what the hardware can provide. The modified format should be as close as possible to the original request.

type `v4l2_subdev_crop`

Table 266: struct v4l2\_subdev\_crop

<code>_u32</code>	<code>pad</code>	Pad number as reported by the media framework.
<code>_u32</code>	<code>which</code>	Crop rectangle to get or set, from enum <code>v4l2_subdev_format_whence</code> .
<code>struct v4l2_rect</code>	<code>rect</code>	Crop rectangle boundaries, in pixels.
<code>_u32</code>	<code>stream</code>	Stream identifier.
<code>_u32</code>	<code>reserved[7]</code>	Reserved for future extensions. Applications and drivers must set the array to zero.

### Return Value

On success 0 is returned, on error -1 and the errno variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

#### EBUSY

The crop rectangle can't be changed because the pad is currently busy. This can be caused, for instance, by an active video stream on the pad. The ioctl must not be retried without performing another action to fix the problem first. Only returned by VIDIOC\_SUBDEV\_S\_CROP

#### EINVAL

The struct `v4l2_subdev_crop` pad references a non-existing pad, the which field has an unsupported value, or cropping is not supported on the given subdev pad.

#### EPERM

The VIDIOC\_SUBDEV\_S\_CROP ioctl has been called on a read-only subdevice and the which field is set to V4L2\_SUBDEV\_FORMAT\_ACTIVE.

## ioctl VIDIOC\_SUBDEV\_G\_FMT, VIDIOC\_SUBDEV\_S\_FMT

### Name

VIDIOC\_SUBDEV\_G\_FMT - VIDIOC\_SUBDEV\_S\_FMT - Get or set the data format on a subdev pad

## Synopsis

### **VIDIOC\_SUBDEV\_G\_FMT**

```
int ioctl(int fd, VIDIOC_SUBDEV_G_FMT, struct v4l2_subdev_format *argp)
```

### **VIDIOC\_SUBDEV\_S\_FMT**

```
int ioctl(int fd, VIDIOC_SUBDEV_S_FMT, struct v4l2_subdev_format *argp)
```

## Arguments

### **fd**

File descriptor returned by `open()`.

### **argp**

Pointer to struct `v4l2_subdev_format`.

## Description

These ioctls are used to negotiate the frame format at specific subdev pads in the image pipeline.

To retrieve the current format applications set the pad field of a struct `v4l2_subdev_format` to the desired pad number as reported by the media API and the which field to `V4L2_SUBDEV_FORMAT_ACTIVE`. When they call the `VIDIOC_SUBDEV_G_FMT` ioctl with a pointer to this structure the driver fills the members of the format field.

To change the current format applications set both the pad and which fields and all members of the format field. When they call the `VIDIOC_SUBDEV_S_FMT` ioctl with a pointer to this structure the driver verifies the requested format, adjusts it based on the hardware capabilities and configures the device. Upon return the struct `v4l2_subdev_format` contains the current format as would be returned by a `VIDIOC_SUBDEV_G_FMT` call.

Applications can query the device capabilities by setting the which to `V4L2_SUBDEV_FORMAT_TRY`. When set, 'try' formats are not applied to the device by the driver, but are changed exactly as active formats and stored in the sub-device file handle. Two applications querying the same sub-device would thus not interact with each other.

For instance, to try a format at the output pad of a sub-device, applications would first set the try format at the sub-device input with the `VIDIOC_SUBDEV_S_FMT` ioctl. They would then either retrieve the default format at the output pad with the `VIDIOC_SUBDEV_G_FMT` ioctl, or set the desired output pad format with the `VIDIOC_SUBDEV_S_FMT` ioctl and check the returned value.

Try formats do not depend on active formats, but can depend on the current links configuration or sub-device controls value. For instance, a low-pass noise filter might crop pixels at the frame boundaries, modifying its output frame size.

If the subdev device node has been registered in read-only mode, calls to `VIDIOC_SUBDEV_S_FMT` are only valid if the which field is set to `V4L2_SUBDEV_FORMAT_TRY`, otherwise an error is returned and the errno variable is set to `-EPERM`.

Drivers must not return an error solely because the requested format doesn't match the device capabilities. They must instead modify the format to match what the hardware can provide. The modified format should be as close as possible to the original request.

type **v4l2\_subdev\_format**

Table 267: struct v4l2\_subdev\_format

<code>_u32</code>	<code>pad</code>	Pad number as reported by the media controller API.
<code>_u32</code>	<code>which</code>	Format to modified, from enum <code>v4l2_subdev_format_whence</code> .
struct <code>v4l2_mbus_framefmt</code>	<code>format</code>	Definition of an image format, see <code>v4l2_mbus_framefmt</code> for details.
<code>_u32</code>	<code>stream</code>	Stream identifier.
<code>_u32</code>	<code>reserved[7]</code>	Reserved for future extensions. Applications and drivers must set the array to zero.

Table 268: enum v4l2\_subdev\_format\_whence

<code>V4L2_SUBDEV_FORMAT_TRY</code>	0	Try formats, used for querying device capabilities.
<code>V4L2_SUBDEV_FORMAT_ACTIVE</code>	1	Active formats, applied to the hardware.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### EBUSY

The format can't be changed because the pad is currently busy. This can be caused, for instance, by an active video stream on the pad. The ioctl must not be retried without performing another action to fix the problem first. Only returned by VIDIOC\_SUBDEV\_S\_FMT

### EINVAL

The struct `v4l2_subdev_format` pad references a non-existing pad, or the which field has an unsupported value.

### EPERM

The VIDIOC\_SUBDEV\_S\_FMT ioctl has been called on a read-only subdevice and the which field is set to V4L2\_SUBDEV\_FORMAT\_ACTIVE.

---

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## ioctl VIDIOC\_SUBDEV\_G\_FRAME\_INTERVAL, VIDIOC\_SUBDEV\_S\_FRAME\_INTERVAL

### Name

VIDIOC\_SUBDEV\_G\_FRAME\_INTERVAL - VIDIOC\_SUBDEV\_S\_FRAME\_INTERVAL - Get or set the frame interval on a subdev pad

## Synopsis

### **VIDIOC\_SUBDEV\_G\_FRAME\_INTERVAL**

```
int ioctl(int fd, VIDIOC_SUBDEV_G_FRAME_INTERVAL, struct v4l2_subdev_frame_interval
*argp)
```

### **VIDIOC\_SUBDEV\_S\_FRAME\_INTERVAL**

```
int ioctl(int fd, VIDIOC_SUBDEV_S_FRAME_INTERVAL, struct v4l2_subdev_frame_interval
*argp)
```

## Arguments

### **fd**

File descriptor returned by `open()`.

### **argp**

Pointer to struct `v4l2_subdev_frame_interval`.

## Description

These ioctls are used to get and set the frame interval at specific subdev pads in the image pipeline. The frame interval only makes sense for sub-devices that can control the frame period on their own. This includes, for instance, image sensors and TV tuners. Sub-devices that don't support frame intervals must not implement these ioctls.

To retrieve the current frame interval applications set the `pad` field of a struct `v4l2_subdev_frame_interval` to the desired pad number as reported by the media controller API. When they call the `VIDIOC_SUBDEV_G_FRAME_INTERVAL` ioctl with a pointer to this structure the driver fills the members of the `interval` field.

To change the current frame interval applications set both the `pad` field and all members of the `interval` field. When they call the `VIDIOC_SUBDEV_S_FRAME_INTERVAL` ioctl with a pointer to this structure the driver verifies the requested interval, adjusts it based on the hardware capabilities and configures the device. Upon return the struct `v4l2_subdev_frame_interval` contains the current frame interval as would be returned by a `VIDIOC_SUBDEV_G_FRAME_INTERVAL` call.

If the subdev device node has been registered in read-only mode, calls to `VIDIOC_SUBDEV_S_FRAME_INTERVAL` are only valid if the `which` field is set to `V4L2_SUBDEV_FORMAT_TRY`, otherwise an error is returned and the `errno` variable is set to `-EPERM`.

Drivers must not return an error solely because the requested interval doesn't match the device capabilities. They must instead modify the interval to match what the hardware can provide. The modified interval should be as close as possible to the original request.

Changing the frame interval shall never change the format. Changing the format, on the other hand, may change the frame interval.

Sub-devices that support the frame interval ioctls should implement them on a single pad only. Their behaviour when supported on multiple pads of the same sub-device is not defined.

type **v4l2\_subdev\_frame\_interval**

Table 269: struct v4l2\_subdev\_frame\_interval

<code>_u32</code>	<code>pad</code>	Pad number as reported by the media controller API.
struct <i>v4l2_fract</i>	<code>interval</code>	Period, in seconds, between consecutive video frames.
<code>_u32</code>	<code>stream</code>	Stream identifier.
<code>_u32</code>	<code>which</code>	Active or try frame interval, from enum <i>v4l2_subdev_format_whence</i> .
<code>_u32</code>	<code>reserved[7]</code>	Reserved for future extensions. Applications and drivers must set the array to zero.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the *Generic Error Codes* chapter.

### EBUSY

The frame interval can't be changed because the pad is currently busy. This can be caused, for instance, by an active video stream on the pad. The ioctl must not be retried without performing another action to fix the problem first. Only returned by VIDIOC\_SUBDEV\_S\_FRAME\_INTERVAL

### EINVAL

The struct *v4l2\_subdev\_frame\_interval* pad references a non-existing pad, the `which` field has an unsupported value, or the pad doesn't support frame intervals.

### EPERM

The VIDIOC\_SUBDEV\_S\_FRAME\_INTERVAL ioctl has been called on a read-only subdevice and the `which` field is set to V4L2\_SUBDEV\_FORMAT\_ACTIVE.

## ioctl VIDIOC\_SUBDEV\_G\_ROUTING, VIDIOC\_SUBDEV\_S\_ROUTING

### Name

VIDIOC\_SUBDEV\_G\_ROUTING - VIDIOC\_SUBDEV\_S\_ROUTING - Get or set routing between streams of media pads in a media entity.

### Synopsis

#### VIDIOC\_SUBDEV\_G\_ROUTING

```
int ioctl(int fd, VIDIOC_SUBDEV_G_ROUTING, struct v4l2_subdev_routing *argp)
```

#### VIDIOC\_SUBDEV\_S\_ROUTING

```
int ioctl(int fd, VIDIOC_SUBDEV_S_ROUTING, struct v4l2_subdev_routing *argp)
```

## Arguments

### **fd**

File descriptor returned by *open()*.

### **argp**

Pointer to struct *v4l2\_subdev\_routing*.

## Description

These ioctls are used to get and set the routing in a media entity. The routing configuration determines the flows of data inside an entity.

Drivers report their current routing tables using the VIDIOC\_SUBDEV\_G\_ROUTING ioctl and application may enable or disable routes with the VIDIOC\_SUBDEV\_S\_ROUTING ioctl, by adding or removing routes and setting or clearing flags of the `flags` field of a struct *v4l2\_subdev\_route*.

All stream configurations are reset when VIDIOC\_SUBDEV\_S\_ROUTING is called. This means that the userspace must reconfigure all streams after calling the ioctl with e.g. VIDIOC\_SUBDEV\_S\_FMT.

Only subdevices which have both sink and source pads can support routing.

When inspecting routes through VIDIOC\_SUBDEV\_G\_ROUTING and the application provided `num_routes` is not big enough to contain all the available routes the subdevice exposes, drivers return the ENOSPC error code and adjust the value of the `num_routes` field. Application should then reserve enough memory for all the route entries and call VIDIOC\_SUBDEV\_G\_ROUTING again.

On a successful VIDIOC\_SUBDEV\_G\_ROUTING call the driver updates the `num_routes` field to reflect the actual number of routes returned.

### type *v4l2\_subdev\_routing*

Table 270: struct *v4l2\_subdev\_routing*

<code>_u32</code>	<code>which</code>	Routing table to be accessed, from enum <i>v4l2_subdev_format whence</i> .
<code>struct v4l2_subdev_route</code>	<code>routes[]</code>	Array of struct <i>v4l2_subdev_route</i> entries
<code>_u32</code>	<code>num_routes</code>	Number of entries of the routes array
<code>_u32</code>	<code>reserved[5]</code>	Reserved for future extensions. Applications and drivers must set the array to zero.

### type *v4l2\_subdev\_route*

Table 271: struct v4l2\_subdev\_route

<code>__u32</code>	<code>sink_pad</code>	Sink pad number.
<code>__u32</code>	<code>sink_stream</code>	Sink pad stream number.
<code>__u32</code>	<code>source_pad</code>	Source pad number.
<code>__u32</code>	<code>source_stream</code>	Source pad stream number.
<code>__u32</code>	<code>flags</code>	Route enable/disable flags <i>v4l2_subdev_routing_flags</i> .
<code>__u32</code>	<code>reserved[5]</code>	Reserved for future extensions. Applications and drivers must set the array to zero.

Table 272: enum v4l2\_subdev\_routing\_flags

<code>V4L2_SUBDEV_ROUTE_FL_ACTIVE</code>	The route is enabled. Set by applications.
--	--

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### ENOSPC

The application provided `num_routes` is not big enough to contain all the available routes the subdevice exposes.

### EINVAL

The sink or source pad identifiers reference a non-existing pad or reference pads of different types (ie. the `sink_pad` identifiers refers to a source pad), or the `which` field has an unsupported value.

### E2BIG

The application provided `num_routes` for `VIDIOC_SUBDEV_S_ROUTING` is larger than the number of routes the driver can handle.

## ioctl VIDIOC\_SUBDEV\_G\_SELECTION, VIDIOC\_SUBDEV\_S\_SELECTION

### Name

`VIDIOC_SUBDEV_G_SELECTION` - `VIDIOC_SUBDEV_S_SELECTION` - Get or set selection rectangles on a subdev pad

### Synopsis

#### `VIDIOC_SUBDEV_G_SELECTION`

```
int ioctl(int fd, VIDIOC_SUBDEV_G_SELECTION, struct v4l2_subdev_selection
*argp)
```

#### `VIDIOC_SUBDEV_S_SELECTION`

```
int ioctl(int fd, VIDIOC_SUBDEV_S_SELECTION, struct v4l2_subdev_selection
*argp)
```

## Arguments

### `fd`

File descriptor returned by `open()`.

### `argp`

Pointer to struct `v4l2_subdev_selection`.

## Description

The selections are used to configure various image processing functionality performed by the subdevs which affect the image size. This currently includes cropping, scaling and composition.

The selection API replaces *the old subdev crop API*. All the function of the crop API, and more, are supported by the selections API.

See [Sub-device Interface](#) for more information on how each selection target affects the image processing pipeline inside the subdevice.

If the subdev device node has been registered in read-only mode, calls to `VIDIOC_SUBDEV_S_SELECTION` are only valid if the `which` field is set to `V4L2_SUBDEV_FORMAT_TRY`, otherwise an error is returned and the `errno` variable is set to `-EPERM`.

## Types of selection targets

There are two types of selection targets: actual and bounds. The actual targets are the targets which configure the hardware. The BOUNDS target will return a rectangle that contain all possible actual rectangles.

## Discovering supported features

To discover which targets are supported, the user can perform `VIDIOC_SUBDEV_G_SELECTION` on them. Any unsupported target will return `EINVAL`.

Selection targets and flags are documented in [Common selection definitions](#).

type `v4l2_subdev_selection`

Table 273: struct `v4l2_subdev_selection`

<code>__u32</code>	<code>which</code>	Active or try selection, from enum <code>v4l2_subdev_format_whence</code> .
<code>__u32</code>	<code>pad</code>	Pad number as reported by the media framework.
<code>__u32</code>	<code>target</code>	Target selection rectangle. See <a href="#">Common selection definitions</a> .
<code>__u32</code>	<code>flags</code>	Flags. See <a href="#">Selection flags</a> .
struct <code>v4l2_rect</code>	<code>r</code>	Selection rectangle, in pixels.
<code>__u32</code>	<code>stream</code>	Stream identifier.
<code>__u32</code>	<code>reserved[7]</code>	Reserved for future extensions. Applications and drivers must set the array to zero.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### EBUSY

The selection rectangle can't be changed because the pad is currently busy. This can be caused, for instance, by an active video stream on the pad. The ioctl must not be retried without performing another action to fix the problem first. Only returned by `VIDIOC_SUBDEV_S_SELECTION`

### EINVAL

The struct `v4l2_subdev_selection` pad references a non-existing pad, the `which` field has an unsupported value, or the selection target is not supported on the given subdev pad.

### EPERM

The `VIDIOC_SUBDEV_S_SELECTION` ioctl has been called on a read-only subdevice and the `which` field is set to `V4L2_SUBDEV_FORMAT_ACTIVE`.

## ioctl VIDIOC\_SUBDEV\_G\_CLIENT\_CAP, VIDIOC\_SUBDEV\_S\_CLIENT\_CAP

### Name

`VIDIOC_SUBDEV_G_CLIENT_CAP` - `VIDIOC_SUBDEV_S_CLIENT_CAP` - Get or set client capabilities.

### Synopsis

#### `VIDIOC_SUBDEV_G_CLIENT_CAP`

```
int ioctl(int fd, VIDIOC_SUBDEV_G_CLIENT_CAP, struct v4l2_subdev_client_capability *argp)
```

#### `VIDIOC_SUBDEV_S_CLIENT_CAP`

```
int ioctl(int fd, VIDIOC_SUBDEV_S_CLIENT_CAP, struct v4l2_subdev_client_capability *argp)
```

### Arguments

#### `fd`

File descriptor returned by [`open\(\)`](#).

#### `argp`

Pointer to struct `v4l2_subdev_client_capability`.

## Description

These ioctls are used to get and set the client (the application using the subdevice ioctls) capabilities. The client capabilities are stored in the file handle of the opened subdev device node, and the client must set the capabilities for each opened subdev separately.

By default no client capabilities are set when a subdev device node is opened.

The purpose of the client capabilities are to inform the kernel of the behavior of the client, mainly related to maintaining compatibility with different kernel and userspace versions.

The VIDIOC\_SUBDEV\_G\_CLIENT\_CAP ioctl returns the current client capabilities associated with the file handle fd.

The VIDIOC\_SUBDEV\_S\_CLIENT\_CAP ioctl sets client capabilities for the file handle fd. The new capabilities fully replace the current capabilities, the ioctl can therefore also be used to remove capabilities that have previously been set.

VIDIOC\_SUBDEV\_S\_CLIENT\_CAP modifies the struct `v4l2_subdev_client_capability` to reflect the capabilities that have been accepted. A common case for the kernel not accepting a capability is that the kernel is older than the headers the userspace uses, and thus the capability is unknown to the kernel.

Table 274: Client Capabilities

Capability	Description
V4L2_SUBDEV_CLIENT_CAP_STREAMS	The client is aware of streams. Setting this flag enables the use of 'stream' fields (referring to the stream number) with various ioctls. If this is not set (which is the default), the 'stream' fields will be forced to 0 by the kernel.
V4L2_SUBDEV_CLIENT_CAP_INTERVAL_USE	The client is aware of the <code>v4l2_subdev_frame_interval</code> which field. If this is not set (which is the default), the which field is forced to V4L2_SUBDEV_FORMAT_ACTIVE by the kernel.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### ENOIOCTLCMD

The kernel does not support this ioctl.

**ioctl VIDIOC\_SUBDEV\_QUERYCAP****Name**

VIDIOC\_SUBDEV\_QUERYCAP - Query sub-device capabilities

**Synopsis****VIDIOC\_SUBDEV\_QUERYCAP**

```
int ioctl(int fd, VIDIOC_SUBDEV_QUERYCAP, struct v4l2_subdev_capability *argp)
```

**Arguments****fd**

File descriptor returned by *open()*.

**argp**

Pointer to struct *v4l2\_subdev\_capability*.

**Description**

All V4L2 sub-devices support the VIDIOC\_SUBDEV\_QUERYCAP ioctl. It is used to identify kernel devices compatible with this specification and to obtain information about driver and hardware capabilities. The ioctl takes a pointer to a struct *v4l2\_subdev\_capability* which is filled by the driver. When the driver is not compatible with this specification the ioctl returns ENOTTY error code.

**type *v4l2\_subdev\_capability***

Table 275: struct v4l2\_subdev\_capability

<code>_u32</code>	<code>version</code>	Version number of the driver. The version reported is provided by the V4L2 subsystem following the kernel numbering scheme. However, it may not always return the same version as the kernel if, for example, a stable or distribution-modified kernel uses the V4L2 stack from a newer kernel. The version number is formatted using the KERNEL_VERSION() macro:
<pre>#define KERNEL_VERSION(a,b,c) (((a) &lt;&lt; 16) + ((b) &lt;&lt; 8) + (c)) __u32 version = KERNEL_VERSION(0, 8, 1); printf ("Version: %u.%u.%u\n", (version &gt;&gt; 16) &amp; 0xFF, (version &gt;&gt; 8) &amp; 0xFF, version &amp; 0xFF);</pre>		
<code>_u32</code>	<code>capabilities</code>	Sub-device capabilities of the opened device, see <i>Sub-Device Capabilities Flags</i> .
<code>_u32</code>	<code>reserved[14]</code>	Reserved for future extensions. Set to 0 by the V4L2 core.

Table 276: Sub-Device Capabilities Flags

V4L2_SUBDEV_CAP_RO_SUBDEV	0x00000001	The sub-device device node is registered in read-only mode. Access to the sub-device ioctls that modify the device state is restricted. Refer to each individual sub-device ioctl documentation for a description of which restrictions apply to a read-only sub-device.
---------------------------	------------	--

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### ENOTTY

The device node is not a V4L2 sub-device.

## ioctl VIDIOC\_SUBSCRIBE\_EVENT, VIDIOC\_UNSUBSCRIBE\_EVENT

### Name

`VIDIOC_SUBSCRIBE_EVENT` - `VIDIOC_UNSUBSCRIBE_EVENT` - Subscribe or unsubscribe event

### Synopsis

#### `VIDIOC_SUBSCRIBE_EVENT`

```
int ioctl(int fd, VIDIOC_SUBSCRIBE_EVENT, struct v4l2_event_subscription *argp)
```

#### `VIDIOC_UNSUBSCRIBE_EVENT`

```
int ioctl(int fd, VIDIOC_UNSUBSCRIBE_EVENT, struct v4l2_event_subscription *argp)
```

### Arguments

#### `fd`

File descriptor returned by `open()`.

#### `argp`

Pointer to struct `v4l2_event_subscription`.

## Description

Subscribe or unsubscribe V4L2 event. Subscribed events are dequeued by using the [ioctl VIDIOC\\_DQEVENT](#) ioctl.

type **v4l2\_event\_subscription**

Table 277: struct v4l2\_event\_subscription

<code>_u32</code>	<code>type</code>	Type of the event, see <a href="#">Event Types</a> .  <b>Note:</b> <code>V4L2_EVENT_ALL</code> can be used with <a href="#">VIDIOC_UNSUBSCRIBE_EVENT</a> for unsubscribing all events at once.
<code>_u32</code>	<code>id</code>	ID of the event source. If there is no ID associated with the event source, then set this to 0. Whether or not an event needs an ID depends on the event type.
<code>_u32</code>	<code>flags</code>	Event flags, see <a href="#">Event Flags</a> .
<code>_u32</code>	<code>reserved[5]</code>	Reserved for future extensions. Drivers and applications must set the array to zero.

Table 278: Event Flags

<code>V4L2_EVENT_SUB_FL_SEND_INITIAL</code>	0x0001	When this event is subscribed an initial event will be sent containing the current status. This only makes sense for events that are triggered by a status change such as <code>V4L2_EVENT_CTRL</code> . Other events will ignore this flag.
<code>V4L2_EVENT_SUB_FL_ALLOW_FEEDBACK</code>	0x0002	If set, then events directly caused by an ioctl will also be sent to the filehandle that called that ioctl. For example, changing a control using <code>VIDIOC_S_CTRL</code> will cause a <code>V4L2_EVENT_CTRL</code> to be sent back to that same filehandle. Normally such events are suppressed to prevent feedback loops where an application changes a control to a one value and then another, and then receives an event telling it that that control has changed to the first value. Since it can't tell whether that event was caused by another application or by the <code>VIDIOC_S_CTRL</code> call it is hard to decide whether to set the control to the value in the event, or ignore it. Think carefully when you set this flag so you won't get into situations like that.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## V4L2 mmap()

### Name

`v4l2-mmap` - Map device memory into application address space

### Synopsis

```
#include <unistd.h>
#include <sys/mman.h>
```

```
void *mmap(void *start, size_t length, int prot, int flags, int fd, off_t offset)
```

### Arguments

#### start

Map the buffer to this address in the application's address space. When the `MAP_FIXED` flag is specified, `start` must be a multiple of the pagesize and `mmap` will fail when the specified address cannot be used. Use of this option is discouraged; applications should just specify a `NULL` pointer here.

#### length

Length of the memory area to map. This must be the same value as returned by the driver in the struct `v4l2_buffer` `length` field for the single-planar API, and the same value as returned by the driver in the struct `v4l2_plane` `length` field for the multi-planar API.

#### prot

The `prot` argument describes the desired memory protection. Regardless of the device type and the direction of data exchange it should be set to `PROT_READ | PROT_WRITE`, permitting read and write access to image buffers. Drivers should support at least this combination of flags.

---

#### Note:

1. The Linux videobuf kernel module, which is used by some drivers supports only `PROT_READ | PROT_WRITE`. When the driver does not support the desired protection, the `mmap()` function fails.
  2. Device memory accesses (e. g. the memory on a graphics card with video capturing hardware) may incur a performance penalty compared to main memory accesses, or reads may be significantly slower than writes or vice versa. Other I/O methods may be more efficient in such case.
-

## flags

The `flags` parameter specifies the type of the mapped object, mapping options and whether modifications made to the mapped copy of the page are private to the process or are to be shared with other references.

`MAP_FIXED` requests that the driver selects no other address than the one specified. If the specified address cannot be used, `mmap()` will fail. If `MAP_FIXED` is specified, `start` must be a multiple of the pagesize. Use of this option is discouraged.

One of the `MAP_SHARED` or `MAP_PRIVATE` flags must be set. `MAP_SHARED` allows applications to share the mapped memory with other (e. g. child-) processes.

---

**Note:** The Linux `videobuf` module which is used by some drivers supports only `MAP_SHARED`. `MAP_PRIVATE` requests copy-on-write semantics. V4L2 applications should not set the `MAP_PRIVATE`, `MAP_DENYWRITE`, `MAP_EXECUTABLE` or `MAP_ANON` flags.

---

## fd

File descriptor returned by `open()`.

## offset

Offset of the buffer in device memory. This must be the same value as returned by the driver in the struct `v4l2_buffer` `m_union offset` field for the single-planar API, and the same value as returned by the driver in the struct `v4l2_plane` `m_union mem_offset` field for the multi-planar API.

## Description

The `mmap()` function asks to map `length` bytes starting at `offset` in the memory of the device specified by `fd` into the application address space, preferably at address `start`. This latter address is a hint only, and is usually specified as 0.

Suitable `length` and `offset` parameters are queried with the `ioctl VIDIOC_QUERYBUF` ioctl. Buffers must be allocated with the `ioctl VIDIOC_REQBUFS` ioctl before they can be queried.

To unmap buffers the `munmap()` function is used.

## Return Value

On success `mmap()` returns a pointer to the mapped buffer. On error `MAP_FAILED` (-1) is returned, and the `errno` variable is set appropriately. Possible error codes are:

### EBADF

`fd` is not a valid file descriptor.

### EACCES

`fd` is not open for reading and writing.

### EINVAL

The `start` or `length` or `offset` are not suitable. (E. g. they are too large, or not aligned on a `PAGESIZE` boundary.)

The `flags` or `prot` value is not supported.

No buffers have been allocated with the `ioctl VIDIOC REQBUFS` ioctl.

## ENOMEM

Not enough physical or virtual memory was available to complete the request.

## V4L2 munmap()

### Name

v4l2-munmap - Unmap device memory

### Synopsis

```
#include <unistd.h>
#include <sys/mman.h>
```

```
int munmap(void *start, size_t length)
```

### Arguments

#### start

Address of the mapped buffer as returned by the `mmap()` function.

#### length

Length of the mapped buffer. This must be the same value as given to `mmap()` and returned by the driver in the struct `v4l2_buffer` `length` field for the single-planar API and in the struct `v4l2_plane` `length` field for the multi-planar API.

### Description

Unmaps a previously with the `mmap()` function mapped buffer and frees it, if possible.

### Return Value

On success `munmap()` returns 0, on failure -1 and the `errno` variable is set appropriately:

#### EINVAL

The `start` or `length` is incorrect, or no buffers have been mapped yet.

## V4L2 open()

### Name

v4l2-open - Open a V4L2 device

### Synopsis

```
#include <fcntl.h>
```

```
int open(const char *device_name, int flags)
```

### Arguments

#### device\_name

Device to be opened.

#### flags

Open flags. Access mode must be `O_RDWR`. This is just a technicality, input devices still support only reading and output devices only writing.

When the `O_NONBLOCK` flag is given, the `read()` function and the `VIDIOC_DQBUF` ioctl will return the `EAGAIN` error code when no data is available or no buffer is in the driver outgoing queue, otherwise these functions block until data becomes available. All V4L2 drivers exchanging data with applications must support the `O_NONBLOCK` flag.

Other flags have no effect.

### Description

To open a V4L2 device applications call `open()` with the desired device name. This function has no side effects; all data format parameters, current input or output, control values or other properties remain unchanged. At the first `open()` call after loading the driver they will be reset to default values, drivers are never in an undefined state.

### Return Value

On success `open()` returns the new file descriptor. On error -1 is returned, and the `errno` variable is set appropriately. Possible error codes are:

#### EACCES

The caller has no permission to access the device.

#### EBUSY

The driver does not support multiple opens and the device is already in use.

#### ENXIO

No device corresponding to this device special file exists.

**ENOMEM**

Not enough kernel memory was available to complete the request.

**EMFILE**

The process already has the maximum number of files open.

**ENFILE**

The limit on the total number of files open on the system has been reached.

**V4L2 poll()****Name**

v4l2-poll - Wait for some event on a file descriptor

**Synopsis**

```
#include <sys/poll.h>
```

```
int poll(struct pollfd *ufds, unsigned int nfds, int timeout)
```

**Arguments****Description**

With the `poll()` function applications can suspend execution until the driver has captured data or is ready to accept data for output.

When streaming I/O has been negotiated this function waits until a buffer has been filled by the capture device and can be dequeued with the `VIDIOC_DQBUF` ioctl. For output devices this function waits until the device is ready to accept a new buffer to be queued up with the `VIDIOC_QBUF` ioctl for display. When buffers are already in the outgoing queue of the driver (capture) or the incoming queue isn't full (display) the function returns immediately.

On success `poll()` returns the number of file descriptors that have been selected (that is, file descriptors for which the `revents` field of the respective `struct pollfd` structure is non-zero). Capture devices set the POLLIN and POLLRDNORM flags in the `revents` field, output devices the POLLOUT and POLLWRNORM flags. When the function timed out it returns a value of zero, on failure it returns -1 and the `errno` variable is set appropriately. When the application did not call `VIDIOC_STREAMON` the `poll()` function succeeds, but sets the POLLERR flag in the `revents` field. When the application has called `VIDIOC_STREAMON` for a capture device but hasn't yet called `VIDIOC_QBUF`, the `poll()` function succeeds and sets the POLLERR flag in the `revents` field. For output devices this same situation will cause `poll()` to succeed as well, but it sets the POLLOUT and POLLWRNORM flags in the `revents` field.

If an event occurred (see `ioctl VIDIOC_DQEVENT`) then POLLPRI will be set in the `revents` field and `poll()` will return.

When use of the `read()` function has been negotiated and the driver does not capture yet, the `poll()` function starts capturing. When that fails it returns a POLLERR as above. Otherwise it

waits until data has been captured and can be read. When the driver captures continuously (as opposed to, for example, still images) the function may return immediately.

When use of the `write()` function has been negotiated and the driver does not stream yet, the `poll()` function starts streaming. When that fails it returns a POLLERR as above. Otherwise it waits until the driver is ready for a non-blocking `write()` call.

If the caller is only interested in events (just POLLPRI is set in the events field), then `poll()` will *not* start streaming if the driver does not stream yet. This makes it possible to just poll for events and not for buffers.

All drivers implementing the `read()` or `write()` function or streaming I/O must also support the `poll()` function.

For more details see the `poll()` manual page.

## Return Value

On success, `poll()` returns the number structures which have non-zero `revents` fields, or zero if the call timed out. On error -1 is returned, and the `errno` variable is set appropriately:

### **EBADF**

One or more of the `ufds` members specify an invalid file descriptor.

### **EBUSY**

The driver does not support multiple read or write streams and the device is already in use.

### **EFAULT**

`ufds` references an inaccessible memory area.

### **EINTR**

The call was interrupted by a signal.

### **EINVAL**

The `nfds` value exceeds the `RLIMIT_NOFILE` value. Use `getrlimit()` to obtain this value.

## V4L2 read()

### Name

`v4l2-read` - Read from a V4L2 device

### Synopsis

```
#include <unistd.h>
```

```
ssize_t read(int fd, void *buf, size_t count)
```

## Arguments

### **fd**

File descriptor returned by [open\(\)](#).

### **buf**

Buffer to be filled

### **count**

Max number of bytes to read

## Description

[read\(\)](#) attempts to read up to count bytes from file descriptor fd into the buffer starting at buf. The layout of the data in the buffer is discussed in the respective device interface section, see [##](#). If count is zero, [read\(\)](#) returns zero and has no other results. If count is greater than [SSIZE\\_MAX](#), the result is unspecified. Regardless of the count value each [read\(\)](#) call will provide at most one frame (two fields) worth of data.

By default [read\(\)](#) blocks until data becomes available. When the [O\\_NONBLOCK](#) flag was given to the [open\(\)](#) function it returns immediately with an [EAGAIN](#) error code when no data is available. The [select\(\)](#) or [poll\(\)](#) functions can always be used to suspend execution until data becomes available. All drivers supporting the [read\(\)](#) function must also support [select\(\)](#) and [poll\(\)](#).

Drivers can implement read functionality in different ways, using a single or multiple buffers and discarding the oldest or newest frames once the internal buffers are filled.

[read\(\)](#) never returns a "snapshot" of a buffer being filled. Using a single buffer the driver will stop capturing when the application starts reading the buffer until the read is finished. Thus only the period of the vertical blanking interval is available for reading, or the capture rate must fall below the nominal frame rate of the video standard.

The behavior of [read\(\)](#) when called during the active picture period or the vertical blanking separating the top and bottom field depends on the discarding policy. A driver discarding the oldest frames keeps capturing into an internal buffer, continuously overwriting the previously, not read frame, and returns the frame being received at the time of the [read\(\)](#) call as soon as it is complete.

A driver discarding the newest frames stops capturing until the next [read\(\)](#) call. The frame being received at [read\(\)](#) time is discarded, returning the following frame instead. Again this implies a reduction of the capture rate to one half or less of the nominal frame rate. An example of this model is the video read mode of the bttv driver, initiating a DMA to user memory when [read\(\)](#) is called and returning when the DMA finished.

In the multiple buffer model drivers maintain a ring of internal buffers, automatically advancing to the next free buffer. This allows continuous capturing when the application can empty the buffers fast enough. Again, the behavior when the driver runs out of free buffers depends on the discarding policy.

Applications can get and set the number of buffers used internally by the driver with the [VIDIOC\\_G\\_PARM](#) and [VIDIOC\\_S\\_PARM](#) ioctls. They are optional, however. The discarding policy is not reported and cannot be changed. For minimum requirements see [Interfaces](#).

### Return Value

On success, the number of bytes read is returned. It is not an error if this number is smaller than the number of bytes requested, or the amount of data required for one frame. This may happen for example because `read()` was interrupted by a signal. On error, -1 is returned, and the `errno` variable is set appropriately. In this case the next read will start at the beginning of a new frame. Possible error codes are:

#### EAGAIN

Non-blocking I/O has been selected using `O_NONBLOCK` and no data was immediately available for reading.

#### EBADF

`fd` is not a valid file descriptor or is not open for reading, or the process already has the maximum number of files open.

#### EBUSY

The driver does not support multiple read streams and the device is already in use.

#### EFAULT

`buf` references an inaccessible memory area.

#### EINTR

The call was interrupted by a signal before any data was read.

#### EIO

I/O error. This indicates some hardware problem or a failure to communicate with a remote device (USB camera etc.).

#### EINVAL

The `read()` function is not supported by this driver, not on this device, or generally not on this type of device.

## V4L2 select()

### Name

v4l2-select - Synchronous I/O multiplexing

### Synopsis

```
#include <sys/time.h>
#include <sys/types.h>
#include <unistd.h>
```

```
int select(int nfds, fd_set *readfds, fd_set *writefds, fd_set *exceptfds, struct timeval
           *timeout)
```

## Arguments

### **nfds**

The highest-numbered file descriptor in any of the three sets, plus 1.

### **readfds**

File descriptions to be watched if a read() call won't block.

### **writelfds**

File descriptions to be watched if a write() won't block.

### **exceptfds**

File descriptions to be watched for V4L2 events.

### **timeout**

Maximum time to wait.

## Description

With the `select()` function applications can suspend execution until the driver has captured data or is ready to accept data for output.

When streaming I/O has been negotiated this function waits until a buffer has been filled or displayed and can be dequeued with the `VIDIOC_DQBUF` ioctl. When buffers are already in the outgoing queue of the driver the function returns immediately.

On success `select()` returns the total number of bits set in `fd_set`. When the function timed out it returns a value of zero. On failure it returns -1 and the `errno` variable is set appropriately. When the application did not call `ioctl VIDIOC_QBUF`, `VIDIOC_DQBUF` or `ioctl VIDIOC_STREAMON`, `VIDIOC_STREAMOFF` yet the `select()` function succeeds, setting the bit of the file descriptor in `readfds` or `writelfds`, but subsequent `VIDIOC_DQBUF` calls will fail.<sup>1</sup>

When use of the `read()` function has been negotiated and the driver does not capture yet, the `select()` function starts capturing. When that fails, `select()` returns successful and a subsequent `read()` call, which also attempts to start capturing, will return an appropriate error code. When the driver captures continuously (as opposed to, for example, still images) and data is already available the `select()` function returns immediately.

When use of the `write()` function has been negotiated the `select()` function just waits until the driver is ready for a non-blocking `write()` call.

All drivers implementing the `read()` or `write()` function or streaming I/O must also support the `select()` function.

For more details see the `select()` manual page.

---

<sup>1</sup> The Linux kernel implements `select()` like the `poll()` function, but `select()` cannot return a POLLERR.

### Return Value

On success, `select()` returns the number of descriptors contained in the three returned descriptor sets, which will be zero if the timeout expired. On error -1 is returned, and the `errno` variable is set appropriately; the sets and `timeout` are undefined. Possible error codes are:

#### **EBADF**

One or more of the file descriptor sets specified a file descriptor that is not open.

#### **EBUSY**

The driver does not support multiple read or write streams and the device is already in use.

#### **EFAULT**

The `readfds`, `writelfds`, `exceptfds` or `timeout` pointer references an inaccessible memory area.

#### **EINTR**

The call was interrupted by a signal.

#### **EINVAL**

The `nfds` argument is less than zero or greater than `FD_SETSIZE`.

## V4L2 write()

### Name

v4l2-write - Write to a V4L2 device

### Synopsis

```
#include <unistd.h>
```

```
ssize_t write(int fd, void *buf, size_t count)
```

### Arguments

#### **fd**

File descriptor returned by `open()`.

#### **buf**

Buffer with data to be written

#### **count**

Number of bytes at the buffer

## Description

`write()` writes up to count bytes to the device referenced by the file descriptor fd from the buffer starting at buf. When the hardware outputs are not active yet, this function enables them. When count is zero, `write()` returns 0 without any other effect.

When the application does not provide more data in time, the previous video frame, raw VBI image, sliced VPS or WSS data is displayed again. Sliced Teletext or Closed Caption data is not repeated, the driver inserts a blank line instead.

## Return Value

On success, the number of bytes written are returned. Zero indicates nothing was written. On error, -1 is returned, and the `errno` variable is set appropriately. In this case the next write will start at the beginning of a new frame. Possible error codes are:

### EAGAIN

Non-blocking I/O has been selected using the `O_NONBLOCK` flag and no buffer space was available to write the data immediately.

### EBADF

fd is not a valid file descriptor or is not open for writing.

### EBUSY

The driver does not support multiple write streams and the device is already in use.

### EFAULT

buf references an inaccessible memory area.

### EINTR

The call was interrupted by a signal before any data was written.

### EIO

I/O error. This indicates some hardware problem.

### EINVAL

The `write()` function is not supported by this driver, not on this device, or generally not on this type of device.

## 13.2.8 Common definitions for V4L2 and V4L2 subdev interfaces

### Common selection definitions

While the *V4L2 selection API* and *V4L2 subdev selection APIs* are very similar, there's one fundamental difference between the two. On sub-device API, the selection rectangle refers to the media bus format, and is bound to a sub-device's pad. On the V4L2 interface the selection rectangles refer to the in-memory pixel format.

This section defines the common definitions of the selection interfaces on the two APIs.

## Selection targets

The precise meaning of the selection targets may be dependent on which of the two interfaces they are used.

Table 279: Selection target definitions

Target name	id	Definition	Valid for V4L2	Valid for V4L2 sub-dev
V4L2_SEL_TGT_CROP	0x0000	Crop rectangle. Defines the cropped area.	Yes	Yes
V4L2_SEL_TGT_CROP_DEFAULT	0x0001	Suggested cropping rectangle that covers the "whole picture". This includes only active pixels and excludes other non-active pixels such as black pixels.	Yes	Yes
V4L2_SEL_TGT_CROP_BOUNDS	0x0002	Bounds of the crop rectangle. All valid crop rectangles fit inside the crop bounds rectangle.	Yes	Yes
V4L2_SEL_TGT_NATIVE_SIZE	0x0003	The native size of the device, e.g. a sensor's pixel array. <code>left</code> and <code>top</code> fields are zero for this target.	Yes	Yes
V4L2_SEL_TGT_COMPOSE	0x0100	Compose rectangle. Used to configure scaling and composition.	Yes	Yes
V4L2_SEL_TGT_COMPOSE_DEFAULT	0x0101	Suggested composition rectangle that covers the "whole picture".	Yes	No
V4L2_SEL_TGT_COMPOSE_BOUNDS	0x0102	Bounds of the compose rectangle. All valid compose rectangles fit inside the compose bounds rectangle.	Yes	Yes
V4L2_SEL_TGT_COMPOSE_PADDED	0x0103	The active area and all padding pixels that are inserted or modified by hardware.	Yes	No

## Selection flags

Table 280: Selection flag definitions

Flag name	id	Definition	Valid for V4L2	Valid for V4L2 sub-dev
V4L2_SEL_FLAG_GE	(1 << 0)	Suggest the driver it should choose greater or equal rectangle (in size) than was requested. Albeit the driver may choose a lesser size, it will only do so due to hardware limitations. Without this flag (and V4L2_SEL_FLAG_LE) the behaviour is to choose the closest possible rectangle.	Yes	Yes

continues on next page

Table 280 – continued from previous page

Flag name	id	Definition	Valid for V4L2	Valid for V4L2 sub-dev
V4L2_SEL_FLAG_LE	(1 << 1)	Suggest the driver it should choose lesser or equal rectangle (in size) than was requested. Albeit the driver may choose a greater size, it will only do so due to hardware limitations.	Yes	Yes
V4L2_SEL_FLAG_KEEP_CONFIG	(1 << 2)	The configuration must not be propagated to any further processing steps. If this flag is not given, the configuration is propagated inside the subdevice to all further processing steps.	No	Yes

### 13.2.9 Video For Linux Two Header File

#### videodev2.h

```
/* SPDX-License-Identifier: ((GPL-2.0+ WITH Linux-syscall-note) OR
 * BSD-3-Clause) */
/*
 * Video for Linux Two header file
 *
 * Copyright (C) 1999-2012 the contributors
 *
 * This program is free software; you can redistribute it and/or modify
 * it under the terms of the GNU General Public License as published by
 * the Free Software Foundation; either version 2 of the License, or
 * (at your option) any later version.
 *
 * This program is distributed in the hope that it will be useful,
 * but WITHOUT ANY WARRANTY; without even the implied warranty of
 * MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
 * GNU General Public License for more details.
 *
 * Alternatively you can redistribute this file under the terms of the
 * BSD license as stated below:
 *
 * Redistribution and use in source and binary forms, with or without
 * modification, are permitted provided that the following conditions
 * are met:
 * 1. Redistributions of source code must retain the above copyright
 *    notice, this list of conditions and the following disclaimer.
 * 2. Redistributions in binary form must reproduce the above copyright
 *    notice, this list of conditions and the following disclaimer in
 *    the documentation and/or other materials provided with the
 *    distribution.
 */


```

```
* 3. The names of its contributors may not be used to endorse or promote
*    products derived from this software without specific prior written
*    permission.
*
* THIS SOFTWARE IS PROVIDED BY THE COPYRIGHT HOLDERS AND CONTRIBUTORS
* "AS IS" AND ANY EXPRESS OR IMPLIED WARRANTIES, INCLUDING, BUT NOT
* LIMITED TO, THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR
* A PARTICULAR PURPOSE ARE DISCLAIMED. IN NO EVENT SHALL THE COPYRIGHT
* OWNER OR CONTRIBUTORS BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL,
* SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED
* TO, PROCUREMENT OF SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR
* PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF
* LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING
* NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE USE OF THIS
* SOFTWARE, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE.
*
* Header file for v4l or V4L2 drivers and applications
* with public API.
* All kernel-specific stuff were moved to media/v4l2-dev.h, so
* no #if __KERNEL tests are allowed here
*
* See https://linuxtv.org for more info
*
* Author: Bill Dirks <bill@thedirks.org>
*          Justin Schoeman
*          Hans Verkuil <hverkuil@xs4all.nl>
*          et al.
*/
#ifndef _UAPI_LINUX_VIDEODEV2_H
#define _UAPI_LINUX_VIDEODEV2_H

#ifndef __KERNEL__
#include <sys/time.h>
#endif
#include <linux/compiler.h>
#include <linux/ioctl.h>
#include <linux/types.h>
#include <linux/v4l2-common.h>
#include <linux/v4l2-controls.h>

/*
 * Common stuff for both V4L1 and V4L2
 * Moved from videodev.h
 */
#define VIDEO_MAX_FRAME          32
#define VIDEO_MAX_PLANES         8

/*
 *      M I S C E L L A N E O U S
*/
```

```

/* Four-character-code (FOURCC) */
#define v4l2_fourcc(a, b, c, d) \
    ((__u32)(a) | ((__u32)(b) << 8) | ((__u32)(c) << 16) | ((__u32)(d) << \
     24))
#define v4l2_fourcc_be(a, b, c, d)      (v4l2_fourcc(a, b, c, d) | (1U << 31))

/*
 * E N U M S
 */
enum v4l2_field {
    V4L2_FIELD_ANY          = 0, /* driver can choose from none,
                                    top, bottom, interlaced
                                    depending on whatever it thinks
                                    is approximate ... */
    V4L2_FIELD_NONE         = 1, /* this device has no fields ... */
    V4L2_FIELD_TOP          = 2, /* top field only */
    V4L2_FIELD_BOTTOM        = 3, /* bottom field only */
    V4L2_FIELD_INTERLACED   = 4, /* both fields interlaced */
    V4L2_FIELD_SEQ_TB        = 5, /* both fields sequential into one
                                    buffer, top-bottom order */
    V4L2_FIELD_SEQ_BT        = 6, /* same as above + bottom-top order */
    V4L2_FIELD_ALTERNATE    = 7, /* both fields alternating into
                                    separate buffers */
    V4L2_FIELD_INTERLACED_TB = 8, /* both fields interlaced, top field
                                    first and the top field is
                                    transmitted first */
    V4L2_FIELD_INTERLACED_BT = 9, /* both fields interlaced, top field
                                    first and the bottom field is
                                    transmitted first */
};

#define V4L2_FIELD_HAS_TOP(field) \
    ((field) == V4L2_FIELD_TOP || \
     (field) == V4L2_FIELD_INTERLACED || \
     (field) == V4L2_FIELD_INTERLACED_TB || \
     (field) == V4L2_FIELD_INTERLACED_BT || \
     (field) == V4L2_FIELD_SEQ_TB || \
     (field) == V4L2_FIELD_SEQ_BT)

#define V4L2_FIELD_HAS_BOTTOM(field) \
    ((field) == V4L2_FIELD_BOTTOM || \
     (field) == V4L2_FIELD_INTERLACED || \
     (field) == V4L2_FIELD_INTERLACED_TB || \
     (field) == V4L2_FIELD_INTERLACED_BT || \
     (field) == V4L2_FIELD_SEQ_TB || \
     (field) == V4L2_FIELD_SEQ_BT)

#define V4L2_FIELD_HAS_BOTH(field) \
    ((field) == V4L2_FIELD_INTERLACED || \
     (field) == V4L2_FIELD_INTERLACED_TB || \
     (field) == V4L2_FIELD_INTERLACED_BT || \
     (field) == V4L2_FIELD_SEQ_TB || \
     (field) == V4L2_FIELD_SEQ_BT)

#define V4L2_FIELD_HAS_T_OR_B(field) \

```

```

        ((field) == V4L2_FIELD_BOTTOM ||\
         (field) == V4L2_FIELD_TOP ||\
         (field) == V4L2_FIELD_ALTERNATE)
#define V4L2_FIELD_IS_INTERLACED(field) \
        ((field) == V4L2_FIELD_INTERLACED ||\
         (field) == V4L2_FIELD_INTERLACED_TB ||\
         (field) == V4L2_FIELD_INTERLACED_BT)
#define V4L2_FIELD_IS_SEQUENTIAL(field) \
        ((field) == V4L2_FIELD_SEQ_TB ||\
         (field) == V4L2_FIELD_SEQ_BT)

enum v4l2_buf_type {
    V4L2_BUF_TYPE_VIDEO_CAPTURE          = 1,
    V4L2_BUF_TYPE_VIDEO_OUTPUT          = 2,
    V4L2_BUF_TYPE_VIDEO_OVERLAY         = 3,
    V4L2_BUF_TYPE_VBI_CAPTURE          = 4,
    V4L2_BUF_TYPE_VBI_OUTPUT           = 5,
    V4L2_BUF_TYPE_SLICED_VBI_CAPTURE   = 6,
    V4L2_BUF_TYPE_SLICED_VBI_OUTPUT    = 7,
    V4L2_BUF_TYPE_VIDEO_OUTPUT_OVERLAY = 8,
    V4L2_BUF_TYPE_VIDEO_CAPTURE_MPLANE = 9,
    V4L2_BUF_TYPE_VIDEO_OUTPUT_MPLANE  = 10,
    V4L2_BUF_TYPE_SDR_CAPTURE          = 11,
    V4L2_BUF_TYPE_SDR_OUTPUT           = 12,
    V4L2_BUF_TYPE_META_CAPTURE         = 13,
    V4L2_BUF_TYPE_META_OUTPUT          = 14,
    /* Deprecated, do not use */
    V4L2_BUF_TYPE_PRIVATE              = 0x80,
};

#define V4L2_TYPE_IS_MULTIPLANAR(type) \
    ((type) == V4L2_BUF_TYPE_VIDEO_CAPTURE_MPLANE \
     || (type) == V4L2_BUF_TYPE_VIDEO_OUTPUT_MPLANE)

#define V4L2_TYPE_IS_OUTPUT(type) \
    ((type) == V4L2_BUF_TYPE_VIDEO_OUTPUT \
     || (type) == V4L2_BUF_TYPE_VIDEO_OUTPUT_MPLANE \
     || (type) == V4L2_BUF_TYPE_VIDEO_OVERLAY \
     || (type) == V4L2_BUF_TYPE_VIDEO_OUTPUT_OVERLAY \
     || (type) == V4L2_BUF_TYPE_VBI_OUTPUT \
     || (type) == V4L2_BUF_TYPE_SLICED_VBI_OUTPUT \
     || (type) == V4L2_BUF_TYPE_SDR_OUTPUT \
     || (type) == V4L2_BUF_TYPE_META_OUTPUT)

#define V4L2_TYPE_IS_CAPTURE(type) (!V4L2_TYPE_IS_OUTPUT(type))

enum v4l2_tuner_type {
    V4L2_TUNER_RADIO                  = 1,
    V4L2_TUNER_ANALOG_TV               = 2,
    V4L2_TUNER_DIGITAL_TV              = 3,
    V4L2_TUNER_SDR                     = 4,
}

```

```

        V4L2_TUNER_RF          = 5,
};

/* Deprecated, do not use */
#define V4L2_TUNER_ADC  V4L2_TUNER_SDR

enum v4l2_memory {
        V4L2_MEMORY_MMAP      = 1,
        V4L2_MEMORY_USERPTR   = 2,
        V4L2_MEMORY_OVERLAY   = 3,
        V4L2_MEMORY_DMABUF    = 4,
};

/* see also http://vektor.theorem.ca/graphics/ycbcr/ */
enum v4l2_colorspace {
        /*
         * Default colorspace, i.e. let the driver figure it out.
         * Can only be used with video capture.
         */
        V4L2_COLORSPACE_DEFAULT = 0,

        /* SMPTE 170M: used for broadcast NTSC/PAL SDTV */
        V4L2_COLORSPACE_SMPTE170M = 1,

        /* Obsolete pre-1998 SMPTE 240M HDTV standard, superseded by Rec 709 */
        V4L2_COLORSPACE_SMPTE240M = 2,

        /* Rec.709: used for HDTV */
        V4L2_COLORSPACE_REC709 = 3,

        /*
         * Deprecated, do not use. No driver will ever return this. This was
         * based on a misunderstanding of the bt878 datasheet.
         */
        V4L2_COLORSPACE_BT878 = 4,

        /*
         * NTSC 1953 colorspace. This only makes sense when dealing with
         * really, really old NTSC recordings. Superseded by SMPTE 170M.
         */
        V4L2_COLORSPACE_470_SYSTEM_M = 5,

        /*
         * EBU Tech 3213 PAL/SECAM colorspace.
         */
        V4L2_COLORSPACE_470_SYSTEM_BG = 6,

        /*
         * Effectively shorthand for V4L2_COLORSPACE_SRGB, V4L2_YCBCR_ENC_601
         * and V4L2_QUANTIZATION_FULL_RANGE. To be used for (Motion-)JPEG.
         */
}

```

```

V4L2_COLORSPACE_JPEG          = 7,
/* For RGB colorspaces such as produces by most webcams. */
V4L2_COLORSPACE_SRGB          = 8,
/* opRGB colorspace */
V4L2_COLORSPACE_OPRGB         = 9,
/* BT.2020 colorspace, used for UHDTV. */
V4L2_COLORSPACE_BT2020        = 10,
/* Raw colorspace: for RAW unprocessed images */
V4L2_COLORSPACE_RAW           = 11,
/* DCI-P3 colorspace, used by cinema projectors */
V4L2_COLORSPACE_DCI_P3        = 12,

#ifndef __KERNEL__
/*
 * Largest supported colorspace value, assigned by the compiler, used
 * by the framework to check for invalid values.
 */
V4L2_COLORSPACE_LAST,
#endif
};

/*
 * Determine how COLORSPACE_DEFAULT should map to a proper colorspace.
 * This depends on whether this is a SDTV image (use SMPTE 170M), an
 * HDTV image (use Rec. 709), or something else (use sRGB).
 */
#define V4L2_MAP_COLORSPACE_DEFAULT(is_sdtv, is_hdtv) \
    ((is_sdtv) ? V4L2_COLORSPACE_SMPTE170M : \
     ((is_hdtv) ? V4L2_COLORSPACE_REC709 : V4L2_COLORSPACE_SRGB))

enum v4l2_xfer_func {
/*
 * Mapping of V4L2_XFER_FUNC_DEFAULT to actual transfer functions
 * for the various colorspaces:
 *
 * V4L2_COLORSPACE_SMPTE170M, V4L2_COLORSPACE_470_SYSTEM_M,
 * V4L2_COLORSPACE_470_SYSTEM_BG, V4L2_COLORSPACE_REC709 and
 * V4L2_COLORSPACE_BT2020: V4L2_XFER_FUNC_709
 *
 * V4L2_COLORSPACE_SRGB, V4L2_COLORSPACE_JPEG: V4L2_XFER_FUNC_SRGB
 *
 * V4L2_COLORSPACE_OPRGB: V4L2_XFER_FUNC_OPRGB
 *
 * V4L2_COLORSPACE_SMPTE240M: V4L2_XFER_FUNC_SMPTE240M
 *
 * V4L2_COLORSPACE_RAW: V4L2_XFER_FUNC_NONE

```

```

/*
 * V4L2_COLORSPACE_DCI_P3: V4L2_XFER_FUNC_DCI_P3
 */
V4L2_XFER_FUNC_DEFAULT      = 0,
V4L2_XFER_FUNC_709          = 1,
V4L2_XFER_FUNC_SRGB         = 2,
V4L2_XFER_FUNC_OPRGB        = 3,
V4L2_XFER_FUNC SMPTE240M    = 4,
V4L2_XFER_FUNC_NONE         = 5,
V4L2_XFER_FUNC_DCI_P3       = 6,
V4L2_XFER_FUNC SMPTE2084    = 7,
#endif __KERNEL__
/*
 * Largest supported transfer function value, assigned by the compiler,
 * used by the framework to check for invalid values.
 */
V4L2_XFER_FUNC_LAST,
#endif
};

/*
 * Determine how XFER_FUNC_DEFAULT should map to a proper transfer function.
 * This depends on the colorspace.
 */
#define V4L2_MAP_XFER_FUNC_DEFAULT(colsp) \
    ((colsp) == V4L2_COLORSPACE_OPRGB ? V4L2_XFER_FUNC_OPRGB : \
     ((colsp) == V4L2_COLORSPACE SMPTE240M ? V4L2_XFER_FUNC SMPTE240M : \
      ((colsp) == V4L2_COLORSPACE_DCI_P3 ? V4L2_XFER_FUNC_DCI_P3 : \
       ((colsp) == V4L2_COLORSPACE_RAW ? V4L2_XFER_FUNC_NONE : \
        ((colsp) == V4L2_COLORSPACE_SRGB || (colsp) == V4L2_COLORSPACE_ \
        ↵JPEG ? \
            V4L2_XFER_FUNC_SRGB : V4L2_XFER_FUNC_709))))))

enum v4l2_ycbcr_encoding {
/*
 * Mapping of V4L2_YCBCR_ENC_DEFAULT to actual encodings for the
 * various colorspaces:
 *
 * V4L2_COLORSPACE SMPTE170M, V4L2_COLORSPACE_470_SYSTEM_M,
 * V4L2_COLORSPACE_470_SYSTEM_BG, V4L2_COLORSPACE_SRGB,
 * V4L2_COLORSPACE_OPRGB and V4L2_COLORSPACE_JPEG: V4L2_YCBCR_ENC_601
 *
 * V4L2_COLORSPACE_REC709 and V4L2_COLORSPACE_DCI_P3: V4L2_YCBCR_ENC_ \
709
 *
 * V4L2_COLORSPACE_BT2020: V4L2_YCBCR_ENC_BT2020
 *
 * V4L2_COLORSPACE SMPTE240M: V4L2_YCBCR_ENC SMPTE240M
 */
V4L2_YCBCR_ENC_DEFAULT      = 0,

```

```

/* ITU-R 601 -- SDTV */
V4L2_YCBCR_ENC_601          = 1,

/* Rec. 709 -- HDTV */
V4L2_YCBCR_ENC_709          = 2,

/* ITU-R 601/EN 61966-2-4 Extended Gamut -- SDTV */
V4L2_YCBCR_ENC_XV601        = 3,

/* Rec. 709/EN 61966-2-4 Extended Gamut -- HDTV */
V4L2_YCBCR_ENC_XV709        = 4,

#ifndef __KERNEL__
/*
 * sYCC (Y'CbCr encoding of sRGB), identical to ENC_601. It was added
 * originally due to a misunderstanding of the sYCC standard. It should
 * not be used, instead use V4L2_YCBCR_ENC_601.
 */
V4L2_YCBCR_ENC_SYCC         = 5,
#endif

/* BT.2020 Non-constant Luminance Y'CbCr */
V4L2_YCBCR_ENC_BT2020        = 6,

/* BT.2020 Constant Luminance Y'CbcCrc */
V4L2_YCBCR_ENC_BT2020_CONST_LUM = 7,

/* SMPTE 240M -- Obsolete HDTV */
V4L2_YCBCR_ENC_SMPTE240M     = 8,
#endif __KERNEL__
/*
 * Largest supported encoding value, assigned by the compiler, used by
 * the framework to check for invalid values.
 */
V4L2_YCBCR_ENC_LAST,
#endif
};

/*
 * enum v4l2_hsv_encoding values should not collide with the ones from
 * enum v4l2_ycbcrr_encoding.
 */
enum v4l2_hsv_encoding {

    /* Hue mapped to 0 - 179 */
    V4L2_HSV_ENC_180            = 128,

    /* Hue mapped to 0-255 */
    V4L2_HSV_ENC_256             = 129,
};

```

```

/*
 * Determine how YCBCR_ENC_DEFAULT should map to a proper Y'CbCr encoding.
 * This depends on the colorspace.
 */
#define V4L2_MAP_YCBCR_ENC_DEFAULT(colsp) \
    (((colsp) == V4L2_COLORSPACE_REC709 || \
      (colsp) == V4L2_COLORSPACE_DCI_P3) ? V4L2_YCBCR_ENC_709 : \
     ((colsp) == V4L2_COLORSPACE_BT2020 ? V4L2_YCBCR_ENC_BT2020 : \
      ((colsp) == V4L2_COLORSPACE_SMPTE240M ? V4L2_YCBCR_ENC_SMPTE240M : \
       V4L2_YCBCR_ENC_601)))

enum v4l2_quantization {
    /*
     * The default for R'G'B' quantization is always full range.
     * For Y'CbCr the quantization is always limited range, except
     * for COLORSPACE_JPEG: this is full range.
     */
    V4L2_QUANTIZATION_DEFAULT      = 0,
    V4L2_QUANTIZATION_FULL_RANGE  = 1,
    V4L2_QUANTIZATION_LIM_RANGE   = 2,
};

/*
 * Determine how QUANTIZATION_DEFAULT should map to a proper quantization.
 * This depends on whether the image is RGB or not, the colorspace.
 * The Y'CbCr encoding is not used anymore, but is still there for backwards
 * compatibility.
 */
#define V4L2_MAP_QUANTIZATION_DEFAULT(is_rgb_or_hsv, colsp, ycbcr_enc) \
    (((is_rgb_or_hsv) || (colsp) == V4L2_COLORSPACE_JPEG) ? \
     V4L2_QUANTIZATION_FULL_RANGE : V4L2_QUANTIZATION_LIM_RANGE)

/*
 * Deprecated names for opRGB colorspace (IEC 61966-2-5)
 *
 * WARNING: Please don't use these deprecated defines in your code, as
 * there is a chance we have to remove them in the future.
 */
#ifndef __KERNEL__
#define V4L2_COLORSPACE_ADOBERGB V4L2_COLORSPACE_OPRGB
#define V4L2_XFER_FUNC_ADOBERGB V4L2_XFER_FUNC_OPRGB
#endif

enum v4l2_priority {
    V4L2_PRIORITY_UNSET      = 0, /* not initialized */
    V4L2_PRIORITY_BACKGROUND  = 1,
    V4L2_PRIORITY_INTERACTIVE = 2,
    V4L2_PRIORITY_RECORD     = 3,
    V4L2_PRIORITY_DEFAULT    = V4L2_PRIORITY_INTERACTIVE,
};

```

```

struct v4l2_rect {
    __s32 left;
    __s32 top;
    __u32 width;
    __u32 height;
};

struct v4l2_fract {
    __u32 numerator;
    __u32 denominator;
};

struct v4l2_area {
    __u32 width;
    __u32 height;
};

/**
 * struct v4l2_capability - Describes V4L2 device caps returned by VIDIOC_
 * QUERYCAP
 *
 * @driver:      name of the driver module (e.g. "btv")
 * @card:        name of the card (e.g. "Hauppauge WinTV")
 * @bus_info:    name of the bus (e.g. "PCI:" + pci_name(pci_dev) )
 * @version:     KERNEL_VERSION
 * @capabilities: capabilities of the physical device as a whole
 * @device_caps: capabilities accessed via this particular device (node)
 * @reserved:    reserved fields for future extensions
 */
struct v4l2_capability {
    __u8 driver[16];
    __u8 card[32];
    __u8 bus_info[32];
    __u32 version;
    __u32 capabilities;
    __u32 device_caps;
    __u32 reserved[3];
};

/* Values for 'capabilities' field */
#define V4L2_CAP_VIDEO_CAPTURE          0x00000001 /* Is a video capture */
#define V4L2_CAP_VIDEO_OUTPUT           0x00000002 /* Is a video output */
#define V4L2_CAP_VIDEO_OVERLAY          0x00000004 /* Can do video overlay */
#define V4L2_CAP_VBI_CAPTURE            0x00000010 /* Is a raw VBI capture */
#define V4L2_CAP_VBI_OUTPUT             0x00000020 /* Is a raw VBI output */
#define V4L2_CAP_SLICED_VBI_CAPTURE     0x00000040 /* Is a sliced VBI capture */

```

```

#define V4L2_CAP_SLICED_VBI_OUTPUT      0x00000080 /* Is a sliced VBI output, u
↳device */
#define V4L2_CAP_RDS_CAPTURE           0x00000100 /* RDS data capture */
#define V4L2_CAP_VIDEO_OUTPUT_OVERLAY   0x00000200 /* Can do video output, u
↳overlay */
#define V4L2_CAP_HW_FREQ_SEEK          0x00000400 /* Can do hardware, u
↳frequency seek */
#define V4L2_CAP_RDS_OUTPUT            0x00000800 /* Is an RDS encoder */

/* Is a video capture device that supports multiplanar formats */
#define V4L2_CAP_VIDEO_CAPTURE_MPLANE  0x00001000
/* Is a video output device that supports multiplanar formats */
#define V4L2_CAP_VIDEO_OUTPUT_MPLANE   0x00002000
/* Is a video mem-to-mem device that supports multiplanar formats */
#define V4L2_CAP_VIDEO_M2M_MPLANE     0x00004000
/* Is a video mem-to-mem device */
#define V4L2_CAP_VIDEO_M2M             0x00008000

#define V4L2_CAP_TUNER                0x00010000 /* has a tuner */
#define V4L2_CAP_AUDIO                 0x00020000 /* has audio support */
#define V4L2_CAP_RADIO                 0x00040000 /* is a radio device */
#define V4L2_CAP_MODULATOR              0x00080000 /* has a modulator */

#define V4L2_CAP_SDR_CAPTURE           0x00100000 /* Is a SDR capture device, u
↳*/
#define V4L2_CAP_EXT_PIX_FORMAT        0x00200000 /* Supports the extended, u
↳pixel format */
#define V4L2_CAP_SDR_OUTPUT             0x00400000 /* Is a SDR output device, u
↳*/
#define V4L2_CAP_META_CAPTURE          0x00800000 /* Is a metadata capture, u
↳device */

#define V4L2_CAP_READWRITE              0x01000000 /* read/write systemcalls, u
↳*/
#define V4L2_CAP_STREAMING              0x04000000 /* streaming I/O ioctls */
#define V4L2_CAP_META_OUTPUT             0x08000000 /* Is a metadata output, u
↳device */

#define V4L2_CAP_TOUCH                  0x10000000 /* Is a touch device */
#define V4L2_CAP_IO_MC                  0x20000000 /* Is input/output, u
↳controlled by the media controller */

#define V4L2_CAP_DEVICE_CAPS            0x80000000 /* sets device, u
↳capabilities field */

/*
 *      V I D E O      I M A G E      F O R M A T
 */
struct v4l2_pix_format {
    __u32                                width;

```

```

    __u32           height;
    __u32           pixelformat;
    __u32           field;      /* enum v4l2_field */
    __u32           bytesperline; /* for padding, zero if unused */

    __u32           sizeimage;
    __u32           colorspace; /* enum v4l2_colorspace */
    __u32           priv;       /* private data, depends on */

/* pixelformat */
    __u32           flags;      /* format flags (V4L2_PIX_FMT_*
    __u32           FLAG_*) */
    union {
        /* enum v4l2_ycbcr_encoding */
        __u32           ycbcr_enc;
        /* enum v4l2_hsv_encoding */
        __u32           hsv_enc;
    };
    __u32           quantization; /* enum v4l2_quantization */
    __u32           xfer_func;   /* enum v4l2_xfer_func */
};

/* Pixel format          FOURCC                depth */
/* Description */

/* RGB formats (1 or 2 bytes per pixel) */
#define V4L2_PIX_FMT_RGB32  v4l2_fourcc('R', 'G', 'B', '1') /* 8  RGB-3-3-2 */
#define V4L2_PIX_FMT_RGB44  v4l2_fourcc('R', '4', '4', '4') /* 16 xxxxxxxx
   ↳ggggbbbb */
#define V4L2_PIX_FMT_ARGB44 v4l2_fourcc('A', 'R', '1', '2') /* 16 aaaarrrr
   ↳ggggbbbb */
#define V4L2_PIX_FMT_XRGB44 v4l2_fourcc('X', 'R', '1', '2') /* 16 xxxxxxxx
   ↳ggggbbbb */
#define V4L2_PIX_FMT_RGBA44 v4l2_fourcc('R', 'A', '1', '2') /* 16 rrrrgggg
   ↳bbbbaaaa */
#define V4L2_PIX_FMT_RGBX44 v4l2_fourcc('R', 'X', '1', '2') /* 16 rrrrgggg
   ↳bbbbxxxx */
#define V4L2_PIX_FMT_ABGR44 v4l2_fourcc('A', 'B', '1', '2') /* 16 aaaabbbb
   ↳ggggrrrr */
#define V4L2_PIX_FMT_XBGR44 v4l2_fourcc('X', 'B', '1', '2') /* 16 xxxxbbbb
   ↳ggggrrrr */
#define V4L2_PIX_FMT_BGRA44 v4l2_fourcc('G', 'A', '1', '2') /* 16 bbbbffff
   ↳rrrraaaa */
#define V4L2_PIX_FMT_BGRX44 v4l2_fourcc('B', 'X', '1', '2') /* 16 bbbbgggg
   ↳rrrrxxxx */
#define V4L2_PIX_FMT_RGB555 v4l2_fourcc('R', 'G', 'B', '0') /* 16 RGB-5-5-5 */
#define V4L2_PIX_FMT_ARGB555 v4l2_fourcc('A', 'R', '1', '5') /* 16
   ↳ARGB-1-5-5-5 */
#define V4L2_PIX_FMT_XRGB555 v4l2_fourcc('X', 'R', '1', '5') /* 16
   ↳XRGB-1-5-5-5 */

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#define V4L2_PIX_FMT_RGBA555 v4l2_fourcc('R', 'A', '1', '5') /* 16 */
#define V4L2_PIX_FMT_RGBX555 v4l2_fourcc('R', 'X', '1', '5') /* 16 */
#define V4L2_PIX_FMT_ABGR555 v4l2_fourcc('A', 'B', '1', '5') /* 16 */
#define V4L2_PIX_FMT_XBGR555 v4l2_fourcc('X', 'B', '1', '5') /* 16 */
#define V4L2_PIX_FMT_BGRA555 v4l2_fourcc('B', 'A', '1', '5') /* 16 */
#define V4L2_PIX_FMT_BGRX555 v4l2_fourcc('B', 'X', '1', '5') /* 16 */
#define V4L2_PIX_FMT_RGB565 v4l2_fourcc('R', 'G', 'B', 'P') /* 16 RGB-5-6-5 */
#define V4L2_PIX_FMT_RGB55X v4l2_fourcc('R', 'G', 'B', 'Q') /* 16 RGB-5-5-5 */
#define V4L2_PIX_FMT_ARGB55X v4l2_fourcc_be('A', 'R', '1', '5') /* 16 ARGB-5-5-5 BE */
#define V4L2_PIX_FMT_XRGB55X v4l2_fourcc_be('X', 'R', '1', '5') /* 16 XRGB-5-5-5 BE */
#define V4L2_PIX_FMT_RGB565X v4l2_fourcc('R', 'G', 'B', 'R') /* 16 RGB-5-6-5 */
#define V4L2_PIX_FMT_BGR666 v4l2_fourcc('B', 'G', 'R', 'H') /* 18 BGR-6-6-6 */
#define V4L2_PIX_FMT_BGR24 v4l2_fourcc('B', 'G', 'R', '3') /* 24 BGR-8-8-8 */
#define V4L2_PIX_FMT_RGB24 v4l2_fourcc('R', 'G', 'B', '3') /* 24 RGB-8-8-8 */
#define V4L2_PIX_FMT_BGR32 v4l2_fourcc('B', 'G', 'R', '4') /* 32 BGR-8-8-8-8 */
#define V4L2_PIX_FMT_ABGR32 v4l2_fourcc('A', 'R', '2', '4') /* 32 BGRA-8-8-8-8 */
#define V4L2_PIX_FMT_XBGR32 v4l2_fourcc('X', 'R', '2', '4') /* 32 XBGR-8-8-8-8 */
#define V4L2_PIX_FMT_BGRA32 v4l2_fourcc('R', 'A', '2', '4') /* 32 ABGR-8-8-8-8 */
#define V4L2_PIX_FMT_BGRX32 v4l2_fourcc('R', 'X', '2', '4') /* 32 BGRX-8-8-8-8 */
#define V4L2_PIX_FMT_RGB32 v4l2_fourcc('R', 'G', 'B', '4') /* 32 RGB-8-8-8-8 */
#define V4L2_PIX_FMT_RGBA32 v4l2_fourcc('A', 'B', '2', '4') /* 32 RGBA-8-8-8-8 */
#define V4L2_PIX_FMT_RGBX32 v4l2_fourcc('X', 'B', '2', '4') /* 32 RGBX-8-8-8-8 */
#define V4L2_PIX_FMT_ARGB32 v4l2_fourcc('B', 'A', '2', '4') /* 32 ARGB-8-8-8-8 */
#define V4L2_PIX_FMT_XRGB32 v4l2_fourcc('B', 'X', '2', '4') /* 32 XRGB-8-8-8-8 */
#define V4L2_PIX_FMT_RGBX1010102 v4l2_fourcc('R', 'X', '3', '0') /* 32 */

/* RGB formats (3 or 4 bytes per pixel) */
#define V4L2_PIX_FMT_BGR666 v4l2_fourcc('B', 'G', 'R', 'H') /* 18 BGR-6-6-6 */
#define V4L2_PIX_FMT_BGR24 v4l2_fourcc('B', 'G', 'R', '3') /* 24 BGR-8-8-8 */
#define V4L2_PIX_FMT_RGB24 v4l2_fourcc('R', 'G', 'B', '3') /* 24 RGB-8-8-8 */
#define V4L2_PIX_FMT_BGR32 v4l2_fourcc('B', 'G', 'R', '4') /* 32 BGR-8-8-8-8 */
#define V4L2_PIX_FMT_ABGR32 v4l2_fourcc('A', 'R', '2', '4') /* 32 BGRA-8-8-8-8 */
#define V4L2_PIX_FMT_XBGR32 v4l2_fourcc('X', 'R', '2', '4') /* 32 XBGR-8-8-8-8 */
#define V4L2_PIX_FMT_BGRA32 v4l2_fourcc('R', 'A', '2', '4') /* 32 ABGR-8-8-8-8 */
#define V4L2_PIX_FMT_BGRX32 v4l2_fourcc('R', 'X', '2', '4') /* 32 BGRX-8-8-8-8 */
#define V4L2_PIX_FMT_RGB32 v4l2_fourcc('R', 'G', 'B', '4') /* 32 RGB-8-8-8-8 */
#define V4L2_PIX_FMT_RGBA32 v4l2_fourcc('A', 'B', '2', '4') /* 32 RGBA-8-8-8-8 */
#define V4L2_PIX_FMT_RGBX32 v4l2_fourcc('X', 'B', '2', '4') /* 32 RGBX-8-8-8-8 */
#define V4L2_PIX_FMT_ARGB32 v4l2_fourcc('B', 'A', '2', '4') /* 32 ARGB-8-8-8-8 */
#define V4L2_PIX_FMT_XRGB32 v4l2_fourcc('B', 'X', '2', '4') /* 32 XRGB-8-8-8-8 */
#define V4L2_PIX_FMT_RGBX1010102 v4l2_fourcc('R', 'X', '3', '0') /* 32 */

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→RGBX-10-10-10-2 */
#define V4L2_PIX_FMT_RGBA1010102 v4l2_fourcc('R', 'A', '3', '0') /* 32
→RGBX-10-10-10-2 */
#define V4L2_PIX_FMT_ARGB2101010 v4l2_fourcc('A', 'R', '3', '0') /* 32
→ARGB-2-10-10-10 */

/* RGB formats (6 or 8 bytes per pixel) */
#define V4L2_PIX_FMT_BGR48_12    v4l2_fourcc('B', '3', '1', '2') /* 48 BGR
→12-bit per component */
#define V4L2_PIX_FMT_ABGR64_12   v4l2_fourcc('B', '4', '1', '2') /* 64 BGRA
→12-bit per component */

/* Grey formats */
#define V4L2_PIX_FMT_GREY      v4l2_fourcc('G', 'R', 'E', 'Y') /* 8 Greyscale
→ */
#define V4L2_PIX_FMT_Y4        v4l2_fourcc('Y', '0', '4', ' ') /* 4 Greyscale
→ */
#define V4L2_PIX_FMT_Y6        v4l2_fourcc('Y', '0', '6', ' ') /* 6 Greyscale
→ */
#define V4L2_PIX_FMT_Y10       v4l2_fourcc('Y', '1', '0', ' ') /* 10 Greyscale
→ */
#define V4L2_PIX_FMT_Y12       v4l2_fourcc('Y', '1', '2', ' ') /* 12 Greyscale
→ */
#define V4L2_PIX_FMT_Y012      v4l2_fourcc('Y', '0', '1', '2') /* 12 Greyscale
→ */
#define V4L2_PIX_FMT_Y14       v4l2_fourcc('Y', '1', '4', ' ') /* 14 Greyscale
→ */
#define V4L2_PIX_FMT_Y16       v4l2_fourcc('Y', '1', '6', ' ') /* 16 Greyscale
→ */
#define V4L2_PIX_FMT_Y16_BE    v4l2_fourcc_be('Y', '1', '6', ' ') /* 16
→Greyscale BE */

/* Grey bit-packed formats */
#define V4L2_PIX_FMT_Y10BPACK  v4l2_fourcc('Y', '1', '0', 'B') /* 10
→Greyscale bit-packed */
#define V4L2_PIX_FMT_Y10P      v4l2_fourcc('Y', '1', '0', 'P') /* 10 Greyscale,
→MIPI RAW10 packed */
#define V4L2_PIX_FMT_IPU3_Y10   v4l2_fourcc('i', 'p', '3', 'y') /*_
→IPU3 packed 10-bit greyscale */

/* Palette formats */
#define V4L2_PIX_FMT_PAL8     v4l2_fourcc('P', 'A', 'L', '8') /* 8 8-bit
→palette */

/* Chrominance formats */
#define V4L2_PIX_FMT_UV8       v4l2_fourcc('U', 'V', '8', ' ') /* 8 UV 4:4 */

/* Luminance+Chrominance formats */
#define V4L2_PIX_FMT_YUYV     v4l2_fourcc('Y', 'U', 'Y', 'V') /* 16 YUV 4:2:2
→ */
#define V4L2_PIX_FMT_YYUV     v4l2_fourcc('Y', 'Y', 'U', 'V') /* 16 YUV 4:2:2
→ */

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    */
#define V4L2_PIX_FMT_YVYU      v4l2_fourcc('Y', 'V', 'Y', 'U') /* 16 YUV 4:2:2 */
#define V4L2_PIX_FMT_UYVY      v4l2_fourcc('U', 'Y', 'V', 'Y') /* 16 YUV 4:2:2 */
    */
#define V4L2_PIX_FMT_VYUY      v4l2_fourcc('V', 'Y', 'U', 'Y') /* 16 YUV 4:2:2 */
    */
#define V4L2_PIX_FMT_Y41P      v4l2_fourcc('Y', '4', '1', 'P') /* 12 YUV 4:1:1 */
    */
#define V4L2_PIX_FMT_YUV444    v4l2_fourcc('Y', '4', '4', '4') /* 16 xxxxxxxx */
    */
#define V4L2_PIX_FMT_YUV555    v4l2_fourcc('Y', 'U', 'V', '0') /* 16 YUV-5-5-5 */
    */
#define V4L2_PIX_FMT_YUV565    v4l2_fourcc('Y', 'U', 'V', 'P') /* 16 YUV-5-6-5 */
    */
#define V4L2_PIX_FMT_YUV24     v4l2_fourcc('Y', 'U', 'V', '3') /* 24 YUV-8-8-8 */
    */
#define V4L2_PIX_FMT_YUV32     v4l2_fourcc('Y', 'U', 'V', '4') /* 32 */
    */
#define V4L2_PIX_FMT_AYUV32    v4l2_fourcc('A', 'Y', 'U', 'V') /* 32 */
    */
#define V4L2_PIX_FMT_XYUV32    v4l2_fourcc('X', 'Y', 'U', 'V') /* 32 */
    */
#define V4L2_PIX_FMT_VUYA32    v4l2_fourcc('V', 'U', 'Y', 'A') /* 32 */
    */
#define V4L2_PIX_FMT_VUYX32    v4l2_fourcc('V', 'U', 'Y', 'X') /* 32 */
    */
#define V4L2_PIX_FMT_YUVA32    v4l2_fourcc('Y', 'U', 'V', 'A') /* 32 */
    */
#define V4L2_PIX_FMT_YUVX32    v4l2_fourcc('Y', 'U', 'V', 'X') /* 32 */
    */
#define V4L2_PIX_FMT_M420       v4l2_fourcc('M', '4', '2', '0') /* 12 YUV 4:2:0 */
    */
#define V4L2_PIX_FMT_YUV48_12   v4l2_fourcc('Y', '3', '1', '2') /* 48 YUV */
    */
/* YCbCr packed format. For each Y2xx format, xx bits of valid data occupy the
 * MSBs of the 16 bit components, and 16-xx bits of zero padding occupy the LSBs.
 */
#define V4L2_PIX_FMT_Y210      v4l2_fourcc('Y', '2', '1', '0') /* 32 YUYV 4:2:2 */
    */
#define V4L2_PIX_FMT_Y212      v4l2_fourcc('Y', '2', '1', '2') /* 32 YUYV 4:2:2 */
    */
#define V4L2_PIX_FMT_Y216      v4l2_fourcc('Y', '2', '1', '6') /* 32 YUYV 4:2:2 */
    */
/* two planes -- one Y, one Cr + Cb interleaved */
#define V4L2_PIX_FMT_NV12      v4l2_fourcc('N', 'V', '1', '2') /* 12 Y/CbCr */
    */
#define V4L2_PIX_FMT_NV21      v4l2_fourcc('N', 'V', '2', '1') /* 12 Y/CrCb */

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→4:2:0 */
#define V4L2_PIX_FMT_NV16      v4l2_fourcc('N', 'V', '1', '6') /* 16 Y/CbCr
→4:2:2 */
#define V4L2_PIX_FMT_NV61      v4l2_fourcc('N', 'V', '6', '1') /* 16 Y/CrCb
→4:2:2 */
#define V4L2_PIX_FMT_NV24      v4l2_fourcc('N', 'V', '2', '4') /* 24 Y/CbCr
→4:4:4 */
#define V4L2_PIX_FMT_NV42      v4l2_fourcc('N', 'V', '4', '2') /* 24 Y/CrCb
→4:4:4 */
#define V4L2_PIX_FMT_P010      v4l2_fourcc('P', '0', '1', '0') /* 24 Y/CbCr
→4:2:0 10-bit per component */
#define V4L2_PIX_FMT_P012      v4l2_fourcc('P', '0', '1', '2') /* 24 Y/CbCr
→4:2:0 12-bit per component */

/* two non contiguous planes - one Y, one Cr + Cb interleaved */
#define V4L2_PIX_FMT_NV12M     v4l2_fourcc('N', 'M', '1', '2') /* 12 Y/CbCr
→4:2:0 */
#define V4L2_PIX_FMT_NV21M     v4l2_fourcc('N', 'M', '2', '1') /* 21 Y/CrCb
→4:2:0 */
#define V4L2_PIX_FMT_NV16M     v4l2_fourcc('N', 'M', '1', '6') /* 16 Y/CbCr
→4:2:2 */
#define V4L2_PIX_FMT_NV61M     v4l2_fourcc('N', 'M', '6', '1') /* 16 Y/CrCb
→4:2:2 */
#define V4L2_PIX_FMT_P012M     v4l2_fourcc('P', 'M', '1', '2') /* 24 Y/CbCr
→4:2:0 12-bit per component */

/* three planes - Y Cb, Cr */
#define V4L2_PIX_FMT_YUV410    v4l2_fourcc('Y', 'U', 'V', '9') /* 9 YUV 4:1:0
→ */
#define V4L2_PIX_FMT_YVU410    v4l2_fourcc('Y', 'V', 'U', '9') /* 9 YVU 4:1:0
→ */
#define V4L2_PIX_FMT_YUV411P   v4l2_fourcc('4', '1', '1', 'P') /* 12 YVU411
→ planar */
#define V4L2_PIX_FMT_YUV420    v4l2_fourcc('Y', 'U', '1', '2') /* 12 YUV 4:2:0
→ */
#define V4L2_PIX_FMT_YVU420    v4l2_fourcc('Y', 'V', '1', '2') /* 12 YVU 4:2:0
→ */
#define V4L2_PIX_FMT_YUV422P   v4l2_fourcc('4', '2', '2', 'P') /* 16 YVU422
→ planar */

/* three non contiguous planes - Y, Cb, Cr */
#define V4L2_PIX_FMT_YUV420M   v4l2_fourcc('Y', 'M', '1', '2') /* 12 YUV420
→ planar */
#define V4L2_PIX_FMT_YVU420M   v4l2_fourcc('Y', 'M', '2', '1') /* 12 YVU420
→ planar */
#define V4L2_PIX_FMT_YUV422M   v4l2_fourcc('Y', 'M', '1', '6') /* 16 YUV422
→ planar */
#define V4L2_PIX_FMT_YVU422M   v4l2_fourcc('Y', 'M', '6', '1') /* 16 YVU422
→ planar */
#define V4L2_PIX_FMT_YUV444M   v4l2_fourcc('Y', 'M', '2', '4') /* 24 YUV444
→ planar */

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#define V4L2_PIX_FMT_YVU444M v4l2_fourcc('Y', 'M', '4', '2') /* 24 YVU444M
↳ planar */

/* Tiled YUV formats */
#define V4L2_PIX_FMT_NV12_4L4 v4l2_fourcc('V', 'T', '1', '2') /* 12 Y/CbCr
↳ 4:2:0 4x4 tiles */
#define V4L2_PIX_FMT_NV12_16L16 v4l2_fourcc('H', 'M', '1', '2') /* 12 Y/CbCr
↳ 4:2:0 16x16 tiles */
#define V4L2_PIX_FMT_NV12_32L32 v4l2_fourcc('S', 'T', '1', '2') /* 12 Y/CbCr
↳ 4:2:0 32x32 tiles */
#define V4L2_PIX_FMT_NV15_4L4 v4l2_fourcc('V', 'T', '1', '5') /* 15 Y/CbCr
↳ 4:2:0 10-bit 4x4 tiles */
#define V4L2_PIX_FMT_P010_4L4 v4l2_fourcc('T', '0', '1', '0') /* 12 Y/CbCr
↳ 4:2:0 10-bit 4x4 macroblocks */
#define V4L2_PIX_FMT_NV12_8L128 v4l2_fourcc('A', 'T', '1', '2') /* Y/
↳ CbCr 4:2:0 8x128 tiles */
#define V4L2_PIX_FMT_NV12_10BE_8L128 v4l2_fourcc_be('A', 'X', '1', '2') /* Y/
↳ CbCr 4:2:0 10-bit 8x128 tiles */

/* Tiled YUV formats, non contiguous planes */
#define V4L2_PIX_FMT_NV12MT v4l2_fourcc('T', 'M', '1', '2') /* 12 Y/CbCr
↳ 4:2:0 64x32 tiles */
#define V4L2_PIX_FMT_NV12MT_16X16 v4l2_fourcc('V', 'M', '1', '2') /* 12 Y/
↳ CbCr 4:2:0 16x16 tiles */
#define V4L2_PIX_FMT_NV12M_8L128 v4l2_fourcc('N', 'A', '1', '2') /* Y/
↳ CbCr 4:2:0 8x128 tiles */
#define V4L2_PIX_FMT_NV12M_10BE_8L128 v4l2_fourcc_be('N', 'T', '1', '2') /* Y/
↳ CbCr 4:2:0 10-bit 8x128 tiles */

/* Bayer formats - see http://www.siliconimaging.com/RGB%20Bayer.htm */
#define V4L2_PIX_FMT_SBGGR8 v4l2_fourcc('B', 'A', '8', '1') /* 8 BGBG...
↳ GRGR... */
#define V4L2_PIX_FMT_SGBRG8 v4l2_fourcc('G', 'B', 'R', 'G') /* 8 GBGB...
↳ RGRG... */
#define V4L2_PIX_FMT_SGRBG8 v4l2_fourcc('G', 'R', 'B', 'G') /* 8 GRGR...
↳ BGBG... */
#define V4L2_PIX_FMT_SRGGB8 v4l2_fourcc('R', 'G', 'G', 'B') /* 8 RGRG...
↳ GBGB... */
#define V4L2_PIX_FMT_SBGGR10 v4l2_fourcc('B', 'G', '1', '0') /* 10 BGBG...
↳ GRGR... */
#define V4L2_PIX_FMT_SGBRG10 v4l2_fourcc('G', 'B', '1', '0') /* 10 GBGB...
↳ RGRG... */
#define V4L2_PIX_FMT_SGRBG10 v4l2_fourcc('B', 'A', '1', '0') /* 10 GRGR...
↳ BGBG... */
#define V4L2_PIX_FMT_SRGGB10 v4l2_fourcc('R', 'G', '1', '0') /* 10 RGRG...
↳ GBGB... */

/* 10bit raw bayer packed, 5 bytes for every 4 pixels */
#define V4L2_PIX_FMT_SBGGR10P v4l2_fourcc('p', 'B', 'A', 'A')
#define V4L2_PIX_FMT_SGBRG10P v4l2_fourcc('p', 'G', 'A', 'A')
#define V4L2_PIX_FMT_SGRBG10P v4l2_fourcc('p', 'g', 'A', 'A')
#define V4L2_PIX_FMT_SRGGB10P v4l2_fourcc('p', 'R', 'A', 'A')

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        /* 10bit raw bayer a-law compressed to 8 bits */
#define V4L2_PIX_FMT_SBGGR10ALAW8 v4l2_fourcc('a', 'B', 'A', '8')
#define V4L2_PIX_FMT_SGBRG10ALAW8 v4l2_fourcc('a', 'G', 'A', '8')
#define V4L2_PIX_FMT_SGRBG10ALAW8 v4l2_fourcc('a', 'g', 'A', '8')
#define V4L2_PIX_FMT_SRGGGB10ALAW8 v4l2_fourcc('a', 'R', 'A', '8')
        /* 10bit raw bayer DPCM compressed to 8 bits */
#define V4L2_PIX_FMT_SBGGR10DPCM8 v4l2_fourcc('b', 'B', 'A', '8')
#define V4L2_PIX_FMT_SGBRG10DPCM8 v4l2_fourcc('b', 'G', 'A', '8')
#define V4L2_PIX_FMT_SGRBG10DPCM8 v4l2_fourcc('B', 'D', '1', '0')
#define V4L2_PIX_FMT_SRGGGB10DPCM8 v4l2_fourcc('b', 'R', 'A', '8')
#define V4L2_PIX_FMT_SBGGR12 v4l2_fourcc('B', 'G', '1', '2') /* 12 BGBG... */
    ↳GRGR... */
#define V4L2_PIX_FMT_SGBRG12 v4l2_fourcc('G', 'B', '1', '2') /* 12 GBGB... */
    ↳RGRG... */
#define V4L2_PIX_FMT_SGRBG12 v4l2_fourcc('B', 'A', '1', '2') /* 12 GRGR... */
    ↳BGBG... */
#define V4L2_PIX_FMT_SRGGGB12 v4l2_fourcc('R', 'G', '1', '2') /* 12 RGRG... */
    ↳GBGB... */
        /* 12bit raw bayer packed, 6 bytes for every 4 pixels */
#define V4L2_PIX_FMT_SBGGR12P v4l2_fourcc('p', 'B', 'C', 'C')
#define V4L2_PIX_FMT_SGBRG12P v4l2_fourcc('p', 'G', 'C', 'C')
#define V4L2_PIX_FMT_SGRBG12P v4l2_fourcc('p', 'g', 'C', 'C')
#define V4L2_PIX_FMT_SRGGGB12P v4l2_fourcc('p', 'R', 'C', 'C')
#define V4L2_PIX_FMT_SBGGR14 v4l2_fourcc('B', 'G', '1', '4') /* 14 BGBG... */
    ↳GRGR... */
#define V4L2_PIX_FMT_SGBRG14 v4l2_fourcc('G', 'B', '1', '4') /* 14 GBGB... */
    ↳RGRG... */
#define V4L2_PIX_FMT_SGRBG14 v4l2_fourcc('G', 'R', '1', '4') /* 14 GRGR... */
    ↳BGBG... */
#define V4L2_PIX_FMT_SRGGGB14 v4l2_fourcc('R', 'G', '1', '4') /* 14 RGRG... */
    ↳GBGB... */
        /* 14bit raw bayer packed, 7 bytes for every 4 pixels */
#define V4L2_PIX_FMT_SBGGR14P v4l2_fourcc('p', 'B', 'E', 'E')
#define V4L2_PIX_FMT_SGBRG14P v4l2_fourcc('p', 'G', 'E', 'E')
#define V4L2_PIX_FMT_SGRBG14P v4l2_fourcc('p', 'g', 'E', 'E')
#define V4L2_PIX_FMT_SRGGGB14P v4l2_fourcc('p', 'R', 'E', 'E')
#define V4L2_PIX_FMT_SBGGR16 v4l2_fourcc('B', 'Y', 'R', '2') /* 16 BGBG... */
    ↳GRGR... */
#define V4L2_PIX_FMT_SGBRG16 v4l2_fourcc('G', 'B', '1', '6') /* 16 GBGB... */
    ↳RGRG... */
#define V4L2_PIX_FMT_SGRBG16 v4l2_fourcc('G', 'R', '1', '6') /* 16 GRGR... */
    ↳BGBG... */
#define V4L2_PIX_FMT_SRGGGB16 v4l2_fourcc('R', 'G', '1', '6') /* 16 RGRG... */
    ↳GBGB... */

/* HSV formats */
#define V4L2_PIX_FMT_HSV24 v4l2_fourcc('H', 'S', 'V', '3')
#define V4L2_PIX_FMT_HSV32 v4l2_fourcc('H', 'S', 'V', '4')

/* compressed formats */
#define V4L2_PIX_FMT_MJPEG      v4l2_fourcc('M', 'J', 'P', 'G') /* Motion-JPEG */

```

```

/* */
#define V4L2_PIX_FMT_JPEG      v4l2_fourcc('J', 'P', 'E', 'G') /* JFIF JPEG */
/* */
#define V4L2_PIX_FMT_DV        v4l2_fourcc('d', 'v', 's', 'd') /* 1394 */
/* */
#define V4L2_PIX_FMT_MPEG      v4l2_fourcc('M', 'P', 'E', 'G') /* MPEG-1/2/4 */
/* Multiplexed */
#define V4L2_PIX_FMT_H264       v4l2_fourcc('H', '2', '6', '4') /* H264 with */
/* start codes */
#define V4L2_PIX_FMT_H264_NO_SC v4l2_fourcc('A', 'V', 'C', '1') /* H264 */
/* without start codes */
#define V4L2_PIX_FMT_H264_MVC   v4l2_fourcc('M', '2', '6', '4') /* H264 MVC */
#define V4L2_PIX_FMT_H263       v4l2_fourcc('H', '2', '6', '3') /* H263 */
/* */
#define V4L2_PIX_FMT_MPEG1     v4l2_fourcc('M', 'P', 'G', '1') /* MPEG-1 ES */
/* */
#define V4L2_PIX_FMT_MPEG2     v4l2_fourcc('M', 'P', 'G', '2') /* MPEG-2 ES */
/* */
#define V4L2_PIX_FMT_MPEG2_SLICE v4l2_fourcc('M', 'G', '2', 'S') /* MPEG-2 */
/* parsed slice data */
#define V4L2_PIX_FMT_MPEG4     v4l2_fourcc('M', 'P', 'G', '4') /* MPEG-4 part 2 */
/* ES */
#define V4L2_PIX_FMT_XVID      v4l2_fourcc('X', 'V', 'I', 'D') /* Xvid */
/* */
#define V4L2_PIX_FMT_VC1_ANNEX_G v4l2_fourcc('V', 'C', '1', 'G') /* SMPTE 421M */
/* Annex G compliant stream */
#define V4L2_PIX_FMT_VC1_ANNEX_L v4l2_fourcc('V', 'C', '1', 'L') /* SMPTE 421M */
/* Annex L compliant stream */
#define V4L2_PIX_FMT_VP8        v4l2_fourcc('V', 'P', '8', '0') /* VP8 */
#define V4L2_PIX_FMT_VP8_FRAME  v4l2_fourcc('V', 'P', '8', 'F') /* VP8 parsed */
/* frame */
#define V4L2_PIX_FMT_VP9        v4l2_fourcc('V', 'P', '9', '0') /* VP9 */
#define V4L2_PIX_FMT_VP9_FRAME  v4l2_fourcc('V', 'P', '9', 'F') /* VP9 parsed */
/* frame */
#define V4L2_PIX_FMT_HEVC       v4l2_fourcc('H', 'E', 'V', 'C') /* HEVC aka H.
/* 265 */
#define V4L2_PIX_FMT_FWHT       v4l2_fourcc('F', 'W', 'H', 'T') /* Fast Walsh */
/* Hadamard Transform (vicodec) */
#define V4L2_PIX_FMT_FWHT_STATELESS v4l2_fourcc('S', 'F', 'W', 'H') /* */
/* Stateless FWHT (vicodec) */
#define V4L2_PIX_FMT_H264_SLICE v4l2_fourcc('S', '2', '6', '4') /* H264 parsed */
/* slices */
#define V4L2_PIX_FMT_HEVC_SLICE v4l2_fourcc('S', '2', '6', '5') /* HEVC parsed */
/* slices */
#define V4L2_PIX_FMT_AV1_FRAME  v4l2_fourcc('A', 'V', '1', 'F') /* AV1 parsed */
/* frame */
#define V4L2_PIX_FMT_SPK        v4l2_fourcc('S', 'P', 'K', '0') /* Sorenson */
/* Spark */
#define V4L2_PIX_FMT_RV30       v4l2_fourcc('R', 'V', '3', '0') /* RealVideo 8 */
#define V4L2_PIX_FMT_RV40       v4l2_fourcc('R', 'V', '4', '0') /* RealVideo 9 &
/* 10 */

```

```

/* Vendor-specific formats */
#define V4L2_PIX_FMT_CPIA1 v4l2_fourcc('C', 'P', 'I', 'A') /* cpi1 YUV */
#define V4L2_PIX_FMT_WNVA v4l2_fourcc('W', 'N', 'V', 'A') /* Winnov hw_
→compress */
#define V4L2_PIX_FMT_SN9C10X v4l2_fourcc('S', '9', '1', '0') /* SN9C10x_
→compression */
#define V4L2_PIX_FMT_SN9C20X_I420 v4l2_fourcc('S', '9', '2', '0') /* SN9C20x_
→YUV 4:2:0 */
#define V4L2_PIX_FMT_PWC1 v4l2_fourcc('P', 'W', 'C', '1') /* pwc older_
→webcam */
#define V4L2_PIX_FMT_PWC2 v4l2_fourcc('P', 'W', 'C', '2') /* pwc newer_
→webcam */
#define V4L2_PIX_FMT_ET61X251 v4l2_fourcc('E', '6', '2', '5') /* ET61X251_
→compression */
#define V4L2_PIX_FMT_SPCA501 v4l2_fourcc('S', '5', '0', '1') /* YUYV per line_
→*/
#define V4L2_PIX_FMT_SPCA505 v4l2_fourcc('S', '5', '0', '5') /* YYUV per line_
→*/
#define V4L2_PIX_FMT_SPCA508 v4l2_fourcc('S', '5', '0', '8') /* YUVY per line_
→*/
#define V4L2_PIX_FMT_SPCA561 v4l2_fourcc('S', '5', '6', '1') /* compressed_
→GBRG bayer */
#define V4L2_PIX_FMT_PAC207 v4l2_fourcc('P', '2', '0', '7') /* compressed_
→BGGR bayer */
#define V4L2_PIX_FMT_MR97310A v4l2_fourcc('M', '3', '1', '0') /* compressed_
→BGGR bayer */
#define V4L2_PIX_FMT_JL2005BCD v4l2_fourcc('J', 'L', '2', '0') /* compressed_
→RGGB bayer */
#define V4L2_PIX_FMT_SN9C2028 v4l2_fourcc('S', '0', 'N', 'X') /* compressed_
→GBRG bayer */
#define V4L2_PIX_FMT_SQ905C v4l2_fourcc('9', '0', '5', 'C') /* compressed_
→RGGB bayer */
#define V4L2_PIX_FMT_PJPG v4l2_fourcc('P', 'J', 'P', 'G') /* Pixart 73xx_
→JPEG */
#define V4L2_PIX_FMT_OV511 v4l2_fourcc('0', '5', '1', '1') /* ov511 JPEG */
#define V4L2_PIX_FMT_OV518 v4l2_fourcc('0', '5', '1', '8') /* ov518 JPEG */
#define V4L2_PIX_FMT_STV0680 v4l2_fourcc('S', '6', '8', '0') /* stv0680 bayer_
→*/
#define V4L2_PIX_FMT_TM6000 v4l2_fourcc('T', 'M', '6', '0') /* tm5600/tm60x0_
→*/
#define V4L2_PIX_FMT_CIT_YYVYUY v4l2_fourcc('C', 'I', 'T', 'V') /* one line of_
→Y then 1 line of VYUY */
#define V4L2_PIX_FMT_KONICA420 v4l2_fourcc('K', '0', 'N', 'I') /* YUV420_
→planar in blocks of 256 pixels */
#define V4L2_PIX_FMT_JPGL v4l2_fourcc('J', 'P', 'G', 'L') /* JPEG-Lite */
#define V4L2_PIX_FMT_SE401 v4l2_fourcc('S', '4', '0', '1') /* se401_
→janggu compressed rgb */
#define V4L2_PIX_FMT_S5C_UYVY_JPG v4l2_fourcc('S', '5', 'C', 'I') /* S5C73M3_
→interleaved UYVY/JPEG */
#define V4L2_PIX_FMT_Y8I v4l2_fourcc('Y', '8', 'I', ' ') /* Greyscale_
→*/

```

```

→ 8-bit L/R interleaved */
#define V4L2_PIX_FMT_Y12I      v4l2_fourcc('Y', '1', '2', 'I') /* Greyscale */
→ 12-bit L/R interleaved */
#define V4L2_PIX_FMT_Z16        v4l2_fourcc('Z', '1', '6', ' ') /* Depth data */
→ 16-bit */
#define V4L2_PIX_FMT_MT21C      v4l2_fourcc('M', 'T', '2', '1') /* Mediatek */
→ compressed block mode */
#define V4L2_PIX_FMT_MM21        v4l2_fourcc('M', 'M', '2', '1') /* Mediatek */
→ 8-bit block mode, two non-contiguous planes */
#define V4L2_PIX_FMT_MT2110T    v4l2_fourcc('M', 'T', '2', 'T') /* Mediatek */
→ 10-bit block tile mode */
#define V4L2_PIX_FMT_MT2110R    v4l2_fourcc('M', 'T', '2', 'R') /* Mediatek */
→ 10-bit block raster mode */
#define V4L2_PIX_FMT_INZI       v4l2_fourcc('I', 'N', 'Z', 'I') /* Intel Planar */
→ Greyscale 10-bit and Depth 16-bit */
#define V4L2_PIX_FMT_CNF4       v4l2_fourcc('C', 'N', 'F', '4') /* Intel 4-bit */
→ packed depth confidence information */
#define V4L2_PIX_FMT_HI240      v4l2_fourcc('H', 'I', '2', '4') /* BTTV 8-bit */
→ dithered RGB */
#define V4L2_PIX_FMT_QC08C      v4l2_fourcc('Q', '0', '8', 'C') /* Qualcomm */
→ 8-bit compressed */
#define V4L2_PIX_FMT_QC10C      v4l2_fourcc('Q', '1', '0', 'C') /* Qualcomm */
→ 10-bit compressed */
#define V4L2_PIX_FMT_AJPG       v4l2_fourcc('A', 'J', 'P', 'G') /* Aspeed JPEG */
#define V4L2_PIX_FMT_HEXTILE    v4l2_fourcc('H', 'X', 'T', 'L') /* Hextile */
→ compressed */

/* 10bit raw packed, 32 bytes for every 25 pixels, last LSB 6 bits unused */
#define V4L2_PIX_FMT_IPU3_SBGGR10   v4l2_fourcc('i', 'p', '3', 'b') /* */
→ IPU3 packed 10-bit BGGR bayer */
#define V4L2_PIX_FMT_IPU3_SGBRG10   v4l2_fourcc('i', 'p', '3', 'g') /* */
→ IPU3 packed 10-bit GBRG bayer */
#define V4L2_PIX_FMT_IPU3_SGRBG10   v4l2_fourcc('i', 'p', '3', 'G') /* */
→ IPU3 packed 10-bit GRBG bayer */
#define V4L2_PIX_FMT_IPU3_SRGGB10   v4l2_fourcc('i', 'p', '3', 'r') /* */
→ IPU3 packed 10-bit RGGB bayer */

/* SDR formats - used only for Software Defined Radio devices */
#define V4L2_SDR_FMT CU8          v4l2_fourcc('C', 'U', '0', '8') /* IQ u8 */
#define V4L2_SDR_FMT CU16LE       v4l2_fourcc('C', 'U', '1', '6') /* IQ u16le */
→ */
#define V4L2_SDR_FMT CS8          v4l2_fourcc('C', 'S', '0', '8') /* complex */
→ s8 */
#define V4L2_SDR_FMT CS14LE       v4l2_fourcc('C', 'S', '1', '4') /* complex */
→ s14le */
#define V4L2_SDR_FMT RU12LE       v4l2_fourcc('R', 'U', '1', '2') /* real */
→ u12le */
#define V4L2_SDR_FMT PCU16BE      v4l2_fourcc('P', 'C', '1', '6') /* planar */
→ complex u16be */
#define V4L2_SDR_FMT PCU18BE      v4l2_fourcc('P', 'C', '1', '8') /* planar */
→ complex u18be */

```

```

#define V4L2_SDR_FMT_PCU20BE      v4l2_fourcc('P', 'C', '2', '0') /* planar
→complex u20be */

/* Touch formats - used for Touch devices */
#define V4L2_TCH_FMT_DELTA_TD16 v4l2_fourcc('T', 'D', '1', '6') /* 16-bit
→signed deltas */
#define V4L2_TCH_FMT_DELTA_TD08 v4l2_fourcc('T', 'D', '0', '8') /* 8-bit
→signed deltas */
#define V4L2_TCH_FMT_TU16         v4l2_fourcc('T', 'U', '1', '6') /* 16-bit
→unsigned touch data */
#define V4L2_TCH_FMT_TU08         v4l2_fourcc('T', 'U', '0', '8') /* 8-bit
→unsigned touch data */

/* Meta-data formats */
#define V4L2_META_FMT_VSP1_HGO    v4l2_fourcc('V', 'S', 'P', 'H') /* R-Car
→VSP1 1-D Histogram */
#define V4L2_META_FMT_VSP1_HGT    v4l2_fourcc('V', 'S', 'P', 'T') /* R-Car
→VSP1 2-D Histogram */
#define V4L2_META_FMT_UVC         v4l2_fourcc('U', 'V', 'C', 'H') /* UVC
→Payload Header metadata */
#define V4L2_META_FMT_D4XX        v4l2_fourcc('D', '4', 'X', 'X') /* D4XX
→Payload Header metadata */
#define V4L2_META_FMT_VIVID       v4l2_fourcc('V', 'I', 'V', 'D') /* Vivid
→Metadata */

/* Vendor specific - used for RK_ISP1 camera sub-system */
#define V4L2_META_FMT_RK_ISP1_PARAMS v4l2_fourcc('R', 'K', '1', 'P') /* Rockchip ISP1 3A Parameters */
#define V4L2_META_FMT_RK_ISP1_STAT_3A   v4l2_fourcc('R', 'K', '1', 'S') /* Rockchip ISP1 3A Statistics */

/* priv field value to indicates that subsequent fields are valid. */
#define V4L2_PIX_FMT_PRIV_MAGIC     0xfeedcafe

/* Flags */
#define V4L2_PIX_FMT_FLAG_PREMUL_ALPHA 0x00000001
#define V4L2_PIX_FMT_FLAG_SET_CSC      0x00000002

/*
 *      F O R M A T   E N U M E R A T I O N
 */
struct v4l2_fmtdesc {
    __u32                  index;           /* Format number */
    __u32                  type;            /* enum v4l2_buf_type */
    __u32                  flags;
    __u8                   description[32]; /* Description string */
    __u32                  pixelformat;    /* Format fourcc */
    __u32                  mbus_code;       /* Media bus code */
    __u32                  reserved[3];
};


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```

#define V4L2_FMT_FLAG_COMPRESSED          0x0001
#define V4L2_FMT_FLAG_EMULATED           0x0002
#define V4L2_FMT_FLAG_CONTINUOUS_BYTESTREAM 0x0004
#define V4L2_FMT_FLAG_DYN_RESOLUTION     0x0008
#define V4L2_FMT_FLAG_ENC_CAP_FRAME_INTERVAL 0x0010
#define V4L2_FMT_FLAG_CSC_COLORSPACE    0x0020
#define V4L2_FMT_FLAG_CSC_XFER_FUNC      0x0040
#define V4L2_FMT_FLAG_CSC_YCBCR_ENC      0x0080
#define V4L2_FMT_FLAG_CSC_HSV_ENC        V4L2_FMT_FLAG_CSC_YCBCR_ENC
#define V4L2_FMT_FLAG_CSC_QUANTIZATION   0x0100

/* Frame Size and frame rate enumeration */
/*
 *      F R A M E      S I Z E      E N U M E R A T I O N
 */
enum v4l2_frmsizetypes {
    V4L2_FRMSIZE_TYPE_DISCRETE      = 1,
    V4L2_FRMSIZE_TYPE_CONTINUOUS    = 2,
    V4L2_FRMSIZE_TYPE_STEPWISE      = 3,
};

struct v4l2_frmsize_discrete {
    __u32                           width;          /* Frame width [pixel] */
    __u32                           height;         /* Frame height [pixel] */
};

struct v4l2_frmsize_stepwise {
    __u32                           min_width;       /* Minimum frame width [pixel] */
    __u32                           max_width;       /* Maximum frame width [pixel] */
    __u32                           step_width;      /* Frame width step size */
    __u32                           min_height;     /* Minimum frame height */
    __u32                           max_height;     /* Maximum frame height */
    __u32                           step_height;    /* Frame height step size */
};

struct v4l2_frmsizeenum {
    __u32                           index;          /* Frame size number */
    __u32                           pixel_format;   /* Pixel format */
    __u32                           type;           /* Frame size type the device */
    __u32                           supports;        /* */

    union {
        struct v4l2_frmsize_discrete discrete;
        struct v4l2_frmsize_stepwise stepwise;
    };
};

```

```

        __u32    reserved[2];                      /* Reserved space for future */

use */
};

/*
 *      F R A M E      R A T E      E N U M E R A T I O N
 */
enum v4l2_frmivaltypes {
    V4L2_FRMIVAL_TYPE_DISCRETE      = 1,
    V4L2_FRMIVAL_TYPE_CONTINUOUS    = 2,
    V4L2_FRMIVAL_TYPE_STEPWISE     = 3,
};

struct v4l2_frmival_stepwise {
    struct v4l2_fract      min;                /* Minimum frame interval [s] */
use */
    struct v4l2_fract      max;                /* Maximum frame interval [s] */
use */
    struct v4l2_fract      step;               /* Frame interval step size [s] */
};

struct v4l2_frmivalenum {
    __u32          index;             /* Frame format index */
    __u32          pixel_format;      /* Pixel format */
    __u32          width;            /* Frame width */
    __u32          height;           /* Frame height */
    __u32          type;             /* Frame interval type the device supports */

    union {
        struct v4l2_fract discrete;
        struct v4l2_frmival_stepwise stepwise;
    };
};

        __u32    reserved[2];                      /* Reserved space for future */

use */
};

/*
 *      T I M E C O D E
 */
struct v4l2_timecode {
    __u32    type;
    __u32    flags;
    __u8     frames;
    __u8     seconds;
    __u8     minutes;
    __u8     hours;
    __u8     userbits[4];
};

```

```

};

/* Type */
#define V4L2_TC_TYPE_24FPS 1
#define V4L2_TC_TYPE_25FPS 2
#define V4L2_TC_TYPE_30FPS 3
#define V4L2_TC_TYPE_50FPS 4
#define V4L2_TC_TYPE_60FPS 5

/* Flags */
#define V4L2_TC_FLAG_DROPFRAME 0x0001 /* "drop-frame" mode */
#define V4L2_TC_FLAG_COLORFRAME 0x0002
#define V4L2_TC_USERBITS_field 0x000C
#define V4L2_TC_USERBITS_USERDEFINED 0x0000
#define V4L2_TC_USERBITS_8BITCHARS 0x0008
/* The above is based on SMPTE timecodes */

struct v4l2_jpegcompression {
    int quality;

    int APPn;           /* Number of APP segment to be written,
                           * must be 0..15 */
    int APP_len;         /* Length of data in JPEG APPn segment */
    char APP_data[60];   /* Data in the JPEG APPn segment. */

    int COM_len;         /* Length of data in JPEG COM segment */
    char COM_data[60];   /* Data in JPEG COM segment */

    __u32 jpeg_markers; /* Which markers should go into the JPEG
                           * output. Unless you exactly know what
                           * you do, leave them untouched.
                           * Including less markers will make the
                           * resulting code smaller, but there will
                           * be fewer applications which can read it.
                           * The presence of the APP and COM marker
                           * is influenced by APP_len and COM_len
                           * ONLY, not by this property! */

#define V4L2_JPEG_MARKER_DHT (1<<3)    /* Define Huffman Tables */
#define V4L2_JPEG_MARKER_DQT (1<<4)    /* Define Quantization Tables */
#define V4L2_JPEG_MARKER_DRI (1<<5)    /* Define Restart Interval */
#define V4L2_JPEG_MARKER_COM (1<<6)    /* Comment segment */
#define V4L2_JPEG_MARKER_APP (1<<7)    /* App segment, driver will
                           * always use APP0 */

};

/*
 *      M E M O R Y - M A P P I N G     B U F F E R S
*/
#endif _KERNEL_

```

```

/*
 * This corresponds to the user space version of timeval
 * for 64-bit time_t. sparc64 is different from everyone
 * else, using the microseconds in the wrong half of the
 * second 64-bit word.
 */
struct __kernel_v4l2_timeval {
    long long          tv_sec;
#if defined(__sparc__) && defined(__arch64__)
    int               tv_usec;
    int               __pad;
#else
    long long          tv_usec;
#endif
};

struct v4l2_requestbuffers {
    __u32              count;
    __u32              type;           /* enum v4l2_buf_type */
    __u32              memory;        /* enum v4l2_memory */
    __u32              capabilities;
    __u8               flags;
    __u8               reserved[3];
};

#define V4L2_MEMORY_FLAG_NON_COHERENT          (1 << 0)

/* capabilities for struct v4l2_requestbuffers and v4l2_create_buffers */
#define V4L2_BUF_CAP_SUPPORTS_MMAP            (1 << 0)
#define V4L2_BUF_CAP_SUPPORTS_USERPTR         (1 << 1)
#define V4L2_BUF_CAP_SUPPORTS_DMABUF          (1 << 2)
#define V4L2_BUF_CAP_SUPPORTS_REQUESTS        (1 << 3)
#define V4L2_BUF_CAP_SUPPORTS_ORPHANED_BUFS   (1 << 4)
#define V4L2_BUF_CAP_SUPPORTS_M2M_HOLD_CAPTURE_BUF (1 << 5)
#define V4L2_BUF_CAP_SUPPORTS_MMAP_CACHE_HINTS (1 << 6)
#define V4L2_BUF_CAP_SUPPORTS_MAX_NUM_BUFFERS (1 << 7)

/**
 * struct v4l2_plane - plane info for multi-planar buffers
 * @bytesused:           number of bytes occupied by data in the plane (payload)
 * @length:              size of this plane (NOT the payload) in bytes
 * @mem_offset:          when memory in the associated struct v4l2_buffer is
 *                      V4L2_MEMORY_MMAP, equals the offset from the start of
 *                      the device memory for this plane (or is a "cookie" that
 *                      should be passed to mmap() called on the video node)
 * @userptr:             when memory is V4L2_MEMORY_USERPTR, a userspace pointer
 *                      pointing to this plane
 * @fd:                  when memory is V4L2_MEMORY_DMABUF, a userspace file
 *                      descriptor associated with this plane
 * @m:                   union of @mem_offset, @userptr and @fd

```

```

* @data_offset:          offset in the plane to the start of data; usually 0,
*                       unless there is a header in front of the data
* @reserved:             drivers and applications must zero this array
*
* Multi-planar buffers consist of one or more planes, e.g. an YCbCr buffer
* with two planes can have one plane for Y, and another for interleaved CbCr
* components. Each plane can reside in a separate memory buffer, or even in
* a completely separate memory node (e.g. in embedded devices).
*/
struct v4l2_plane {
    __u32                  bytesused;
    __u32                  length;
    union {
        __u32      mem_offset;
        unsigned long userptr;
        __s32      fd;
    } m;
    __u32      data_offset;
    __u32      reserved[11];
};

/**
 * struct v4l2_buffer - video buffer info
 * @index:           id number of the buffer
 * @type:            enum v4l2_buf_type; buffer type (type == *_MPLANE for
 *                   multiplanar buffers);
 * @bytesused:       number of bytes occupied by data in the buffer (payload);
 *                   unused (set to 0) for multiplanar buffers
 * @flags:           buffer informational flags
 * @field:           enum v4l2_field; field order of the image in the buffer
 * @timestamp:       frame timestamp
 * @timecode:        frame timecode
 * @sequence:        sequence count of this frame
 * @memory:          enum v4l2_memory; the method, in which the actual video data is
 *                   passed
 * @offset:          for non-multiplanar buffers with memory == V4L2_MEMORY_MMAP;
 *                   offset from the start of the device memory for this plane,
 *                   (or a "cookie" that should be passed to mmap() as offset)
 * @userptr:         for non-multiplanar buffers with memory == V4L2_MEMORY_USERPTR;
 *                   a userspace pointer pointing to this buffer
 * @fd:              for non-multiplanar buffers with memory == V4L2_MEMORY_DMABUF;
 *                   a userspace file descriptor associated with this buffer
 * @planes:          for multiplanar buffers; userspace pointer to the array of plane
 * @m:               info structs for this buffer
 * @length:          union of @offset, @userptr, @planes and @fd
 * @reserved2:        drivers and applications must zero this field
 * @request_fd:      fd of the request that this buffer should use

```

```

* @reserved:    for backwards compatibility with applications that do not know
*               about @request_fd
*
* Contains data exchanged by application and driver using one of the Streaming
* I/O methods.
*/
struct v4l2_buffer {
    __u32 index;
    __u32 type;
    __u32 bytesused;
    __u32 flags;
    __u32 field;
#ifdef __KERNEL__
    struct __kernel_v4l2_timeval timestamp;
#else
    struct timeval timestamp;
#endif
    struct v4l2_timecode timecode;
    __u32 sequence;

    /* memory location */
    __u32 memory;
    union {
        __u32 offset;
        unsigned long userptr;
        struct v4l2_plane *planes;
        __s32 fd;
    } m;
    __u32 length;
    __u32 reserved2;
    union {
        __s32 request_fd;
        __u32 reserved;
    };
};

#ifndef __KERNEL__
/** 
 * v4l2_timeval_to_ns - Convert timeval to nanoseconds
 * @tv:          pointer to the timeval variable to be converted
 *
 * Returns the scalar nanosecond representation of the timeval
 * parameter.
 */
static inline __u64 v4l2_timeval_to_ns(const struct timeval *tv)
{
    return (__u64)tv->tv_sec * 1000000000ULL + tv->tv_usec * 1000;
}
#endif

/* Flags for 'flags' field */

```

```

/* Buffer is mapped (flag) */
#define V4L2_BUF_FLAG_MAPPED                                0x00000001
/* Buffer is queued for processing */
#define V4L2_BUF_FLAG_QUEUED                                0x00000002
/* Buffer is ready */
#define V4L2_BUF_FLAG_DONE                                 0x00000004
/* Image is a keyframe (I-frame) */
#define V4L2_BUF_FLAG_KEYFRAME                            0x00000008
/* Image is a P-frame */
#define V4L2_BUF_FLAG_PFRAME                            0x00000010
/* Image is a B-frame */
#define V4L2_BUF_FLAG_BFRAME                            0x00000020
/* Buffer is ready, but the data contained within is corrupted. */
#define V4L2_BUF_FLAG_ERROR                                0x00000040
/* Buffer is added to an unqueued request */
#define V4L2_BUF_FLAG_IN_REQUEST                         0x00000080
/* timecode field is valid */
#define V4L2_BUF_FLAG_TIMECODE                           0x00000100
/* Don't return the capture buffer until OUTPUT timestamp changes */
#define V4L2_BUF_FLAG_M2M_HOLD_CAPTURE_BUF                0x00000200
/* Buffer is prepared for queuing */
#define V4L2_BUF_FLAG_PREPARED                           0x00000400
/* Cache handling flags */
#define V4L2_BUF_FLAG_NO_CACHE_INVALIDATE                 0x00000800
#define V4L2_BUF_FLAG_NO_CACHE_CLEAN                      0x00001000
/* Timestamp type */
#define V4L2_BUF_FLAG_TIMESTAMP_MASK                     0x0000e000
#define V4L2_BUF_FLAG_TIMESTAMP_UNKNOWN                  0x00000000
#define V4L2_BUF_FLAG_TIMESTAMP_MONOTONIC                0x00002000
#define V4L2_BUF_FLAG_TIMESTAMP_COPY                      0x00004000
/* Timestamp sources. */
#define V4L2_BUF_FLAG_TSTAMP_SRC_MASK                   0x00070000
#define V4L2_BUF_FLAG_TSTAMP_SRC_EOF                     0x00000000
#define V4L2_BUF_FLAG_TSTAMP_SRC_SOE                    0x00010000
/* mem2mem encoder/decoder */
#define V4L2_BUF_FLAG_LAST                             0x00100000
/* request_fd is valid */
#define V4L2_BUF_FLAG_REQUEST_FD                      0x00800000

/**
 * struct v4l2_exportbuffer - export of video buffer as DMABUF file descriptor
 *
 * @index:      id number of the buffer
 * @type:       enum v4l2_buf_type; buffer type (type == *_MPLANE for
 *              multiplanar buffers);
 * @plane:      index of the plane to be exported, 0 for single plane queues
 * @flags:       flags for newly created file, currently only O_CLOEXEC is
 *              supported, refer to manual of open syscall for more details
 * @fd:         file descriptor associated with DMABUF (set by driver)
 * @reserved:   drivers and applications must zero this array
 */

```

```

* Contains data used for exporting a video buffer as DMABUF file descriptor.
* The buffer is identified by a 'cookie' returned by VIDIOC_QUERYBUF
* (identical to the cookie used to mmap() the buffer to userspace). All
* reserved fields must be set to zero. The field reserved0 is expected to
* become a structure 'type' allowing an alternative layout of the structure
* content. Therefore this field should not be used for any other extensions.
*/
struct v4l2_exportbuffer {
    __u32          type; /* enum v4l2_buf_type */
    __u32          index;
    __u32          plane;
    __u32          flags;
    __s32          fd;
    __u32          reserved[11];
};

/*
 *      O V E R L A Y   P R E V I E W
 */
struct v4l2_framebuffer {
    __u32          capability;
    __u32          flags;
/* FIXME: in theory we should pass something like PCI device + memory
 * region + offset instead of some physical address */
    void           *base;
    struct {
        __u32          width;
        __u32          height;
        __u32          pixelformat;
        __u32          field;      /* enum v4l2_field */
        __u32          bytesperline; /* for padding, zero if unused */
    } fmt;
};

/* Flags for the 'capability' field. Read only */
#define V4L2_FBUF_CAP_EXTERNOVERLAY      0x0001
#define V4L2_FBUF_CAP_CHROMAKEY         0x0002
#ifndef __KERNEL__
#define V4L2_FBUF_CAP_LIST_CLIPPING     0x0004
#define V4L2_FBUF_CAP_BITMAP_CLIPPING    0x0008
#endif
#define V4L2_FBUF_CAP_LOCAL_ALPHA       0x0010
#define V4L2_FBUF_CAP_GLOBAL_ALPHA      0x0020
#define V4L2_FBUF_CAP_LOCAL_INV_ALPHA   0x0040
#define V4L2_FBUF_CAP_SRC_CHROMAKEY    0x0080
/* Flags for the 'flags' field. */
#define V4L2_FBUF_FLAG_PRIMARY          0x0001
#define V4L2_FBUF_FLAG_OVERLAY         0x0002

```

```

#define V4L2_FBUF_FLAG_CHROMAKEY      0x0004
#define V4L2_FBUF_FLAG_LOCAL_ALPHA    0x0008
#define V4L2_FBUF_FLAG_GLOBAL_ALPHA   0x0010
#define V4L2_FBUF_FLAG_LOCAL_INV_ALPHA 0x0020
#define V4L2_FBUF_FLAG_SRC_CHROMAKEY  0x0040

struct v4l2_clip {
    struct v4l2_rect          c;
    struct v4l2_clip         __user *next;
};

struct v4l2_window {
    struct v4l2_rect          w;
    __u32                      field; /* enum v4l2_field */
    __u32                      chromakey;
    struct v4l2_clip        *clips;
    __u32                      clipcount;
    void                      __user *bitmap;
    __u8                       global_alpha;
};

/*
 *      C A P T U R E      P A R A M E T E R S
 */
struct v4l2_captureparm {
    __u32                      capability; /* Supported modes */
    __u32                      capturemode; /* Current mode */
    struct v4l2_fract        timeperframe; /* Time per frame in seconds */
    __u32                      extendedmode; /* Driver-specific extensions */
    __u32                      readbuffers; /* # of buffers for read */
    __u32                      reserved[4];
};

/* Flags for 'capability' and 'capturemode' fields */
#define V4L2_MODE_HIGHQUALITY 0x0001 /* High quality imaging mode */
#define V4L2_CAP_TIMEPERFRAME 0x1000 /* timeperframe field is supported */

struct v4l2_outputparm {
    __u32                      capability; /* Supported modes */
    __u32                      outputmode; /* Current mode */
    struct v4l2_fract        timeperframe; /* Time per frame in seconds */
    __u32                      extendedmode; /* Driver-specific extensions */
    __u32                      writebuffers; /* # of buffers for write */
    __u32                      reserved[4];
};

/*
 *      I N P U T      I M A G E      C R O P P I N G
 */
struct v4l2_cropcap {
    __u32                      type; /* enum v4l2_buf_type */

```

```

        struct v4l2_rect           bounds;
        struct v4l2_rect           defrect;
        struct v4l2_fract          pixelaspect;
};

struct v4l2_crop {
    __u32                         type;      /* enum v4l2_buf_type */
    struct v4l2_rect               c;
};

/***
 * struct v4l2_selection - selection info
 * @type:          buffer type (do not use *_MPLANE types)
 * @target:        Selection target, used to choose one of possible rectangles;
 *                 defined in v4l2-common.h; V4L2_SEL_TGT_*
 * @flags:         constraints flags, defined in v4l2-common.h; V4L2_SEL_FLAG_*
 * @r:             coordinates of selection window
 * @reserved:     for future use, rounds structure size to 64 bytes, set to zero
 *
 * Hardware may use multiple helper windows to process a video stream.
 * The structure is used to exchange this selection areas between
 * an application and a driver.
 */
struct v4l2_selection {
    __u32                         type;
    __u32                         target;
    __u32                         flags;
    struct v4l2_rect               r;
    __u32                         reserved[9];
};

/*
 *      A N A L O G      V I D E O      S T A N D A R D
 */

typedef __u64 v4l2_std_id;

/*
 * Attention: Keep the V4L2_STD_* bit definitions in sync with
 * include/dt-bindings/display/sdtv-standards.h SDTV_STD_* bit definitions.
 */
/* one bit for each */
#define V4L2_STD_PAL_B            ((v4l2_std_id)0x00000001)
#define V4L2_STD_PAL_B1           ((v4l2_std_id)0x00000002)
#define V4L2_STD_PAL_G            ((v4l2_std_id)0x00000004)
#define V4L2_STD_PAL_H            ((v4l2_std_id)0x00000008)
#define V4L2_STD_PAL_I            ((v4l2_std_id)0x00000010)
#define V4L2_STD_PAL_D            ((v4l2_std_id)0x00000020)
#define V4L2_STD_PAL_D1           ((v4l2_std_id)0x00000040)
#define V4L2_STD_PAL_K            ((v4l2_std_id)0x00000080)

```

```

#define V4L2_STD_PAL_M          (((v4l2_std_id)0x00000100))
#define V4L2_STD_PAL_N          (((v4l2_std_id)0x00000200))
#define V4L2_STD_PAL_Nc         (((v4l2_std_id)0x00000400))
#define V4L2_STD_PAL_60         (((v4l2_std_id)0x00000800))

#define V4L2_STD_NTSC_M          (((v4l2_std_id)0x00001000))      /* BTSC */
#define V4L2_STD_NTSC_M_JP        (((v4l2_std_id)0x00002000))      /* EIA-J */
#define V4L2_STD_NTSC_443         (((v4l2_std_id)0x00004000))
#define V4L2_STD_NTSC_M_KR        (((v4l2_std_id)0x00008000))      /* FM A2 */

#define V4L2_STD_SECAM_B          (((v4l2_std_id)0x00010000))
#define V4L2_STD_SECAM_D          (((v4l2_std_id)0x00020000))
#define V4L2_STD_SECAM_G          (((v4l2_std_id)0x00040000))
#define V4L2_STD_SECAM_H          (((v4l2_std_id)0x00080000))
#define V4L2_STD_SECAM_K          (((v4l2_std_id)0x00100000))
#define V4L2_STD_SECAM_K1         (((v4l2_std_id)0x00200000))
#define V4L2_STD_SECAM_L          (((v4l2_std_id)0x00400000))
#define V4L2_STD_SECAM_LC         (((v4l2_std_id)0x00800000))

/* ATSC/HDTV */
#define V4L2_STD_ATSC_8_VSB       (((v4l2_std_id)0x01000000))
#define V4L2_STD_ATSC_16_VSB       (((v4l2_std_id)0x02000000))

/* FIXME:
   Although std_id is 64 bits, there is an issue on PPC32 architecture that
   makes switch(__u64) to break. So, there's a hack on v4l2-common.c rounding
   this value to 32 bits.
   As, currently, the max value is for V4L2_STD_ATSC_16_VSB (30 bits wide),
   it should work fine. However, if needed to add more than two standards,
   v4l2-common.c should be fixed.
*/
/* Some macros to merge video standards in order to make live easier for the
 * drivers and V4L2 applications
*/
/* "Common" NTSC/M - It should be noticed that V4L2_STD_NTSC_443 is
 * Missing here.
*/
#define V4L2_STD_NTSC            ((V4L2_STD_NTSC_M          | \
                                V4L2_STD_NTSC_M_JP        | \
                                V4L2_STD_NTSC_M_KR)

/* Secam macros */
#define V4L2_STD_SECAM_DK         ((V4L2_STD_SECAM_D          | \
                                V4L2_STD_SECAM_K          | \
                                V4L2_STD_SECAM_K1)

/* All Secam Standards */
#define V4L2_STD_SECAM            ((V4L2_STD_SECAM_B          | \
                                V4L2_STD_SECAM_G)

```

```

        V4L2_STD_SECAM_H      \\
        V4L2_STD_SECAM_DK     \\
        V4L2_STD_SECAM_L      \\
        V4L2_STD_SECAM_LC)

/* PAL macros */
#define V4L2_STD_PAL_BG      (V4L2_STD_PAL_B      \\
                           V4L2_STD_PAL_B1     \\
                           V4L2_STD_PAL_G)
#define V4L2_STD_PAL_DK      (V4L2_STD_PAL_D      \\
                           V4L2_STD_PAL_D1     \\
                           V4L2_STD_PAL_K)

/*
 * "Common" PAL - This macro is there to be compatible with the old
 * V4L1 concept of "PAL": /BGDKHI.
 * Several PAL standards are missing here: /M, /N and /Nc
 */
#define V4L2_STD_PAL          (V4L2_STD_PAL_BG      \\
                           V4L2_STD_PAL_DK     \\
                           V4L2_STD_PAL_H      \\
                           V4L2_STD_PAL_I)

/* Chroma "agnostic" standards */
#define V4L2_STD_B            (V4L2_STD_PAL_B      \\
                           V4L2_STD_PAL_B1     \\
                           V4L2_STD_SECAM_B)
#define V4L2_STD_G            (V4L2_STD_PAL_G      \\
                           V4L2_STD_SECAM_G)
#define V4L2_STD_H            (V4L2_STD_PAL_H      \\
                           V4L2_STD_SECAM_H)
#define V4L2_STD_L            (V4L2_STD_SECAM_L      \\
                           V4L2_STD_SECAM_LC)
#define V4L2_STD_GH           (V4L2_STD_G      \\
                           V4L2_STD_H)
#define V4L2_STD_DK           (V4L2_STD_PAL_DK     \\
                           V4L2_STD_SECAM_DK)
#define V4L2_STD_BG           (V4L2_STD_B      \\
                           V4L2_STD_G)
#define V4L2_STD_MN           (V4L2_STD_PAL_M      \\
                           V4L2_STD_PAL_N      \\
                           V4L2_STD_PAL_Nc     \\
                           V4L2_STD_NTSC)

/* Standards where MTS/BTSC stereo could be found */
#define V4L2_STD_MTS          (V4L2_STD_NTSC_M      \\
                           V4L2_STD_PAL_M      \\
                           V4L2_STD_PAL_N      \\
                           V4L2_STD_PAL_Nc)

/* Standards for Countries with 60Hz Line frequency */
#define V4L2_STD_525_60         (V4L2_STD_PAL_M      \\
                           V4L2_STD_PAL_60      \\
                           V4L2_STD_NTSC)

```

```

V4L2_STD_NTSC_443)
/* Standards for Countries with 50Hz Line frequency */
#define V4L2_STD_625_50          (V4L2_STD_PAL           | \
                                V4L2_STD_PAL_N        | \
                                V4L2_STD_PAL_Nc       | \
                                V4L2_STD_SECAM)

#define V4L2_STD_ATSC           (V4L2_STD_ATSC_8_VSB  | \
                                V4L2_STD_ATSC_16_VSB) | \
/* Macros with none and all analog standards */
#define V4L2_STD_UNKNOWN         0
#define V4L2_STD_ALL              (V4L2_STD_525_60      | \
                                V4L2_STD_625_50) | \
                               

struct v4l2_standard {
    __u32                  index;
    v4l2_std_id            id;
    __u8                   name[24];
    struct v4l2_fract     frameperiod; /* Frames, not fields */
    __u32                  framelines;
    __u32                  reserved[4];
};

/*
 *      D V      B T      T I M I N G S
*/
/** struct v4l2_bt_timings - BT.656/BT.1120 timing data
 * @width:      total width of the active video in pixels
 * @height:     total height of the active video in lines
 * @interlaced: Interlaced or progressive
 * @polarities: Positive or negative polarities
 * @pixelclock: Pixel clock in HZ. Ex. 74.25MHz->74250000
 * @hfrontporch:Horizontal front porch in pixels
 * @hsync:       Horizontal Sync length in pixels
 * @hbackporch: Horizontal back porch in pixels
 * @vfrontporch:Vertical front porch in lines
 * @vsync:       Vertical Sync length in lines
 * @vbackporch: Vertical back porch in lines
 * @il_vfrontporch:Vertical front porch for the even field
 *                  (aka field 2) of interlaced field formats
 * @il_vsync:     Vertical Sync length for the even field
 *                  (aka field 2) of interlaced field formats
 * @il_vbackporch:Vertical back porch for the even field
 *                  (aka field 2) of interlaced field formats
 * @standards:   Standards the timing belongs to
 * @flags:       Flags
 * @picture_aspect: The picture aspect ratio (hor/vert).
 * @cea861_vic:  VIC code as per the CEA-861 standard.
 * @hdmi_vic:   VIC code as per the HDMI standard.
 * @reserved:   Reserved fields, must be zeroed.

```

```

/*
 * A note regarding vertical interlaced timings: height refers to the total
 * height of the active video frame (= two fields). The blanking timings refer
 * to the blanking of each field. So the height of the total frame is
 * calculated as follows:
 */
* tot_height = height + vfrontporch + vsync + vbackporch +
*               il_vfrontporch + il_vsync + il_vbackporch
*
* The active height of each field is height / 2.
*/
struct v4l2_bt_timings {
    __u32 width;
    __u32 height;
    __u32 interlaced;
    __u32 polarities;
    __u64 pixelclock;
    __u32 hfrontporch;
    __u32 hsync;
    __u32 hbackporch;
    __u32 vfrontporch;
    __u32 vsync;
    __u32 vbackporch;
    __u32 il_vfrontporch;
    __u32 il_vsync;
    __u32 il_vbackporch;
    __u32 standards;
    __u32 flags;
    struct v4l2_fract picture_aspect;
    __u8 cea861_vic;
    __u8 hdmi_vic;
    __u8 reserved[46];
} __attribute__((packed));

/* Interlaced or progressive format */
#define V4L2_DV_PROGRESSIVE      0
#define V4L2_DV_INTERLACED       1

/* Polarities. If bit is not set, it is assumed to be negative polarity */
#define V4L2_DV_VSYNC_POS_POL   0x00000001
#define V4L2_DV_HSYNC_POS_POL   0x00000002

/* Timings standards */
#define V4L2_DV_BT_STD_CEA861   (1 << 0) /* CEA-861 Digital TV Profile */
#define V4L2_DV_BT_STD_DMT     (1 << 1) /* VESA Discrete Monitor Timings */
#define V4L2_DV_BT_STD_CVT     (1 << 2) /* VESA Coordinated Video Timings */
#define V4L2_DV_BT_STD_GTF     (1 << 3) /* VESA Generalized Timings Formula */
/* */
#define V4L2_DV_BT_STD_SDI     (1 << 4) /* SDI Timings */

/* Flags */

```

```

/*
 * CVT/GTF specific: timing uses reduced blanking (CVT) or the 'Secondary
 * GTF' curve (GTF). In both cases the horizontal and/or vertical blanking
 * intervals are reduced, allowing a higher resolution over the same
 * bandwidth. This is a read-only flag.
*/
#define V4L2_DV_FL_REDUCED_BLANKING          (1 << 0)
/*
 * CEA-861 specific: set for CEA-861 formats with a framerate of a multiple
 * of six. These formats can be optionally played at 1 / 1.001 speed.
 * This is a read-only flag.
*/
#define V4L2_DV_FL_CAN_REDUCE_FPS            (1 << 1)
/*
 * CEA-861 specific: only valid for video transmitters, the flag is cleared
 * by receivers.
 * If the framerate of the format is a multiple of six, then the pixelclock
 * used to set up the transmitter is divided by 1.001 to make it compatible
 * with 60 Hz based standards such as NTSC and PAL-M that use a framerate of
 * 29.97 Hz. Otherwise this flag is cleared. If the transmitter can't generate
 * such frequencies, then the flag will also be cleared.
*/
#define V4L2_DV_FL_REDUCED_FPS               (1 << 2)
/*
 * Specific to interlaced formats: if set, then field 1 is really one half-line
 * longer and field 2 is really one half-line shorter, so each field has
 * exactly the same number of half-lines. Whether half-lines can be detected
 * or used depends on the hardware.
*/
#define V4L2_DV_FL_HALF_LINE                 (1 << 3)
/*
 * If set, then this is a Consumer Electronics (CE) video format. Such formats
 * differ from other formats (commonly called IT formats) in that if RGB
 * encoding is used then by default the RGB values use limited range (i.e.
 * use the range 16-235) as opposed to 0-255. All formats defined in CEA-861
 * except for the 640x480 format are CE formats.
*/
#define V4L2_DV_FL_IS_CE_VIDEO              (1 << 4)
/* Some formats like SMPTE-125M have an interlaced signal with a odd
 * total height. For these formats, if this flag is set, the first
 * field has the extra line. If not, it is the second field.
*/
#define V4L2_DV_FL_FIRST_FIELD_EXTRA_LINE   (1 << 5)
/*
 * If set, then the picture_aspect field is valid. Otherwise assume that the
 * pixels are square, so the picture aspect ratio is the same as the width to
 * height ratio.
*/
#define V4L2_DV_FL_HAS_PICTURE_ASPECT      (1 << 6)
*/

```

```

 * If set, then the cea861_vic field is valid and contains the Video
 * Identification Code as per the CEA-861 standard.
 */
#define V4L2_DV_FL_HAS_CEA861_VIC           (1 << 7)
/*
 * If set, then the hdmi_vic field is valid and contains the Video
 * Identification Code as per the HDMI standard (HDMI Vendor Specific
 * InfoFrame).
*/
#define V4L2_DV_FL_HAS_HDMI_VIC            (1 << 8)
/*
 * CEA-861 specific: only valid for video receivers.
 * If set, then HW can detect the difference between regular FPS and
 * 1000/1001 FPS. Note: This flag is only valid for HDMI VIC codes with
 * the V4L2_DV_FL_CAN_REDUCE_FPS flag set.
*/
#define V4L2_DV_FL_CAN_DETECT_REDUCED_FPS   (1 << 9)

/* A few useful defines to calculate the total blanking and frame sizes */
#define V4L2_DV_BT_BLANKING_WIDTH(bt) \
    ((bt)->hfrontporch + (bt)->hsync + (bt)->hbackporch)
#define V4L2_DV_BT_FRAME_WIDTH(bt) \
    ((bt)->width + V4L2_DV_BT_BLANKING_WIDTH(bt))
#define V4L2_DV_BT_BLANKING_HEIGHT(bt) \
    ((bt)->vfrontporch + (bt)->vsync + (bt)->vbackporch + \
     ((bt)->interlaced ? \
      ((bt)->il_vfrontporch + (bt)->il_vsync + (bt)->il_vbackporch) : 0))
#define V4L2_DV_BT_FRAME_HEIGHT(bt) \
    ((bt)->height + V4L2_DV_BT_BLANKING_HEIGHT(bt))

/** struct v4l2_dv_timings - DV timings
 * @type:          the type of the timings
 * @bt:           BT656/1120 timings
 */
struct v4l2_dv_timings {
    __u32 type;
    union {
        struct v4l2_bt_timings  bt;
        __u32 reserved[32];
    };
} __attribute__ ((packed));

/* Values for the type field */
#define V4L2_DV_BT_656_1120     0          /* BT.656/1120 timing type */

/** struct v4l2_enum_dv_timings - DV timings enumeration
 * @index:         enumeration index
 * @pad:          the pad number for which to enumerate timings (used with
 *               v4l-subdev nodes only)
 * @reserved:     must be zeroed
 * @timings:      the timings for the given index

```

```

*/
struct v4l2_enum_dv_timings {
    __u32 index;
    __u32 pad;
    __u32 reserved[2];
    struct v4l2_dv_timings timings;
};

/** struct v4l2_bt_timings_cap - BT.656/BT.1120 timing capabilities
 * @min_width:           width in pixels
 * @max_width:           width in pixels
 * @min_height:          height in lines
 * @max_height:          height in lines
 * @min_pixelclock:     Pixel clock in HZ. Ex. 74.25MHz->74250000
 * @max_pixelclock:     Pixel clock in HZ. Ex. 74.25MHz->74250000
 * @standards:          Supported standards
 * @capabilities:       Supported capabilities
 * @reserved:           Must be zeroed
 */
struct v4l2_bt_timings_cap {
    __u32 min_width;
    __u32 max_width;
    __u32 min_height;
    __u32 max_height;
    __u64 min_pixelclock;
    __u64 max_pixelclock;
    __u32 standards;
    __u32 capabilities;
    __u32 reserved[16];
} __attribute__ ((packed));

/* Supports interlaced formats */
#define V4L2_DV_BT_CAP_INTERLACED      (1 << 0)
/* Supports progressive formats */
#define V4L2_DV_BT_CAP_PROGRESSIVE    (1 << 1)
/* Supports CVT/GTF reduced blanking */
#define V4L2_DV_BT_CAP_REDUCED_BLANKING (1 << 2)
/* Supports custom formats */
#define V4L2_DV_BT_CAP_CUSTOM        (1 << 3)

/** struct v4l2_dv_timings_cap - DV timings capabilities
 * @type:                the type of the timings (same as in struct v4l2_dv_timings)
 * @pad:                 the pad number for which to query capabilities (used with
 *                      v4l-subdev nodes only)
 * @bt:                  the BT656/1120 timings capabilities
 */
struct v4l2_dv_timings_cap {
    __u32 type;
    __u32 pad;
    __u32 reserved[2];
    union {

```

```

        struct v4l2_bt_timings_cap bt;
        __u32 raw_data[32];
    };
};

/*
 *      V I D E O   I N P U T S
 */
struct v4l2_input {
    __u32 index;           /* Which input */
    __u8 name[32];         /* Label */
    __u32 type;            /* Type of input */
    __u32 audioset;        /* Associated audios (bitfield) */
    __u32 tuner;           /* Tuner index */
    v4l2_std_id std;
    __u32 status;
    __u32 capabilities;
    __u32 reserved[3];
};

/* Values for the 'type' field */
#define V4L2_INPUT_TYPE_TUNER          1
#define V4L2_INPUT_TYPE_CAMERA         2
#define V4L2_INPUT_TYPE_TOUCH          3

/* field 'status' - general */
#define V4L2_IN_ST_NO_POWER     0x00000001 /* Attached device is off */
#define V4L2_IN_ST_NO_SIGNAL    0x00000002
#define V4L2_IN_ST_NO_COLOR     0x00000004

/* field 'status' - sensor orientation */
/* If sensor is mounted upside down set both bits */
#define V4L2_IN_ST_HFLIP       0x00000010 /* Frames are flipped horizontally */
#define V4L2_IN_ST_VFLIP       0x00000020 /* Frames are flipped vertically */

/* field 'status' - analog */
#define V4L2_IN_ST_NO_H_LOCK   0x00000100 /* No horizontal sync lock */
#define V4L2_IN_ST_COLOR_KILL  0x00000200 /* Color killer is active */
#define V4L2_IN_ST_NO_V_LOCK   0x00000400 /* No vertical sync lock */
#define V4L2_IN_ST_NO_STD_LOCK 0x00000800 /* No standard format lock */

/* field 'status' - digital */
#define V4L2_IN_ST_NO_SYNC     0x00010000 /* No synchronization lock */
#define V4L2_IN_ST_NO_EQU      0x00020000 /* No equalizer lock */
#define V4L2_IN_ST_NO_CARRIER  0x00040000 /* Carrier recovery failed */

/* field 'status' - VCR and set-top box */
#define V4L2_IN_ST_MACROVISION 0x01000000 /* Macrovision detected */
#define V4L2_IN_ST_NO_ACCESS   0x02000000 /* Conditional access denied */
#define V4L2_IN_ST_VTR         0x04000000 /* VTR time constant */

```

```

/* capabilities flags */
#define V4L2_IN_CAP_DV_TIMINGS          0x00000002 /* Supports S_DV_TIMINGS */
#define V4L2_IN_CAP_CUSTOM_TIMINGS      /* For compatibility */
#define V4L2_IN_CAP_STD                0x00000004 /* Supports S_STD */
#define V4L2_IN_CAP_NATIVE_SIZE        0x00000008 /* Supports setting native */

/*
 *      V I D E O      O U T P U T S
 */
struct v4l2_output {
    __u32           index;          /* Which output */
    __u8            name[32];       /* Label */
    __u32           type;           /* Type of output */
    __u32           audioset;        /* Associated audios (bitfield) */
    __u32           modulator;       /* Associated modulator */
    v4l2_std_id     std;            1
    __u32           capabilities;
    __u32           reserved[3];
};

/* Values for the 'type' field */
#define V4L2_OUTPUT_TYPE_MODULATOR      1
#define V4L2_OUTPUT_TYPE_ANALOG        2
#define V4L2_OUTPUT_TYPE_ANALOGVGAOVERLAY 3

/* capabilities flags */
#define V4L2_OUT_CAP_DV_TIMINGS         0x00000002 /* Supports S_DV_TIMINGS */
#define V4L2_OUT_CAP_CUSTOM_TIMINGS     /* For compatibility */
#define V4L2_OUT_CAP_STD               0x00000004 /* Supports S_STD */
#define V4L2_OUT_CAP_NATIVE_SIZE        0x00000008 /* Supports setting native */

/*
 *      C O N T R O L S
 */
struct v4l2_control {
    __u32           id;
    __s32           value;
};

struct v4l2_ext_control {
    __u32           id;
    __u32           size;
    __u32           reserved2[1];
    union {
        __s32 value;
        __s64 value64;
        char __user *string;
        __u8  __user *p_u8;
    };
};

```

```

__u16 __user *p_u16;
__u32 __user *p_u32;
__s32 __user *p_s32;
__s64 __user *p_s64;
struct v4l2_area __user *p_area;
struct v4l2_ctrl_h264_sps __user *p_h264_sps;
struct v4l2_ctrl_h264_pps __user *p_h264_pps;
struct v4l2_ctrl_h264_scaling_matrix __user *p_h264_scaling_
matrix;

__params;
    struct v4l2_ctrl_h264_pred_weights __user *p_h264_pred_weights;
    struct v4l2_ctrl_h264_slice_params __user *p_h264_slice_params;
    struct v4l2_ctrl_h264_decode_params __user *p_h264_decode_

__quantisation;
    struct v4l2_ctrl_fwht_params __user *p_fwht_params;
    struct v4l2_ctrl_vp8_frame __user *p_vp8_frame;
    struct v4l2_ctrl_mpeg2_sequence __user *p_mpeg2_sequence;
    struct v4l2_ctrl_mpeg2_picture __user *p_mpeg2_picture;
    struct v4l2_ctrl_mpeg2_quantisation __user *p_mpeg2_

__hdr_probs;
    struct v4l2_ctrl_vp9_compressed_hdr __user *p_vp9_compressed_
    struct v4l2_ctrl_vp9_frame __user *p_vp9_frame;
    struct v4l2_ctrl_hevc_sps __user *p_hevc_sps;
    struct v4l2_ctrl_hevc_pps __user *p_hevc_pps;
    struct v4l2_ctrl_hevc_slice_params __user *p_hevc_slice_params;
    struct v4l2_ctrl_hevc_scaling_matrix __user *p_hevc_scaling_
matrix;

__params;
    struct v4l2_ctrl_hevc_decode_params __user *p_hevc_decode_

__entry;
    struct v4l2_ctrl_av1_sequence __user *p_av1_sequence;
    struct v4l2_ctrl_av1_tile_group_entry __user *p_av1_tile_group_
    struct v4l2_ctrl_av1_frame __user *p_av1_frame;
    struct v4l2_ctrl_av1_film_grain __user *p_av1_film_grain;
    struct v4l2_ctrl_hdr10_cll_info __user *p_hdr10_cll_info;
    struct v4l2_ctrl_hdr10_mastering_display __user *p_hdr10_
mastering_display;
        void __user *ptr;
    };
} __attribute__ ((packed));

struct v4l2_ext_controls {
    union {
#ifndef __KERNEL__
        __u32 ctrl_class;
#endif
        __u32 which;
    };
    __u32 count;
    __u32 error_idx;
    __s32 request_fd;
}

```

```

    __u32 reserved[1];
    struct v4l2_ext_control *controls;
};

#define V4L2_CTRL_ID_MASK          (0xffffffff)
#ifndef __KERNEL__
#define V4L2_CTRL_ID2CLASS(id)    ((id) & 0xffff0000UL)
#endif
#define V4L2_CTRL_ID2WHICH(id)    ((id) & 0xffff0000UL)
#define V4L2_CTRL_DRIVER_PRIV(id)  (((id) & 0xffff) >= 0x1000)
#define V4L2_CTRL_MAX_DIMS        (4)
#define V4L2_CTRL_WHICH_CUR_VAL   0
#define V4L2_CTRL_WHICH_DEF_VAL   0x0f000000
#define V4L2_CTRL_WHICH_REQUEST_VAL 0x0f010000

enum v4l2_ctrl_type {
    V4L2_CTRL_TYPE_INTEGER      = 1,
    V4L2_CTRL_TYPE_BOOLEAN      = 2,
    V4L2_CTRL_TYPE_MENU         = 3,
    V4L2_CTRL_TYPE_BUTTON       = 4,
    V4L2_CTRL_TYPE_INTEGER64     = 5,
    V4L2_CTRL_TYPE_CTRL_CLASS   = 6,
    V4L2_CTRL_TYPE_STRING       = 7,
    V4L2_CTRL_TYPE_BITMASK      = 8,
    V4L2_CTRL_TYPE_INTEGER_MENU = 9,

    /* Compound types are >= 0x0100 */
    V4L2_CTRL_COMPOUND_TYPES   = 0x0100,
    V4L2_CTRL_TYPE_U8           = 0x0100,
    V4L2_CTRL_TYPE_U16          = 0x0101,
    V4L2_CTRL_TYPE_U32          = 0x0102,
    V4L2_CTRL_TYPE_AREA         = 0x0106,

    V4L2_CTRL_TYPE_HDR10 CLL_INFO      = 0x0110,
    V4L2_CTRL_TYPE_HDR10 MASTERING DISPLAY = 0x0111,

    V4L2_CTRL_TYPE_H264_SPS      = 0x0200,
    V4L2_CTRL_TYPE_H264_PPS      = 0x0201,
    V4L2_CTRL_TYPE_H264_SCALING_MATRIX = 0x0202,
    V4L2_CTRL_TYPE_H264_SLICE_PARAMS = 0x0203,
    V4L2_CTRL_TYPE_H264_DECODE_PARAMS = 0x0204,
    V4L2_CTRL_TYPE_H264_PRED_WEIGHTS = 0x0205,

    V4L2_CTRL_TYPE_FWHT_PARAMS   = 0x0220,
    V4L2_CTRL_TYPE_VP8_FRAME     = 0x0240,
    V4L2_CTRL_TYPE_MPEG2_QUANTISATION = 0x0250,
    V4L2_CTRL_TYPE_MPEG2_SEQUENCE = 0x0251,
    V4L2_CTRL_TYPE_MPEG2_PICTURE = 0x0252,

```

```

V4L2_CTRL_TYPE_VP9_COMPRESSED_HDR      = 0x0260,
V4L2_CTRL_TYPE_VP9_FRAME               = 0x0261,

V4L2_CTRL_TYPE_HEVC_SPS                = 0x0270,
V4L2_CTRL_TYPE_HEVC_PPS                = 0x0271,
V4L2_CTRL_TYPE_HEVC_SLICE_PARAMS       = 0x0272,
V4L2_CTRL_TYPE_HEVC_SCALING_MATRIX    = 0x0273,
V4L2_CTRL_TYPE_HEVC_DECODE_PARAMS      = 0x0274,

V4L2_CTRL_TYPE_AV1_SEQUENCE           = 0x280,
V4L2_CTRL_TYPE_AV1_TILE_GROUP_ENTRY   = 0x281,
V4L2_CTRL_TYPE_AV1_FRAME              = 0x282,
V4L2_CTRL_TYPE_AV1_FILM_GRAIN         = 0x283,
};

/* Used in the VIDIOC_QUERYCTRL ioctl for querying controls */
struct v4l2_queryctrl {
    __u32                      id;
    __u32                      type;        /* enum v4l2_ctrl_type */
    __u8                       name[32];  /* Whatever */
    __s32                      minimum;    /* Note signedness */
    __s32                      maximum;
    __s32                      step;
    __s32                      default_value;
    __u32                      flags;
    __u32                      reserved[2];
};

/* Used in the VIDIOC_QUERY_EXT_CTRL ioctl for querying extended controls */
struct v4l2_query_ext_ctrl {
    __u32                      id;
    __u32                      type;
    char                        name[32];
    __s64                      minimum;
    __s64                      maximum;
    __u64                      step;
    __s64                      default_value;
    __u32                      flags;
    __u32                      elem_size;
    __u32                      elems;
    __u32                      nr_of_dims;
    __u32                      dims[V4L2_CTRL_MAX_DIMS];
    __u32                      reserved[32];
};

/* Used in the VIDIOC_QUERYMENU ioctl for querying menu items */
struct v4l2_querymenu {
    __u32                      id;
    __u32                      index;
    union {
        __u8                       name[32];  /* Whatever */

```

```

        __s64    value;
    };
    __u32      reserved;
} __attribute__ ((packed));

/* Control flags */
#define V4L2_CTRL_FLAG_DISABLED          0x0001
#define V4L2_CTRL_FLAG_GRABBED          0x0002
#define V4L2_CTRL_FLAG_READ_ONLY        0x0004
#define V4L2_CTRL_FLAG_UPDATE           0x0008
#define V4L2_CTRL_FLAG_INACTIVE         0x0010
#define V4L2_CTRL_FLAG_SLIDER           0x0020
#define V4L2_CTRL_FLAG_WRITE_ONLY       0x0040
#define V4L2_CTRL_FLAG_VOLATILE         0x0080
#define V4L2_CTRL_FLAG_HAS_PAYLOAD      0x0100
#define V4L2_CTRL_FLAG_EXECUTE_ON_WRITE 0x0200
#define V4L2_CTRL_FLAG MODIFY_LAYOUT    0x0400
#define V4L2_CTRL_FLAG_DYNAMIC_ARRAY    0x0800

/* Query flags, to be ORed with the control ID */
#define V4L2_CTRL_FLAG_NEXT_CTRL        0x80000000
#define V4L2_CTRL_FLAG_NEXT_COMPOUND    0x40000000

/* User-class control IDs defined by V4L2 */
#define V4L2_CID_MAX_CTRLS            1024
/* IDs reserved for driver specific controls */
#define V4L2_CID_PRIVATE_BASE          0x08000000

/*
 *      T U N I N G
 */
struct v4l2_tuner {
    __u32      index;
    __u8       name[32];
    __u32      type; /* enum v4l2_tuner_type */
    __u32      capability;
    __u32      rangelow;
    __u32      rangehigh;
    __u32      rxsubchans;
    __u32      audmode;
    __s32      signal;
    __s32      afc;
    __u32     reserved[4];
};

struct v4l2_modulator {
    __u32      index;
    __u8       name[32];
    __u32      capability;
    __u32      rangelow;
    __u32      rangehigh;
}
```

```

__u32          txsubchans;
__u32          type;    /* enum v4l2_tuner_type */
__u32          reserved[3];
};

/* Flags for the 'capability' field */
#define V4L2_TUNER_CAP_LOW           0x0001
#define V4L2_TUNER_CAP_NORM          0x0002
#define V4L2_TUNER_CAP_HWSEEK_BOUNDED 0x0004
#define V4L2_TUNER_CAP_HWSEEK_WRAP   0x0008
#define V4L2_TUNER_CAP_STEREO        0x0010
#define V4L2_TUNER_CAP_LANG2         0x0020
#define V4L2_TUNER_CAP_SAP           0x0020
#define V4L2_TUNER_CAP_LANG1         0x0040
#define V4L2_TUNER_CAP_RDS           0x0080
#define V4L2_TUNER_CAP_RDS_BLOCK_IO  0x0100
#define V4L2_TUNER_CAP_RDS_CONTROLS  0x0200
#define V4L2_TUNER_CAP_FREQ_BANDS   0x0400
#define V4L2_TUNER_CAP_HWSEEK_PROG_LIM 0x0800
#define V4L2_TUNER_CAP_1HZ           0x1000

/* Flags for the 'rxsubchans' field */
#define V4L2_TUNER_SUB_MONO          0x0001
#define V4L2_TUNER_SUB_STEREO        0x0002
#define V4L2_TUNER_SUB_LANG2         0x0004
#define V4L2_TUNER_SUB_SAP           0x0004
#define V4L2_TUNER_SUB_LANG1         0x0008
#define V4L2_TUNER_SUB_RDS           0x0010

/* Values for the 'audmode' field */
#define V4L2_TUNER_MODE_MONO         0x0000
#define V4L2_TUNER_MODE_STEREO       0x0001
#define V4L2_TUNER_MODE_LANG2        0x0002
#define V4L2_TUNER_MODE_SAP          0x0002
#define V4L2_TUNER_MODE_LANG1        0x0003
#define V4L2_TUNER_MODE_LANG1_LANG2  0x0004

struct v4l2_frequency {
    __u32 tuner;
    __u32 type;    /* enum v4l2_tuner_type */
    __u32 frequency;
    __u32 reserved[8];
};

#define V4L2_BAND_MODULATION_VSB      (1 << 1)
#define V4L2_BAND_MODULATION_FM       (1 << 2)
#define V4L2_BAND_MODULATION_AM       (1 << 3)

struct v4l2_frequency_band {
    __u32 tuner;
    __u32 type;    /* enum v4l2_tuner_type */

```

```

    __u32    index;
    __u32    capability;
    __u32    rangelow;
    __u32    rangehigh;
    __u32    modulation;
    __u32    reserved[9];
};

struct v4l2_hw_freq_seek {
    __u32    tuner;
    __u32    type;      /* enum v4l2_tuner_type */
    __u32    seek_upward;
    __u32    wrap_around;
    __u32    spacing;
    __u32    rangelow;
    __u32    rangehigh;
    __u32    reserved[5];
};

/*
 *      R D S
 */

struct v4l2_rds_data {
    __u8    lsb;
    __u8    msb;
    __u8    block;
} __attribute__ ((packed));

#define V4L2_RDS_BLOCK_MSK      0x7
#define V4L2_RDS_BLOCK_A        0
#define V4L2_RDS_BLOCK_B        1
#define V4L2_RDS_BLOCK_C        2
#define V4L2_RDS_BLOCK_D        3
#define V4L2_RDS_BLOCK_C_ALT    4
#define V4L2_RDS_BLOCK_INVALID  7

#define V4L2_RDS_BLOCK_CORRECTED 0x40
#define V4L2_RDS_BLOCK_ERROR     0x80

/*
 *      A U D I O
 */
struct v4l2_audio {
    __u32    index;
    __u8     name[32];
    __u32    capability;
    __u32    mode;
    __u32    reserved[2];
};

```

```

/* Flags for the 'capability' field */
#define V4L2_AUDCAP_STEREO          0x00001
#define V4L2_AUDCAP_AVL             0x00002

/* Flags for the 'mode' field */
#define V4L2_AUDMODE_AVL            0x00001

struct v4l2_audioout {
    __u32 index;
    __u8 name[32];
    __u32 capability;
    __u32 mode;
    __u32 reserved[2];
};

/*
 *      M P E G      S E R V I C E S
 */
#if 1
#define V4L2_ENC_IDX_FRAME_I        (0)
#define V4L2_ENC_IDX_FRAME_P        (1)
#define V4L2_ENC_IDX_FRAME_B        (2)
#define V4L2_ENC_IDX_FRAME_MASK     (0xf)

struct v4l2_enc_idx_entry {
    __u64 offset;
    __u64 pts;
    __u32 length;
    __u32 flags;
    __u32 reserved[2];
};

#define V4L2_ENC_IDX_ENTRIES (64)
struct v4l2_enc_idx {
    __u32 entries;
    __u32 entries_cap;
    __u32 reserved[4];
    struct v4l2_enc_idx_entry entry[V4L2_ENC_IDX_ENTRIES];
};

#define V4L2_ENC_CMD_START          (0)
#define V4L2_ENC_CMD_STOP           (1)
#define V4L2_ENC_CMD_PAUSE          (2)
#define V4L2_ENC_CMD_RESUME         (3)

/* Flags for V4L2_ENC_CMD_STOP */
#define V4L2_ENC_CMD_STOP_AT_GOP_END (1 << 0)

struct v4l2_encoder_cmd {
    __u32 cmd;
    __u32 flags;

```

```

union {
    struct {
        __u32 data[8];
    } raw;
};

/* Decoder commands */
#define V4L2_DEC_CMD_START          (0)
#define V4L2_DEC_CMD_STOP           (1)
#define V4L2_DEC_CMD_PAUSE          (2)
#define V4L2_DEC_CMD_RESUME         (3)
#define V4L2_DEC_CMD_FLUSH          (4)

/* Flags for V4L2_DEC_CMD_START */
#define V4L2_DEC_CMD_START_MUTE_AUDIO (1 << 0)

/* Flags for V4L2_DEC_CMD_PAUSE */
#define V4L2_DEC_CMD_PAUSE_TO_BLACK (1 << 0)

/* Flags for V4L2_DEC_CMD_STOP */
#define V4L2_DEC_CMD_STOP_TO_BLACK   (1 << 0)
#define V4L2_DEC_CMD_STOP_IMMEDIATELY (1 << 1)

/* Play format requirements (returned by the driver): */

/* The decoder has no special format requirements */
#define V4L2_DEC_START_FMT_NONE      (0)
/* The decoder requires full GOPs */
#define V4L2_DEC_START_FMT_GOP        (1)

/* The structure must be zeroed before use by the application
   This ensures it can be extended safely in the future. */
struct v4l2_decoder_cmd {
    __u32 cmd;
    __u32 flags;
    union {
        struct {
            __u64 pts;
        } stop;

        struct {
            /* 0 or 1000 specifies normal speed,
               1 specifies forward single stepping,
               -1 specifies backward single stepping,
               >1: playback at speed/1000 of the normal speed,
               <-1: reverse playback at (-speed/1000) of the
               normal speed. */
            __s32 speed;
            __u32 format;
        } start;
    };
};

```

```
        struct {
            __u32 data[16];
        } raw;
    };
};

#endif

/*
 *      D A T A      S E R V I C E S      ( V B I )
 *
 *      Data services API by Michael Schimek
 */

/* Raw VBI */
struct v4l2_vbi_format {
    __u32 sampling_rate;           /* in 1 Hz */
    __u32 offset;
    __u32 samples_per_line;
    __u32 sample_format;          /* V4L2_PIX_FMT_* */
    __s32 start[2];
    __u32 count[2];
    __u32 flags;                 /* V4L2_VBI_* */
    __u32 reserved[2];            /* must be zero */
};

/* VBI flags */
#define V4L2_VBI_UNSYNC          (1 << 0)
#define V4L2_VBI_INTERLACED       (1 << 1)

/* ITU-R start lines for each field */
#define V4L2_VBI_ITU_525_F1_START (1)
#define V4L2_VBI_ITU_525_F2_START (264)
#define V4L2_VBI_ITU_625_F1_START (1)
#define V4L2_VBI_ITU_625_F2_START (314)

/* Sliced VBI
 *
 *      This implements is a proposal V4L2 API to allow SLICED VBI
 *      required for some hardware encoders. It should change without
 *      notice in the definitive implementation.
 */

struct v4l2_sliced_vbi_format {
    __u16 service_set;
    /* service_lines[0][...] specifies lines 0-23 (1-23 used) of the firstfield
     * service_lines[1][...] specifies lines 0-23 (1-23 used) of thesecond field
     * (equals frame lines 313-336 for 625 line video
     * standards, 263-286 for 525 line standards) */
}
```

```

        __u16    service_lines[2][24];
        __u32    io_size;
        __u32    reserved[2];           /* must be zero */
};

/* Teletext World System Teletext
   (WST), defined on ITU-R BT.653-2 */
#define V4L2_SLICED_TELETEXT_B          (0x0001)
/* Video Program System, defined on ETS 300 231*/
#define V4L2_SLICED_VPS                (0x0400)
/* Closed Caption, defined on EIA-608 */
#define V4L2_SLICED_CAPTION_525        (0x1000)
/* Wide Screen System, defined on ITU-R BT1119.1 */
#define V4L2_SLICED_WSS_625            (0x4000)

#define V4L2_SLICED_VBI_525            (V4L2_SLICED_CAPTION_525)
#define V4L2_SLICED_VBI_625            (V4L2_SLICED_TELETEXT_B | V4L2_SLICED_
→VPS | V4L2_SLICED_WSS_625)

struct v4l2_sliced_vbi_cap {
    __u16    service_set;
    /* service_lines[0][...] specifies lines 0-23 (1-23 used) of the first
→field
    service_lines[1][...] specifies lines 0-23 (1-23 used) of the
→second field
    (equals frame lines 313-336 for 625 line video
     standards, 263-286 for 525 line standards) */
    __u16    service_lines[2][24];
    __u32    type;                 /* enum v4l2_buf_type */
    __u32    reserved[3];          /* must be 0 */
};

struct v4l2_sliced_vbi_data {
    __u32    id;
    __u32    field;               /* 0: first field, 1: second field */
    __u32    line;                /* 1-23 */
    __u32    reserved;             /* must be 0 */
    __u8     data[48];
};

/*
 * Sliced VBI data inserted into MPEG Streams
 */

/*
 * V4L2_MPEG_STREAM_VBI_FMT_IVTV:
 *
 * Structure of payload contained in an MPEG 2 Private Stream 1 PES Packet in
→an
 * MPEG-2 Program Pack that contains V4L2_MPEG_STREAM_VBI_FMT_IVTV Sliced VBI
 * data

```

```

/*
 * Note, the MPEG-2 Program Pack and Private Stream 1 PES packet header
 * definitions are not included here. See the MPEG-2 specifications for
 * details
 * on these headers.
 */

/* Line type IDs */
#define V4L2_MPEG_VBI_ITV0_TELETEXT_B      (1)
#define V4L2_MPEG_VBI_ITV0_CAPTION_525     (4)
#define V4L2_MPEG_VBI_ITV0_WSS_625         (5)
#define V4L2_MPEG_VBI_ITV0_VPS             (7)

struct v4l2_mpeg_vbi_itv0_line {
    __u8 id;           /* One of V4L2_MPEG_VBI_ITV_* above */
    __u8 data[42];    /* Sliced VBI data for the line */
} __attribute__ ((packed));

struct v4l2_mpeg_vbi_itv0 {
    __le32 linemask[2]; /* Bitmasks of VBI service lines present */
    struct v4l2_mpeg_vbi_itv0_line line[35];
} __attribute__ ((packed));

struct v4l2_mpeg_vbi_ITV0 {
    struct v4l2_mpeg_vbi_itv0_line line[36];
} __attribute__ ((packed));

#define V4L2_MPEG_VBI_ITV0_MAGIC0          "itv0"
#define V4L2_MPEG_VBI_ITV0_MAGIC1          "ITV0"

struct v4l2_mpeg_vbi_fmt_itv0 {
    __u8 magic[4];
    union {
        struct v4l2_mpeg_vbi_itv0 itv0;
        struct v4l2_mpeg_vbi_ITV0 ITV0;
    };
} __attribute__ ((packed));

/*
 *      A G G R E G A T E   S T R U C T U R E S
 */

/**
 * struct v4l2_plane_pix_format - additional, per-plane format definition
 * @sizeimage:           maximum size in bytes required for data, for which
 *                      this plane will be used
 * @bytesperline:        distance in bytes between the leftmost pixels in two
 *                      adjacent lines
 * @reserved:            drivers and applications must zero this array
 */
struct v4l2_plane_pix_format {

```

```

        __u32          sizeimage;
        __u32          bytesperline;
        __u16          reserved[6];
} __attribute__ ((packed));

/***
 * struct v4l2_pix_format_mplane - multiplanar format definition
 * @width:           image width in pixels
 * @height:          image height in pixels
 * @pixelformat:    little endian four character code (fourcc)
 * @field:          enum v4l2_field; field order (for interlaced video)
 * @colorspace:     enum v4l2_colorspace; supplemental to pixelformat
 * @plane_fmt:      per-plane information
 * @num_planes:     number of planes for this format
 * @flags:          format flags (V4L2_PIX_FMT_FLAG_*)
 * @ycbcr_enc:     enum v4l2_ycbcr_encoding, Y'CbCr encoding
 * @hsv_enc:        enum v4l2_hsv_encoding, HSV encoding
 * @quantization:  enum v4l2_quantization, colorspace quantization
 * @xfer_func:      enum v4l2_xfer_func, colorspace transfer function
 * @reserved:       drivers and applications must zero this array
*/
struct v4l2_pix_format_mplane {
        __u32          width;
        __u32          height;
        __u32          pixelformat;
        __u32          field;
        __u32          colorspace;

        struct v4l2_plane_pix_format   plane_fmt[VIDEO_MAX_PLANES];
        __u8            num_planes;
        __u8            flags;
        union {
                __u8          ycbcr_enc;
                __u8          hsv_enc;
        };
        __u8            quantization;
        __u8            xfer_func;
        __u8            reserved[7];
} __attribute__ ((packed));

/***
 * struct v4l2_sdr_format - SDR format definition
 * @pixelformat:    little endian four character code (fourcc)
 * @buffersize:     maximum size in bytes required for data
 * @reserved:       drivers and applications must zero this array
*/
struct v4l2_sdr_format {
        __u32          pixelformat;
        __u32          buffersize;
        __u8           reserved[24];
} __attribute__ ((packed));

```

```

/**
 * struct v4l2_meta_format - metadata format definition
 * @dataformat:          little endian four character code (fourcc)
 * @buffersize:          maximum size in bytes required for data
 */
struct v4l2_meta_format {
    __u32                dataformat;
    __u32                buffersize;
} __attribute__ ((packed));

/**
 * struct v4l2_format - stream data format
 * @type:                enum v4l2_buf_type; type of the data stream
 * @pix:                 definition of an image format
 * @pix_mp:              definition of a multiplanar image format
 * @win:                 definition of an overlaid image
 * @vbi:                 raw VBI capture or output parameters
 * @sliced:              sliced VBI capture or output parameters
 * @raw_data:            placeholder for future extensions and custom formats
 * @fmt:                 union of @pix, @pix_mp, @win, @vbi, @sliced, @sdr, @meta
 *                      and @raw_data
 */
struct v4l2_format {
    __u32    type;
    union {
        struct v4l2_pix_format      pix;      /* V4L2_BUF_TYPE_VIDEO_CAPTURE */
        struct v4l2_pix_format_mplane pix_mp; /* V4L2_BUF_TYPE_VIDEO_CAPTURE_MPLANE */
        struct v4l2_window          win;      /* V4L2_BUF_TYPE_VIDEO_OVERLAY */
        struct v4l2_vbi_format      vbi;      /* V4L2_BUF_TYPE_VBI_CAPTURE */
        struct v4l2_sliced_vbi_format sliced; /* V4L2_BUF_TYPE_SLICED_VBI_CAPTURE */
        struct v4l2_sdr_format      sdr;      /* V4L2_BUF_TYPE_SDR_CAPTURE */
        struct v4l2_meta_format     meta;     /* V4L2_BUF_TYPE_META_CAPTURE */
        __u8     raw_data[200];         /* user-defined */
    } fmt;
};

/* Stream type-dependent parameters */
struct v4l2_streamparm {
    __u32    type;           /* enum v4l2_buf_type */
    union {
        struct v4l2_captureparm capture;
        struct v4l2_outputparm  output;

```

```

        } parm; __u8 raw_data[200]; /* user-defined */
};

/*
 *      E V E N T S
 */

#define V4L2_EVENT_ALL          0
#define V4L2_EVENT_VSYNC         1
#define V4L2_EVENT_EOS           2
#define V4L2_EVENT_CTRL          3
#define V4L2_EVENT_FRAME_SYNC    4
#define V4L2_EVENT_SOURCE_CHANGE 5
#define V4L2_EVENT_MOTION_DET    6
#define V4L2_EVENT_PRIVATE_START 0x08000000

/* Payload for V4L2_EVENT_VSYNC */
struct v4l2_event_vsync {
    /* Can be V4L2_FIELD_ANY, _NONE, _TOP or _BOTTOM */
    __u8 field;
} __attribute__ ((packed));

/* Payload for V4L2_EVENT_CTRL */
#define V4L2_EVENT_CTRL_CH_VALUE          (1 << 0)
#define V4L2_EVENT_CTRL_CH_FLAGS          (1 << 1)
#define V4L2_EVENT_CTRL_CH_RANGE          (1 << 2)
#define V4L2_EVENT_CTRL_CH_DIMENSIONS    (1 << 3)

struct v4l2_event_ctrl {
    __u32 changes;
    __u32 type;
    union {
        __s32 value;
        __s64 value64;
    };
    __u32 flags;
    __s32 minimum;
    __s32 maximum;
    __s32 step;
    __s32 default_value;
};

struct v4l2_event_frame_sync {
    __u32 frame_sequence;
};

#define V4L2_EVENT_SRC_CH_RESOLUTION     (1 << 0)

struct v4l2_event_src_change {
    __u32 changes;
}

```

```

};

#define V4L2_EVENT_MD_FL_HAVE_FRAME_SEQ (1 << 0)

/***
 * struct v4l2_event_motion_det - motion detection event
 * @flags:           if V4L2_EVENT_MD_FL_HAVE_FRAME_SEQ is set, then the
 *                   frame_sequence field is valid.
 * @frame_sequence: the frame sequence number associated with this event.
 * @region_mask:    which regions detected motion.
 */
struct v4l2_event_motion_det {
    __u32 flags;
    __u32 frame_sequence;
    __u32 region_mask;
};

struct v4l2_event {
    __u32 type;
    union {
        struct v4l2_event_vsync      vsync;
        struct v4l2_event_ctrl      ctrl;
        struct v4l2_event_frame_sync frame_sync;
        struct v4l2_event_src_change src_change;
        struct v4l2_event_motion_det motion_det;
        __u8 data[64];
    } u;
    __u32 pending;
    __u32 sequence;
#ifdef __KERNEL__
    struct __kernel_timespec timestamp;
#else
    struct timespec timestamp;
#endif
    __u32 id;
    __u32 reserved[8];
};

#define V4L2_EVENT_SUB_FL_SEND_INITIAL      (1 << 0)
#define V4L2_EVENT_SUB_FL_ALLOW_FEEDBACK    (1 << 1)

struct v4l2_event_subscription {
    __u32 type;
    __u32 id;
    __u32 flags;
    __u32 reserved[5];
};

/*
 *      A D V A N C E D      D E B U G G I N G
 *

```

```

/*
 *      NOTE: EXPERIMENTAL API, NEVER RELY ON THIS IN APPLICATIONS!
 *      FOR DEBUGGING, TESTING AND INTERNAL USE ONLY!
 */

/* VIDIOC_DBG_G_REGISTER and VIDIOC_DBG_S_REGISTER */

#define V4L2_CHIP_MATCH_BRIDGE      0 /* Match against chip ID on the bridge */
#define V4L2_CHIP_MATCH_BRIDGE      0 /* (0 for the bridge) */
#define V4L2_CHIP_MATCH_SUBDEV      4 /* Match against subdev index */

/* The following four defines are no longer in use */
#define V4L2_CHIP_MATCH_HOST V4L2_CHIP_MATCH_BRIDGE
#define V4L2_CHIP_MATCH_I2C_DRIVER 1 /* Match against I2C driver name */
#define V4L2_CHIP_MATCH_I2C_ADDR   2 /* Match against I2C 7-bit address */
#define V4L2_CHIP_MATCH_AC97       3 /* Match against ancillary AC97 chip */

struct v4l2_dbg_match {
    __u32 type; /* Match type */
    union { /* Match this chip, meaning determined by type */
        __u32 addr;
        char name[32];
    };
} __attribute__ ((packed));

struct v4l2_dbg_register {
    struct v4l2_dbg_match match;
    __u32 size; /* register size in bytes */
    __u64 reg;
    __u64 val;
} __attribute__ ((packed));

#define V4L2_CHIP_FL_READABLE (1 << 0)
#define V4L2_CHIP_FL_WRITABLE (1 << 1)

/* VIDIOC_DBG_G_CHIP_INFO */
struct v4l2_dbg_chip_info {
    struct v4l2_dbg_match match;
    char name[32];
    __u32 flags;
    __u32 reserved[32];
} __attribute__ ((packed));

/**
 * struct v4l2_create_buffers - VIDIOC_CREATE_BUFS argument
 * @index:      on return, index of the first created buffer
 * @count:      entry: number of requested buffers,
 *              return: number of created buffers
 * @memory:     enum v4l2_memory; buffer memory type
 * @format:     frame format, for which buffers are requested
 * @capabilities: capabilities of this buffer type.
 * @flags:      additional buffer management attributes (ignored unless the

```

```

*
*           queue has V4L2_BUF_CAP_SUPPORTS_MMAP_CACHE_HINTS capability
*           and configured for MMAP streaming I/O).
* @max_num_buffers: if V4L2_BUF_CAP_SUPPORTS_MAX_NUM_BUFFERS capability flag is set
*           this field indicate the maximum possible number of buffers
*           for this queue.
* @reserved:   future extensions
*/
struct v4l2_create_buffers {
    __u32                                index;
    __u32                                count;
    __u32                                memory;
    struct v4l2_format                     format;
    __u32                                capabilities;
    __u32                                flags;
    __u32                                max_num_buffers;
    __u32                                reserved[5];
};

/*
*      I O C T L   C O D E S   F O R   V I D E O   D E V I C E S
*
*/
#define VIDIOC_QUERYCAP          _IOR('V', 0, struct v4l2_capability)
#define VIDIOC_ENUM_FMT           _IOWR('V', 2, struct v4l2_fmtdesc)
#define VIDIOC_G_FMT              _IOWR('V', 4, struct v4l2_format)
#define VIDIOC_S_FMT              _IOWR('V', 5, struct v4l2_format)
#define VIDIOC_REQBUFS            _IOWR('V', 8, struct v4l2_requestbuffers)
#define VIDIOC_QUERYBUF           _IOWR('V', 9, struct v4l2_buffer)
#define VIDIOC_G_FBUF             _IOR('V', 10, struct v4l2_framebuffer)
#define VIDIOC_S_FBUF             _IOW('V', 11, struct v4l2_framebuffer)
#define VIDIOC_OVERLAY            _IOW('V', 14, int)
#define VIDIOC_QBUF               _IOWR('V', 15, struct v4l2_buffer)
#define VIDIOC_EXPBUF              _IOWR('V', 16, struct v4l2_exportbuffer)
#define VIDIOC_DQBUF              _IOWR('V', 17, struct v4l2_buffer)
#define VIDIOC_STREAMON            _IOW('V', 18, int)
#define VIDIOC_STREAMOFF            _IOW('V', 19, int)
#define VIDIOC_G_PARM              _IOWR('V', 21, struct v4l2_streamparm)
#define VIDIOC_S_PARM              _IOWR('V', 22, struct v4l2_streamparm)
#define VIDIOC_G_STD                _IOR('V', 23, v4l2_std_id)
#define VIDIOC_S_STD                _IOW('V', 24, v4l2_std_id)
#define VIDIOC_ENUMSTD              _IOWR('V', 25, struct v4l2_standard)
#define VIDIOC_ENUMINPUT            _IOWR('V', 26, struct v4l2_input)
#define VIDIOC_G_CTRL                _IOWR('V', 27, struct v4l2_control)
#define VIDIOC_S_CTRL                _IOWR('V', 28, struct v4l2_control)
#define VIDIOC_G_TUNER              _IOWR('V', 29, struct v4l2_tuner)
#define VIDIOC_S_TUNER              _IOW('V', 30, struct v4l2_tuner)
#define VIDIOC_G_AUDIO              _IOR('V', 33, struct v4l2_audio)
#define VIDIOC_S_AUDIO              _IOW('V', 34, struct v4l2_audio)
#define VIDIOC_QUERYCTRL            _IOWR('V', 36, struct v4l2_queryctrl)
#define VIDIOC_QUERYMENU            _IOWR('V', 37, struct v4l2_querymenu)

```

```

#define VIDIOC_G_INPUT           _IOR('V', 38, int)
#define VIDIOC_S_INPUT           _IOWR('V', 39, int)
#define VIDIOC_G_EDID            _IOWR('V', 40, struct v4l2_edid)
#define VIDIOC_S_EDID            _IOWR('V', 41, struct v4l2_edid)
#define VIDIOC_G_OUTPUT           _IOR('V', 46, int)
#define VIDIOC_S_OUTPUT           _IOWR('V', 47, int)
#define VIDIOC_ENUMOUTPUT         _IOWR('V', 48, struct v4l2_output)
#define VIDIOC_G_AUDOUT           _IOR('V', 49, struct v4l2_audioout)
#define VIDIOC_S_AUDOUT           _IOW('V', 50, struct v4l2_audioout)
#define VIDIOC_G_MODULATOR        _IOWR('V', 54, struct v4l2_modulator)
#define VIDIOC_S_MODULATOR        _IOW('V', 55, struct v4l2_modulator)
#define VIDIOC_G_FREQUENCY         _IOWR('V', 56, struct v4l2_frequency)
#define VIDIOC_S_FREQUENCY         _IOW('V', 57, struct v4l2_frequency)
#define VIDIOC_CROPCAP           _IOWR('V', 58, struct v4l2_croppcap)
#define VIDIOC_G_CROP              _IOWR('V', 59, struct v4l2_crop)
#define VIDIOC_S_CROP              _IOW('V', 60, struct v4l2_crop)
#define VIDIOC_G_JPEGCOMP          _IOR('V', 61, struct v4l2_jpegcompression)
#define VIDIOC_S_JPEGCOMP          _IOW('V', 62, struct v4l2_jpegcompression)
#define VIDIOC_QUERYSTD            _IOR('V', 63, v4l2_std_id)
#define VIDIOC_TRY_FMT             _IOWR('V', 64, struct v4l2_format)
#define VIDIOC_ENUMAUDIO           _IOWR('V', 65, struct v4l2_audio)
#define VIDIOC_ENUMAUDOUT          _IOWR('V', 66, struct v4l2_audioout)
#define VIDIOC_G_PRIORITY           _IOR('V', 67, __u32) /* enum v4l2_priority */
#define VIDIOC_S_PRIORITY           _IOW('V', 68, __u32) /* enum v4l2_priority */
#define VIDIOC_G_SLICED_VBI_CAP     _IOWR('V', 69, struct v4l2_sliced_vbi_cap)
#define VIDIOC_LOG_STATUS           _IO('V', 70)
#define VIDIOC_G_EXT_CTRLS          _IOWR('V', 71, struct v4l2_ext_controls)
#define VIDIOC_S_EXT_CTRLS          _IOWR('V', 72, struct v4l2_ext_controls)
#define VIDIOC_TRY_EXT_CTRLS         _IOWR('V', 73, struct v4l2_ext_controls)
#define VIDIOC_ENUM_FRAMESIZES       _IOWR('V', 74, struct v4l2_frmsizeenum)
#define VIDIOC_ENUM_FRAMEINTERVALS   _IOWR('V', 75, struct v4l2_frmvalenum)
#define VIDIOC_G_ENC_INDEX           _IOR('V', 76, struct v4l2_enc_idx)
#define VIDIOC_ENCODER_CMD           _IOWR('V', 77, struct v4l2_encoder_cmd)
#define VIDIOC_TRY_ENCODER_CMD        _IOWR('V', 78, struct v4l2_encoder_cmd)

/*
 * Experimental, meant for debugging, testing and internal use.
 * Only implemented if CONFIG_VIDEO_ADV_DEBUG is defined.
 * You must be root to use these ioctls. Never use these in applications!
 */
#define VIDIOC_DBG_S_REGISTER        _IOW('V', 79, struct v4l2_dbg_register)
#define VIDIOC_DBG_G_REGISTER        _IOWR('V', 80, struct v4l2_dbg_register)

#define VIDIOC_S_HW_FREQ_SEEK         _IOW('V', 82, struct v4l2_hw_freq_seek)
#define VIDIOC_S_DV_TIMINGS           _IOWR('V', 87, struct v4l2_dv_timings)
#define VIDIOC_G_DV_TIMINGS           _IOWR('V', 88, struct v4l2_dv_timings)
#define VIDIOC_DQEVENT                _IOR('V', 89, struct v4l2_event)
#define VIDIOC_SUBSCRIBE_EVENT        _IOW('V', 90, struct v4l2_event_subscription)
#define VIDIOC_UNSUBSCRIBE_EVENT      _IOW('V', 91, struct v4l2_event_subscription)
#define VIDIOC_CREATE_BUFS             _IOWR('V', 92, struct v4l2_create_buffers)
#define VIDIOC_PREPARE_BUF             _IOWR('V', 93, struct v4l2_buffer)

```

```

#define VIDIOC_G_SELECTION           _IOWR('V', 94, struct v4l2_selection)
#define VIDIOC_S_SELECTION           _IOWR('V', 95, struct v4l2_selection)
#define VIDIOC_DECODER_CMD           _IOWR('V', 96, struct v4l2_decoder_cmd)
#define VIDIOC_TRY_DECODER_CMD       _IOWR('V', 97, struct v4l2_decoder_cmd)
#define VIDIOC_ENUM_DV_TIMINGS        _IOWR('V', 98, struct v4l2_enum_dv_timings)
#define VIDIOC_QUERY_DV_TIMINGS       _IOR('V', 99, struct v4l2_dv_timings)
#define VIDIOC_DV_TIMINGS_CAP         _IOWR('V', 100, struct v4l2_dv_timings_cap)
#define VIDIOC_ENUM_FREQ_BANDS        _IOWR('V', 101, struct v4l2_frequency_band)

/*
 * Experimental, meant for debugging, testing and internal use.
 * Never use this in applications!
 */
#define VIDIOC_DBG_G_CHIP_INFO        _IOWR('V', 102, struct v4l2_dbg_chip_info)
#define VIDIOC_QUERY_EXT_CTRL         _IOWR('V', 103, struct v4l2_query_ext_ctrl)

/* Reminder: when adding new ioctls please add support for them to
 drivers/media/v4l2-core/v4l2-compat-ioctl32.c as well! */

#define BASE_VIDIOC_PRIVATE          192                      /* 192-255 are private */

/* Deprecated definitions kept for backwards compatibility */
#ifndef __KERNEL__
#define V4L2_PIX_FMT_HM12 V4L2_PIX_FMT_NV12_16L16
#define V4L2_PIX_FMT_SUNXI_TILED_NV12 V4L2_PIX_FMT_NV12_32L32
/*
 * This capability was never implemented, anyone using this cap should drop it
 * from their code.
 */
#define V4L2_CAP_ASYNCIO 0x02000000
#endif

#endif /* _UAPI__LINUX_VIDEODEV2_H */

```

### 13.2.10 Video Capture Example

file: media/v4l/capture.c

```

/*
 * V4L2 video capture example
 *
 * This program can be used and distributed without restrictions.
 *
 * This program is provided with the V4L2 API
 * see https://linuxtv.org/docs.php for more information
 */

#include <stdio.h>
#include <stdlib.h>

```

```

#include <string.h>
#include <assert.h>

#include <getopt.h>                      /* getopt_long() */
#include <fcntl.h>                         /* low-level i/o */
#include <unistd.h>
#include <errno.h>
#include <sys/stat.h>
#include <sys/types.h>
#include <sys/time.h>
#include <sys/mman.h>
#include <sys/ioctl.h>

#include <linux/videodev2.h>

#define CLEAR(x) memset(&(x), 0, sizeof(x))

enum io_method {
    IO_METHOD_READ,
    IO_METHOD_MMAP,
    IO_METHOD_USERPTR,
};

struct buffer {
    void *start;
    size_t length;
};

static char *dev_name;
static enum io_method io = IO_METHOD_MMAP;
static int fd = -1;
static struct buffer *buffers;
static unsigned int n_buffers;
static int out_buf;
static int force_format;
static int frame_count = 70;

static void errno_exit(const char *s)
{
    fprintf(stderr, "%s error %d, %s\n", s, errno, strerror(errno));
    exit(EXIT_FAILURE);
}

static int xioctl(int fh, int request, void *arg)
{
    int r;

    do {
        r = ioctl(fh, request, arg);

```

```

        } while (-1 == r && EINTR == errno);

    return r;
}

static void process_image(const void *p, int size)
{
    if (out_buf)
        fwrite(p, size, 1, stdout);

    fflush(stderr);
    fprintf(stderr, ".");
    fflush(stdout);
}

static int read_frame(void)
{
    struct v4l2_buffer buf;
    unsigned int i;

    switch (io) {
    case IO_METHOD_READ:
        if (-1 == read(fd, buffers[0].start, buffers[0].length)) {
            switch (errno) {
            case EAGAIN:
                return 0;

            case EIO:
                /* Could ignore EIO, see spec. */
                /* fall through */

            default:
                errno_exit("read");
            }
        }

        process_image(buffers[0].start, buffers[0].length);
        break;

    case IO_METHOD_MMAP:
        CLEAR(buf);

        buf.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
        buf.memory = V4L2_MEMORY_MMAP;

        if (-1 == xioctl(fd, VIDIOC_DQBUF, &buf)) {
            switch (errno) {
            case EAGAIN:
                return 0;
        }
    }
}

```

```

        case EIO:
            /* Could ignore EIO, see spec. */

            /* fall through */

        default:
            errno_exit("VIDIOC_DQBUF");
    }
}

assert(buf.index < n_buffers);

process_image(buffers[buf.index].start, buf.bytesused);

if (-1 == xioctl(fd, VIDIOC_QBUF, &buf))
    errno_exit("VIDIOC_QBUF");
break;

case IO_METHOD_USERPTR:
    CLEAR(buf);

    buf.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
    buf.memory = V4L2_MEMORY_USERPTR;

    if (-1 == xioctl(fd, VIDIOC_DQBUF, &buf)) {
        switch (errno) {
            case EAGAIN:
                return 0;

            case EIO:
                /* Could ignore EIO, see spec. */

                /* fall through */

            default:
                errno_exit("VIDIOC_DQBUF");
    }
}

for (i = 0; i < n_buffers; ++i)
    if (buf.m.userptr == (unsigned long)buffers[i].start
        && buf.length == buffers[i].length)
        break;

assert(i < n_buffers);

process_image((void *)buf.m.userptr, buf.bytesused);

if (-1 == xioctl(fd, VIDIOC_QBUF, &buf))

```

```

                errno_exit("VIDIOC_QBUF");
        break;
    }

    return 1;
}

static void mainloop(void)
{
    unsigned int count;

    count = frame_count;

    while (count-- > 0) {
        for (;;) {
            fd_set fds;
            struct timeval tv;
            int r;

            FD_ZERO(&fds);
            FD_SET(fd, &fds);

            /* Timeout. */
            tv.tv_sec = 2;
            tv.tv_usec = 0;

            r = select(fd + 1, &fds, NULL, NULL, &tv);

            if (-1 == r) {
                if (EINTR == errno)
                    continue;
                errno_exit("select");
            }

            if (0 == r) {
                fprintf(stderr, "select timeout\n");
                exit(EXIT_FAILURE);
            }

            if (read_frame())
                break;
            /* EAGAIN - continue select loop. */
        }
    }
}

static void stop_capturing(void)
{
    enum v4l2_buf_type type;
}

```

```

switch (io) {
case IO_METHOD_READ:
    /* Nothing to do. */
    break;

case IO_METHOD_MMAP:
case IO_METHOD_USERPTR:
    type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
    if (-1 == xioctl(fd, VIDIOC_STREAMOFF, &type))
        errno_exit("VIDIOC_STREAMOFF");
    break;
}

static void start_capturing(void)
{
    unsigned int i;
    enum v4l2_buf_type type;

    switch (io) {
    case IO_METHOD_READ:
        /* Nothing to do. */
        break;

    case IO_METHOD_MMAP:
        for (i = 0; i < n_buffers; ++i) {
            struct v4l2_buffer buf;

            CLEAR(buf);
            buf.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
            buf.memory = V4L2_MEMORY_MMAP;
            buf.index = i;

            if (-1 == xioctl(fd, VIDIOC_QBUF, &buf))
                errno_exit("VIDIOC_QBUF");
        }
        type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
        if (-1 == xioctl(fd, VIDIOC_STREAMON, &type))
            errno_exit("VIDIOC_STREAMON");
        break;

    case IO_METHOD_USERPTR:
        for (i = 0; i < n_buffers; ++i) {
            struct v4l2_buffer buf;

            CLEAR(buf);
            buf.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
            buf.memory = V4L2_MEMORY_USERPTR;
            buf.index = i;
            buf.m.userptr = (unsigned long)buffers[i].start;
        }
    }
}

```

```

        buf.length = buffers[i].length;

        if (-1 == xioctl(fd, VIDIOC_QBUF, &buf))
            errno_exit("VIDIOC_QBUF");
    }
    type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
    if (-1 == xioctl(fd, VIDIOC_STREAMON, &type))
        errno_exit("VIDIOC_STREAMON");
    break;
}
}

static void uninit_device(void)
{
    unsigned int i;

    switch (io) {
    case IO_METHOD_READ:
        free(buffers[0].start);
        break;

    case IO_METHOD_MMAP:
        for (i = 0; i < n_buffers; ++i)
            if (-1 == munmap(buffers[i].start, buffers[i].length))
                errno_exit("munmap");
        break;

    case IO_METHOD_USERPTR:
        for (i = 0; i < n_buffers; ++i)
            free(buffers[i].start);
        break;
    }

    free(buffers);
}

static void init_read(unsigned int buffer_size)
{
    buffers = calloc(1, sizeof(*buffers));

    if (!buffers) {
        fprintf(stderr, "Out of memory\n");
        exit(EXIT_FAILURE);
    }

    buffers[0].length = buffer_size;
    buffers[0].start = malloc(buffer_size);

    if (!buffers[0].start) {
        fprintf(stderr, "Out of memory\n");

```

```

        exit(EXIT_FAILURE);
    }

static void init_mmap(void)
{
    struct v4l2_requestbuffers req;

    CLEAR(req);

    req.count = 4;
    req.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
    req.memory = V4L2_MEMORY_MMAP;

    if (-1 == xioctl(fd, VIDIOC_REQBUFS, &req)) {
        if (EINVAL == errno) {
            fprintf(stderr, "%s does not support "
                    "memory mappingn", dev_name);
            exit(EXIT_FAILURE);
        } else {
            errno_exit("VIDIOC_REQBUFS");
        }
    }

    if (req.count < 2) {
        fprintf(stderr, "Insufficient buffer memory on %s\n",
                dev_name);
        exit(EXIT_FAILURE);
    }

    buffers = calloc(req.count, sizeof(*buffers));

    if (!buffers) {
        fprintf(stderr, "Out of memory\n");
        exit(EXIT_FAILURE);
    }

    for (n_buffers = 0; n_buffers < req.count; ++n_buffers) {
        struct v4l2_buffer buf;

        CLEAR(buf);

        buf.type      = V4L2_BUF_TYPE_VIDEO_CAPTURE;
        buf.memory    = V4L2_MEMORY_MMAP;
        buf.index     = n_buffers;

        if (-1 == xioctl(fd, VIDIOC_QUERYBUF, &buf))
            errno_exit("VIDIOC_QUERYBUF");

        buffers[n_buffers].length = buf.length;
    }
}
```

```

        buffers[n_buffers].start =
            mmap(NULL /* start anywhere */,
                  buf.length,
                  PROT_READ | PROT_WRITE /* required */,
                  MAP_SHARED /* recommended */,
                  fd, buf.m.offset);

        if (MAP_FAILED == buffers[n_buffers].start)
            errno_exit("mmap");
    }
}

static void init_userp(unsigned int buffer_size)
{
    struct v4l2_requestbuffers req;

    CLEAR(req);

    req.count   = 4;
    req.type    = V4L2_BUF_TYPE_VIDEO_CAPTURE;
    req.memory  = V4L2_MEMORY_USERPTR;

    if (-1 == ioctl(fd, VIDIOC_REQBUFS, &req)) {
        if (EINVAL == errno) {
            fprintf(stderr, "%s does not support "
                    "user pointer i/on", dev_name);
            exit(EXIT_FAILURE);
        } else {
            errno_exit("VIDIOC_REQBUFS");
        }
    }

    buffers = calloc(4, sizeof(*buffers));

    if (!buffers) {
        fprintf(stderr, "Out of memory\n");
        exit(EXIT_FAILURE);
    }

    for (n_buffers = 0; n_buffers < 4; ++n_buffers) {
        buffers[n_buffers].length = buffer_size;
        buffers[n_buffers].start = malloc(buffer_size);

        if (!buffers[n_buffers].start) {
            fprintf(stderr, "Out of memory\n");
            exit(EXIT_FAILURE);
        }
    }
}

```

```

static void init_device(void)
{
    struct v4l2_capability cap;
    struct v4l2_cropcap cropcap;
    struct v4l2_crop crop;
    struct v4l2_format fmt;
    unsigned int min;

    if (-1 == xioctl(fd, VIDIOC_QUERYCAP, &cap)) {
        if (EINVAL == errno) {
            fprintf(stderr, "%s is no V4L2 device\n",
                    dev_name);
            exit(EXIT_FAILURE);
        } else {
            errno_exit("VIDIOC_QUERYCAP");
        }
    }

    if (!(cap.capabilities & V4L2_CAP_VIDEO_CAPTURE)) {
        fprintf(stderr, "%s is no video capture device\n",
                dev_name);
        exit(EXIT_FAILURE);
    }

    switch (io) {
        case IO_METHOD_READ:
            if (!(cap.capabilities & V4L2_CAP_READWRITE)) {
                fprintf(stderr, "%s does not support read i/o\n",
                        dev_name);
                exit(EXIT_FAILURE);
            }
            break;

        case IO_METHOD_MMAP:
        case IO_METHOD_USERPTR:
            if (!(cap.capabilities & V4L2_CAP_STREAMING)) {
                fprintf(stderr, "%s does not support streaming i/o\n",
                        dev_name);
                exit(EXIT_FAILURE);
            }
            break;
    }

    /* Select video input, video standard and tune here. */

    CLEAR(cropcap);

    cropcap.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
}

```

```

if (0 == xioctl(fd, VIDIOC_CROPCAP, &cropcap)) {
    crop.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
    crop.c = cropcap.defrect; /* reset to default */

    if (-1 == xioctl(fd, VIDIOC_S_CROP, &crop)) {
        switch (errno) {
            case EINVAL:
                /* Cropping not supported. */
                break;
            default:
                /* Errors ignored. */
                break;
        }
    } else {
        /* Errors ignored. */
    }

CLEAR(fmt);

fmt.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
if (force_format) {
    fmt.fmt.pix.width      = 640;
    fmt.fmt.pix.height     = 480;
    fmt.fmt.pix.pixelformat = V4L2_PIX_FMT_YUYV;
    fmt.fmt.pix.field       = V4L2_FIELD_INTERLACED;

    if (-1 == xioctl(fd, VIDIOC_S_FMT, &fmt))
        errno_exit("VIDIOC_S_FMT");

    /* Note VIDIOC_S_FMT may change width and height. */
} else {
    /* Preserve original settings as set by v4l2-ctl for example */
    if (-1 == xioctl(fd, VIDIOC_G_FMT, &fmt))
        errno_exit("VIDIOC_G_FMT");
}

/* Buggy driver paranoia. */
min = fmt.fmt.pix.width * 2;
if (fmt.fmt.pix.bytesperline < min)
    fmt.fmt.pix.bytesperline = min;
min = fmt.fmt.pix.bytesperline * fmt.fmt.pix.height;
if (fmt.fmt.pix.sizeimage < min)
    fmt.fmt.pix.sizeimage = min;

switch (io) {
case IO_METHOD_READ:
    init_read(fmt.fmt.pix.sizeimage);
}

```

```

        break;

case IO_METHOD_MMAP:
    init_mmap();
    break;

case IO_METHOD_USERPTR:
    init_userp(fmt.fmt.pix.sizeimage);
    break;
}

}

static void close_device(void)
{
    if (-1 == close(fd))
        errno_exit("close");

    fd = -1;
}

static void open_device(void)
{
    struct stat st;

    if (-1 == stat(dev_name, &st)) {
        fprintf(stderr, "Cannot identify '%s': %d, %s\n",
                dev_name, errno, strerror(errno));
        exit(EXIT_FAILURE);
    }

    if (!S_ISCHR(st.st_mode)) {
        fprintf(stderr, "%s is no device", dev_name);
        exit(EXIT_FAILURE);
    }

    fd = open(dev_name, O_RDWR /* required */ | O_NONBLOCK, 0);

    if (-1 == fd) {
        fprintf(stderr, "Cannot open '%s': %d, %s\n",
                dev_name, errno, strerror(errno));
        exit(EXIT_FAILURE);
    }
}

static void usage(FILE *fp, int argc, char **argv)
{
    fprintf(fp,
            "Usage: %s [options]\n\n"
            "Version 1.3\n"
            "Options:\n"

```

```

        "-d | --device name    Video device name [%s]\n"
        "-h | --help           Print this message\n"
        "-m | --mmap            Use memory mapped buffers [default]\n"
        "-r | --read             Use read() calls\n"
        "-u | --userp            Use application allocated buffers\n"
        "-o | --output           Outputs stream to stdout\n"
        "-f | --format           Force format to 640x480 YUYV\n"
        "-c | --count            Number of frames to grab [%i]\n"
        "",
        argv[0], dev_name, frame_count);
}

static const char short_options[] = "d:hmrufc:";

static const struct option
long_options[] = {
    { "device", required_argument, NULL, 'd' },
    { "help",   no_argument,      NULL, 'h' },
    { "mmap",  no_argument,      NULL, 'm' },
    { "read",   no_argument,      NULL, 'r' },
    { "userp",  no_argument,      NULL, 'u' },
    { "output", no_argument,      NULL, 'o' },
    { "format", no_argument,      NULL, 'f' },
    { "count",  required_argument, NULL, 'c' },
    { 0, 0, 0, 0 }
};

int main(int argc, char **argv)
{
    dev_name = "/dev/video0";

    for (;;) {
        int idx;
        int c;

        c = getopt_long(argc, argv,
                        short_options, long_options, &idx);

        if (-1 == c)
            break;

        switch (c) {
        case 0: /* getopt_long() flag */
            break;

        case 'd':
            dev_name = optarg;
            break;

        case 'h':

```

```
        usage(stdout, argc, argv);
        exit(EXIT_SUCCESS);

    case 'm':
        io = IO_METHOD_MMAP;
        break;

    case 'r':
        io = IO_METHOD_READ;
        break;

    case 'u':
        io = IO_METHOD_USERPTR;
        break;

    case 'o':
        out_buf++;
        break;

    case 'f':
        force_format++;
        break;

    case 'c':
        errno = 0;
        frame_count = strtol(optarg, NULL, 0);
        if (errno)
            errno_exit(optarg);
        break;

    default:
        usage(stderr, argc, argv);
        exit(EXIT_FAILURE);
    }

}

open_device();
init_device();
start_capturing();
mainloop();
stop_capturing();
uninit_device();
close_device();
fprintf(stderr, "\n");
return 0;
```

### 13.2.11 Video Grabber example using libv4l

This program demonstrates how to grab V4L2 images in ppm format by using libv4l handlers. The advantage is that this grabber can potentially work with any V4L2 driver.

**file: media/v4l/v4l2grab.c**

```
/*
 * V4L2 video picture grabber
 * Copyright (C) 2009 Mauro Carvalho Chehab <mchehab@kernel.org>
 *
 * This program is free software; you can redistribute it and/or modify
 * it under the terms of the GNU General Public License as published by
 * the Free Software Foundation version 2 of the License.
 *
 * This program is distributed in the hope that it will be useful,
 * but WITHOUT ANY WARRANTY; without even the implied warranty of
 * MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
 * GNU General Public License for more details.
 */
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <fcntl.h>
#include <errno.h>
#include <sys/ioctl.h>
#include <sys/types.h>
#include <sys/time.h>
#include <sys/mman.h>
#include <linux/videoodev2.h>
#include "../libv4l/include/libv4l2.h"

#define CLEAR(x) memset(&(x), 0, sizeof(x))

struct buffer {
    void    *start;
    size_t  length;
};

static void xioctl(int fh, int request, void *arg)
{
    int r;

    do {
        r = v4l2_ioctl(fh, request, arg);
    } while (r == -1 && ((errno == EINTR) || (errno == EAGAIN)));

    if (r == -1) {
        fprintf(stderr, "error %d, %s\n", errno, strerror(errno));
        exit(EXIT_FAILURE);
    }
}
```

```

        }

}

int main(int argc, char **argv)
{
    struct v4l2_format          fmt;
    struct v4l2_buffer           buf;
    struct v4l2_requestbuffers   req;
    enum v4l2_buf_type          type;
    fd_set                      fds;
    struct timeval               tv;
    int                          r, fd = -1;
    unsigned int                 i, n_buffers;
    char                         *dev_name = "/dev/video0";
    char                         out_name[256];
    FILE                        *fout;
    struct buffer                *buffers;

    fd = v4l2_open(dev_name, O_RDWR | O_NONBLOCK, 0);
    if (fd < 0) {
        perror("Cannot open device");
        exit(EXIT_FAILURE);
    }

    CLEAR(fmt);
    fmt.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
    fmt.fmt.pix.width      = 640;
    fmt.fmt.pix.height     = 480;
    fmt.fmt.pix.pixelformat = V4L2_PIX_FMT_RGB24;
    fmt.fmt.pix.field      = V4L2_FIELD_INTERLACED;
    xioctl(fd, VIDIOC_S_FMT, &fmt);
    if (fmt.fmt.pix.pixelformat != V4L2_PIX_FMT_RGB24) {
        printf("Libv4l didn't accept RGB24 format. Can't proceed.\n");
        exit(EXIT_FAILURE);
    }
    if ((fmt.fmt.pix.width != 640) || (fmt.fmt.pix.height != 480))
        printf("Warning: driver is sending image at %dx%d\n",
               fmt.fmt.pix.width, fmt.fmt.pix.height);

    CLEAR(req);
    req.count = 2;
    req.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
    req.memory = V4L2_MEMORY_MMAP;
    xioctl(fd, VIDIOC_REQBUFS, &req);

    buffers = calloc(req.count, sizeof(*buffers));
    for (n_buffers = 0; n_buffers < req.count; ++n_buffers) {
        CLEAR(buf);
        buf.type          = V4L2_BUF_TYPE_VIDEO_CAPTURE;

```

```

buf.memory      = V4L2_MEMORY_MMAP;
buf.index       = n_buffers;

xioctl(fd, VIDIOC_QUERYBUF, &buf);

buffers[n_buffers].length = buf.length;
buffers[n_buffers].start = v4l2_mmap(NULL, buf.length,
                                      PROT_READ | PROT_WRITE, MAP_SHARED,
                                      fd, buf.m.offset);

if (MAP_FAILED == buffers[n_buffers].start) {
    perror("mmap");
    exit(EXIT_FAILURE);
}
}

for (i = 0; i < n_buffers; ++i) {
    CLEAR(buf);
    buf.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
    buf.memory = V4L2_MEMORY_MMAP;
    buf.index = i;
    xioctl(fd, VIDIOC_QBUF, &buf);
}
type = V4L2_BUF_TYPE_VIDEO_CAPTURE;

xioctl(fd, VIDIOC_STREAMON, &type);
for (i = 0; i < 20; i++) {
    do {
        FD_ZERO(&fds);
        FD_SET(fd, &fds);

        /* Timeout. */
        tv.tv_sec = 2;
        tv.tv_usec = 0;

        r = select(fd + 1, &fds, NULL, NULL, &tv);
    } while ((r == -1 && (errno == EINTR)));
    if (r == -1) {
        perror("select");
        return errno;
    }

    CLEAR(buf);
    buf.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
    buf.memory = V4L2_MEMORY_MMAP;
    xioctl(fd, VIDIOC_DQBUF, &buf);

    sprintf(out_name, "out%03d.ppm", i);
    fout = fopen(out_name, "w");
    if (!fout) {

```

```

        perror("Cannot open image");
        exit(EXIT_FAILURE);
    }
    fprintf(fout, "P6\n%d %d 255\n",
            fmt.fmt.pix.width, fmt.fmt.pix.height);
    fwrite(buffers[buf.index].start, buf.bytesused, 1, fout);
    fclose(fout);

    xioctl(fd, VIDIOC_QBUF, &buf);
}

type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
xioctl(fd, VIDIOC_STREAMOFF, &type);
for (i = 0; i < n_buffers; ++i)
    v4l2_munmap(buffers[i].start, buffers[i].length);
v4l2_close(fd);

return 0;
}

```

### 13.2.12 References

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**title**  
 CEA-608-E R-2014 "Line 21 Data Services"

**author**  
 Consumer Electronics Association (<http://www.ce.org>)

#### EN 300 294

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**author**  
 European Telecommunication Standards Institute (<http://www.etsi.org>)

#### ETS 300 231

**title**  
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**author**  
 European Telecommunication Standards Institute (<http://www.etsi.org>)

### ETS 300 706

**title**

ETS 300 706 "Enhanced Teletext specification"

**author**

European Telecommunication Standards Institute (<http://www.etsi.org>)

### ISO 13818-1

**title**

ITU-T Rec. H.222.0 | ISO/IEC 13818-1 "Information technology --- Generic coding of moving pictures and associated audio information: Systems"

**author**

International Telecommunication Union (<http://www.itu.ch>), International Organisation for Standardisation (<http://www.iso.ch>)

### ISO 13818-2

**title**

ITU-T Rec. H.262 | ISO/IEC 13818-2 "Information technology --- Generic coding of moving pictures and associated audio information: Video"

**author**

International Telecommunication Union (<http://www.itu.ch>), International Organisation for Standardisation (<http://www.iso.ch>)

### ITU BT.470

**title**

ITU-R Recommendation BT.470-6 "Conventional Television Systems"

**author**

International Telecommunication Union (<http://www.itu.ch>)

### ITU BT.601

**title**

ITU-R Recommendation BT.601-5 "Studio Encoding Parameters of Digital Television for Standard 4:3 and Wide-Screen 16:9 Aspect Ratios"

**author**

International Telecommunication Union (<http://www.itu.ch>)

## ITU BT.653

**title**

ITU-R Recommendation BT.653-3 "Teletext systems"

**author**

International Telecommunication Union (<http://www.itu.ch>)

## ITU BT.709

**title**

ITU-R Recommendation BT.709-5 "Parameter values for the HDTV standards for production and international programme exchange"

**author**

International Telecommunication Union (<http://www.itu.ch>)

## ITU BT.1119

**title**

ITU-R Recommendation BT.1119 "625-line television Wide Screen Signalling (WSS)"

**author**

International Telecommunication Union (<http://www.itu.ch>)

## ITU-T Rec. H.264 Specification (04/2017 Edition)

**title**

ITU-T Recommendation H.264 "Advanced Video Coding for Generic Audiovisual Services"

**author**

International Telecommunication Union (<http://www.itu.ch>)

## ITU H.265/HEVC

**title**

ITU-T Rec. H.265 | ISO/IEC 23008-2 "High Efficiency Video Coding"

**author**

International Telecommunication Union (<http://www.itu.ch>), International Organisation for Standardisation (<http://www.iso.ch>)

### JFIF

**title**

JPEG File Interchange Format

**subtitle**

Version 1.02

**author**

Independent JPEG Group (<http://www.ijg.org>)

### ITU-T.81

**title**

ITU-T Recommendation T.81 "Information Technology --- Digital Compression and Coding of Continuous-Tone Still Images --- Requirements and Guidelines"

**author**

International Telecommunication Union (<http://www.itu.int>)

### W3C JPEG JFIF

**title**

JPEG JFIF

**author**

The World Wide Web Consortium (<http://www.w3.org>)

### SMPTE 12M

**title**

SMPTE 12M-1999 "Television, Audio and Film - Time and Control Code"

**author**

Society of Motion Picture and Television Engineers (<http://www.smpte.org>)

### SMPTE 170M

**title**

SMPTE 170M-1999 "Television - Composite Analog Video Signal - NTSC for Studio Applications"

**author**

Society of Motion Picture and Television Engineers (<http://www.smpte.org>)

## SMPTE 240M

**title**

SMPTE 240M-1999 "Television - Signal Parameters - 1125-Line High-Definition Production"

**author**

Society of Motion Picture and Television Engineers (<http://www.smpte.org>)

## SMPTE RP 431-2

**title**

SMPTE RP 431-2:2011 "D-Cinema Quality - Reference Projector and Environment"

**author**

Society of Motion Picture and Television Engineers (<http://www.smpte.org>)

## SMPTE ST 2084

**title**

SMPTE ST 2084:2014 "High Dynamic Range Electro-Optical Transfer Function of Master Reference Displays"

**author**

Society of Motion Picture and Television Engineers (<http://www.smpte.org>)

## sRGB

**title**

IEC 61966-2-1 ed1.0 "Multimedia systems and equipment - Colour measurement and management - Part 2-1: Colour management - Default RGB colour space - sRGB"

**author**

International Electrotechnical Commission (<http://www.iec.ch>)

## SYCC

**title**

IEC 61966-2-1-am1 ed1.0 "Amendment 1 - Multimedia systems and equipment - Colour measurement and management - Part 2-1: Colour management - Default RGB colour space - sRGB"

**author**

International Electrotechnical Commission (<http://www.iec.ch>)

### xvYCC

**title**

IEC 61966-2-4 ed1.0 "Multimedia systems and equipment - Colour measurement and management - Part 2-4: Colour management - Extended-gamut YCC colour space for video applications - xvYCC"

**author**

International Electrotechnical Commission (<http://www.iec.ch>)

### opRGB

**title**

IEC 61966-2-5 "Multimedia systems and equipment - Colour measurement and management - Part 2-5: Colour management - Optional RGB colour space - opRGB"

**author**

International Electrotechnical Commission (<http://www.iec.ch>)

### ITU BT.2020

**title**

ITU-R Recommendation BT.2020 (08/2012) "Parameter values for ultra-high definition television systems for production and international programme exchange"

**author**

International Telecommunication Union (<http://www.itu.ch>)

### EBU Tech 3213

**title**

E.B.U. Standard for Chromaticity Tolerances for Studio Monitors

**author**

European Broadcast Union (<http://www.ebu.ch>)

### EBU Tech 3321

**title**

E.B.U. guidelines for Consumer Flat Panel Displays (FPDs)

**author**

European Broadcast Union (<http://www.ebu.ch>)

## IEC 62106

**title**

Specification of the radio data system (RDS) for VHF/FM sound broadcasting in the frequency range from 87,5 to 108,0 MHz

**author**

International Electrotechnical Commission (<http://www.iec.ch>)

## NRSC-4-B

**title**

NRSC-4-B: United States RBDS Standard

**author**

National Radio Systems Committee (<http://www.nrscstandards.org>)

## ISO 12232:2006

**title**

Photography --- Digital still cameras --- Determination of exposure index, ISO speed ratings, standard output sensitivity, and recommended exposure index

**author**

International Organization for Standardization (<http://www.iso.org>)

## CEA-861-E

**title**

A DTV Profile for Uncompressed High Speed Digital Interfaces

**author**

Consumer Electronics Association (<http://www.ce.org>)

## VESA DMT

**title**

VESA and Industry Standards and Guidelines for Computer Display Monitor Timing (DMT)

**author**

Video Electronics Standards Association (<http://www.vesa.org>)

## EDID

**title**

VESA Enhanced Extended Display Identification Data Standard

**subtitle**

Release A, Revision 2

**author**

Video Electronics Standards Association (<http://www.vesa.org>)

## HDCP

**title**

High-bandwidth Digital Content Protection System

**subtitle**

Revision 1.3

**author**

Digital Content Protection LLC (<http://www.digital-cp.com>)

## HDMI

**title**

High-Definition Multimedia Interface

**subtitle**

Specification Version 1.4a

**author**

HDMI Licensing LLC (<http://www.hdmi.org>)

## HDMI2

**title**

High-Definition Multimedia Interface

**subtitle**

Specification Version 2.0

**author**

HDMI Licensing LLC (<http://www.hdmi.org>)

## DP

**title**

VESA DisplayPort Standard

**subtitle**

Version 1, Revision 2

**author**

Video Electronics Standards Association (<http://www.vesa.org>)

## poynton

**title**

Digital Video and HDTV, Algorithms and Interfaces

**author**

Charles Poynton

## colimg

**title**

Color Imaging: Fundamentals and Applications

**author**

Erik Reinhard et al.

## VP8

**title**

RFC 6386: "VP8 Data Format and Decoding Guide"

**author**

J. Bankoski et al.

## VP9

**title**

VP9 Bitstream & Decoding Process Specification

**author**

Adrian Grange (Google), Peter de Rivaz (Argon Design), Jonathan Hunt (Argon Design)

### AV1

**title**

AV1 Bitstream & Decoding Process Specification

**author**

Peter de Rivaz, Argon Design Ltd, Jack Haughton, Argon Design Ltd

### 13.2.13 Revision and Copyright

Authors, in alphabetical order:

- Ailus, Sakari <[sakari.ailus@iki.fi](mailto:sakari.ailus@iki.fi)>
  - Subdev selections API.
- Carvalho Chehab, Mauro <[mchehab+samsung@kernel.org](mailto:mchehab+samsung@kernel.org)>
  - Documented libv4l, designed and added v4l2grab example, Remote Controller chapter.
- Dirks, Bill
  - Original author of the V4L2 API and documentation.
- Figa, Tomasz <[tfiga@chromium.org](mailto:tfiga@chromium.org)>
  - Documented the memory-to-memory decoder interface.
  - Documented the memory-to-memory encoder interface.
- H Schimek, Michael <[mschimek@gmx.at](mailto:mschimek@gmx.at)>
  - Original author of the V4L2 API and documentation.
- Karicheri, Muralidharan <[m-karicheri2@ti.com](mailto:m-karicheri2@ti.com)>
  - Documented the Digital Video timings API.
- Osciak, Paweł <[posciak@chromium.org](mailto:posciak@chromium.org)>
  - Documented the memory-to-memory decoder interface.
  - Documented the memory-to-memory encoder interface.
- Osciak, Paweł <[pawel@osciak.com](mailto:pawel@osciak.com)>
  - Designed and documented the multi-planar API.
- Palosaari, Antti <[crope@iki.fi](mailto:crope@iki.fi)>
  - SDR API.
- Ribalda, Ricardo
  - Introduce HSV formats and other minor changes.
- Rubli, Martin
  - Designed and documented the VIDIOC\_ENUM\_FRAMESIZES and VIDIOC\_ENUM\_FRAMEINTERVALS ioctls.
- Walls, Andy <[awalls@md.metrocast.net](mailto:awalls@md.metrocast.net)>

- Documented the fielded V4L2\_MPEG\_STREAM\_VBI\_FMT\_IVTV MPEG stream embedded, sliced VBI data format in this specification.
- Verkuil, Hans <[hverkuil@xs4all.nl](mailto:hverkuil@xs4all.nl)>
  - Designed and documented the VIDIOC\_LOG\_STATUS ioctl, the extended control ioctls, major parts of the sliced VBI API, the MPEG encoder and decoder APIs and the DV Timings API.

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Except when explicitly stated as GPL, programming examples within this part can be used and distributed without restrictions.

### 13.2.14 Revision History

#### revision

4.10 / 2016-07-15 (rr)

Introduce HSV formats.

#### revision

4.5 / 2015-10-29 (rr)

Extend VIDIOC\_G\_EXT\_CTRLS;. Replace ctrl\_class with a new union with ctrl\_class and which. Which is used to select the current value of the control or the default value.

#### revision

4.4 / 2015-05-26 (ap)

Renamed V4L2\_TUNER\_ADC to V4L2\_TUNER\_SDR. Added V4L2\_CID\_RF\_TUNER\_RF\_GAIN control. Added transmitter support for Software Defined Radio (SDR) Interface.

#### revision

4.1 / 2015-02-13 (mcc)

Fix documentation for media controller device nodes and add support for DVB device nodes. Add support for Tuner sub-device.

#### revision

3.19 / 2014-12-05 (hv)

Rewrote Colorspace chapter, added new enum `v4l2_ycbcr_encoding` and enum `v4l2_quantization` fields to struct `v4l2_pix_format`, struct `v4l2_pix_format_mplane` and struct `v4l2_mbus_framefmt`.

#### revision

3.17 / 2014-08-04 (lp, hv)

Extended struct `v4l2_pix_format`. Added format flags. Added compound control types and VIDIOC\_QUERY\_EXT\_CTRL.

#### revision

3.15 / 2014-02-03 (hv, ap)

Update several sections of "Common API Elements": "Opening and Closing Devices" "Querying Capabilities", "Application Priority", "Video Inputs and Outputs", "Audio Inputs and Outputs"

"Tuners and Modulators", "Video Standards" and "Digital Video (DV) Timings". Added SDR API.

**revision**

3.14 / 2013-11-25 (*rr*)

Set width and height as unsigned on v4l2\_rect.

**revision**

3.11 / 2013-05-26 (*hv*)

Remove obsolete VIDIOC\_DBG\_G\_CHIP\_IDENT ioctl.

**revision**

3.10 / 2013-03-25 (*hv*)

Remove obsolete and unused DV\_PRESET ioctls: VIDIOC\_G\_DV\_PRESET, VIDIOC\_S\_DV\_PRESET, VIDIOC\_QUERY\_DV\_PRESET and VIDIOC\_ENUM\_DV\_PRESET. Remove the related v4l2\_input/output capability flags V4L2\_IN\_CAP\_PRESETS and V4L2\_OUT\_CAP\_PRESETS. Added VIDIOC\_DBG\_G\_CHIP\_INFO.

**revision**

3.9 / 2012-12-03 (*sa, sn*)

Added timestamp types to v4l2\_buffer. Added V4L2\_EVENT\_CTRL\_CH\_RANGE control event changes flag.

**revision**

3.6 / 2012-07-02 (*hv*)

Added VIDIOC\_ENUM\_FREQ\_BANDS.

**revision**

3.5 / 2012-05-07 (*sa, sn, hv*)

Added V4L2\_CTRL\_TYPE\_INTEGER\_MENU and V4L2 subdev selections API. Improved the description of V4L2\_CID\_COLORFX control, added V4L2\_CID\_COLORFX\_CBCR control. Added camera controls V4L2\_CID\_AUTO\_EXPOSURE\_BIAS, V4L2\_CID\_AUTO\_N\_PRESET\_WHITE\_BALANCE, V4L2\_CID\_IMAGE\_STABILIZATION, V4L2\_CID\_ISO\_SENSITIVITY, V4L2\_CID\_ISO\_SENSITIVITY\_AUTO, V4L2\_CID\_EXPOSURE\_METERING, V4L2\_CID\_SCENE\_MODE, V4L2\_CID\_3A\_LOCK, V4L2\_CID\_AUTO\_FOCUS\_START, V4L2\_CID\_AUTO\_FOCUS\_STOP, V4L2\_CID\_AUTO\_FOCUS\_STATUS and V4L2\_CID\_AUTO\_FOCUS\_RANGE. Added VIDIOC\_ENUM\_DV\_TIMINGS, VIDIOC\_QUERY\_DV\_TIMINGS and VIDIOC\_DV\_TIMINGS\_CAP.

**revision**

3.4 / 2012-01-25 (*sn*)

Added [JPEG compression control class](#).

**revision**

3.3 / 2012-01-11 (*hv*)

Added device\_caps field to struct v4l2\_capabilities.

**revision**

3.2 / 2011-08-26 (*hv*)

Added V4L2\_CTRL\_FLAG\_VOLATILE.

**revision**

3.1 / 2011-06-27 (*mcc, po, hv*)

Documented that VIDIOC\_QUERYCAP now returns a per-subsystem version instead of a per-driver one. Standardize an error code for invalid ioctl. Added V4L2\_CTRL\_TYPE\_BITMASK.

**revision**

2.6.39 / 2011-03-01 (*mcc, po*)

Removed VIDIOC\_\*\_OLD from videodev2.h header and update it to reflect latest changes. Added the *multi-planar API*.

**revision**

2.6.37 / 2010-08-06 (*hv*)

Removed obsolete vtx (videotext) API.

**revision**

2.6.33 / 2009-12-03 (*mk*)

Added documentation for the Digital Video timings API.

**revision**

2.6.32 / 2009-08-31 (*mcc*)

Now, revisions will match the kernel version where the V4L2 API changes will be used by the Linux Kernel. Also added Remote Controller chapter.

**revision**

0.29 / 2009-08-26 (*ev*)

Added documentation for string controls and for FM Transmitter controls.

**revision**

0.28 / 2009-08-26 (*gl*)

Added V4L2\_CID\_BAND\_STOP\_FILTER documentation.

**revision**

0.27 / 2009-08-15 (*mcc*)

Added libv4l and Remote Controller documentation; added v4l2grab and keytable application examples.

**revision**

0.26 / 2009-07-23 (*hv*)

Finalized the RDS capture API. Added modulator and RDS encoder capabilities. Added support for string controls.

**revision**

0.25 / 2009-01-18 (*hv*)

Added pixel formats VYUY, NV16 and NV61, and changed the debug ioctls VIDIOC\_DBG\_G/S\_REGISTER and VIDIOC\_DBG\_G\_CHIP\_IDENT. Added camera controls V4L2\_CID\_ZOOM\_ABSOLUTE, V4L2\_CID\_ZOOM\_RELATIVE, V4L2\_CID\_ZOOM\_CONTINUOUS and V4L2\_CID\_PRIVACY.

**revision**

0.24 / 2008-03-04 (*mhs*)

Added pixel formats Y16 and SBGGR16, new controls and a camera controls class. Removed VIDIOC\_G/S\_MPEGCOMP.

**revision**

0.23 / 2007-08-30 (*mhs*)

Fixed a typo in VIDIOC\_DBG\_G/S\_REGISTER. Clarified the byte order of packed pixel formats.

**revision**

0.22 / 2007-08-29 (*mhs*)

Added the Video Output Overlay interface, new MPEG controls, V4L2\_FIELD\_INTERLACED\_TB and V4L2\_FIELD\_INTERLACED\_BT, VIDIOC\_DBG\_G/S\_REGISTER, VIDIOC\_(TRY\_)ENCODER\_CMD, VIDIOC\_G\_CHIP\_IDENT, VIDIOC\_G\_ENC\_INDEX, new pixel formats. Clarifications in the cropping chapter, about RGB pixel formats, the mmap(), poll(), select(), read() and write() functions. Typographical fixes.

**revision**

0.21 / 2006-12-19 (*mhs*)

Fixed a link in the VIDIOC\_G\_EXT\_CTRLS section.

**revision**

0.20 / 2006-11-24 (*mhs*)

Clarified the purpose of the audioset field in struct v4l2\_input and v4l2\_output.

**revision**

0.19 / 2006-10-19 (*mhs*)

Documented V4L2\_PIX\_FMT\_RGB444.

**revision**

0.18 / 2006-10-18 (*mhs*)

Added the description of extended controls by Hans Verkuil. Linked V4L2\_PIX\_FMT\_MPEG to V4L2\_CID\_MPEG\_STREAM\_TYPE.

**revision**

0.17 / 2006-10-12 (*mhs*)

Corrected V4L2\_PIX\_FMT\_HM12 description.

**revision**

0.16 / 2006-10-08 (*mhs*)

VIDIOC\_ENUM\_FRAMESIZES and VIDIOC\_ENUM\_FRAMEINTERVALS are now part of the API.

**revision**

0.15 / 2006-09-23 (*mhs*)

Cleaned up the bibliography, added BT.653 and BT.1119. capture.c/start\_capturing() for user pointer I/O did not initialize the buffer index. Documented the V4L MPEG and MJPEG VID\_TYPES and V4L2\_PIX\_FMT\_SBGGR8. Updated the list of reserved pixel formats. See the history chapter for API changes.

**revision**

0.14 / 2006-09-14 (*mr*)

Added VIDIOC\_ENUM\_FRAMESIZES and VIDIOC\_ENUM\_FRAMEINTERVALS proposal for frame format enumeration of digital devices.

**revision**

0.13 / 2006-04-07 (*mhs*)

Corrected the description of *struct v4l2\_window* clips. New V4L2\_STD\_ and V4L2\_TUNER\_MODE\_LANG1\_LANG2 defines.

**revision**

0.12 / 2006-02-03 (*mhs*)

Corrected the description of struct v4l2\_captureparm and v4l2\_outputparm.

**revision**

0.11 / 2006-01-27 (*mhs*)

Improved the description of struct v4l2\_tuner.

**revision**

0.10 / 2006-01-10 (*mhs*)

VIDIOC\_G\_INPUT and VIDIOC\_S\_PARM clarifications.

**revision**

0.9 / 2005-11-27 (*mhs*)

Improved the 525 line numbering diagram. Hans Verkuil and I rewrote the sliced VBI section. He also contributed a VIDIOC\_LOG\_STATUS page. Fixed VIDIOC\_S\_STD call in the video standard selection example. Various updates.

**revision**

0.8 / 2004-10-04 (*mhs*)

Somehow a piece of junk slipped into the capture example, removed.

**revision**

0.7 / 2004-09-19 (*mhs*)

Fixed video standard selection, control enumeration, downscaling and aspect example. Added read and user pointer i/o to video capture example.

**revision**

0.6 / 2004-08-01 (*mhs*)

v4l2\_buffer changes, added video capture example, various corrections.

**revision**

0.5 / 2003-11-05 (*mhs*)

Pixel format erratum.

**revision**

0.4 / 2003-09-17 (*mhs*)

Corrected source and Makefile to generate a PDF. SGML fixes. Added latest API changes. Closed gaps in the history chapter.

**revision**

0.3 / 2003-02-05 (*mhs*)

Another draft, more corrections.

**revision**

0.2 / 2003-01-15 (*mhs*)

Second draft, with corrections pointed out by Gerd Knorr.

**revision**

0.1 / 2002-12-01 (*mhs*)

First draft, based on documentation by Bill Dirks and discussions on the V4L mailing list.

## 13.3 Part II - Digital TV API

---

**Note:** This API is also known as Linux **DVB API**.

It it was originally written to support the European digital TV standard (DVB), and later extended to support all digital TV standards.

In order to avoid confusion, within this document, it was opted to refer to it, and to associated hardware as **Digital TV**.

The word **DVB** is reserved to be used for:

- the Digital TV API version (e. g. DVB API version 3 or DVB API version 5);
  - digital TV data types (enums, structs, defines, etc);
  - digital TV device nodes (`/dev/dvb/...`);
  - the European DVB standard.
- 

### Version 5.10

#### 13.3.1 Introduction

##### What you need to know

The reader of this document is required to have some knowledge in the area of digital video broadcasting (Digital TV) and should be familiar with part I of the MPEG2 specification ISO/IEC 13818 (aka ITU-T H.222), i.e you should know what a program/transport stream (PS/TS) is and what is meant by a packetized elementary stream (PES) or an I-frame.

Various Digital TV standards documents are available for download at:

- European standards (DVB): <http://www.dvb.org> and/or <http://www.etsi.org>.
- American standards (ATSC): <https://www.atsc.org/standards/>
- Japanese standards (ISDB): <http://www.dibeg.org/>

It is also necessary to know how to access Linux devices and how to use ioctl calls. This also includes the knowledge of C or C++.

## History

The first API for Digital TV cards we used at Convergence in late 1999 was an extension of the Video4Linux API which was primarily developed for frame grabber cards. As such it was not really well suited to be used for Digital TV cards and their new features like recording MPEG streams and filtering several section and PES data streams at the same time.

In early 2000, Convergence was approached by Nokia with a proposal for a new standard Linux Digital TV API. As a commitment to the development of terminals based on open standards, Nokia and Convergence made it available to all Linux developers and published it on <https://linuxtv.org> in September 2000. With the Linux driver for the Siemens/Hauppauge DVB PCI card, Convergence provided a first implementation of the Linux Digital TV API. Convergence was the maintainer of the Linux Digital TV API in the early days.

Now, the API is maintained by the LinuxTV community (i.e. you, the reader of this document). The Linux Digital TV API is constantly reviewed and improved together with the improvements at the subsystem's core at the Kernel.

## Overview

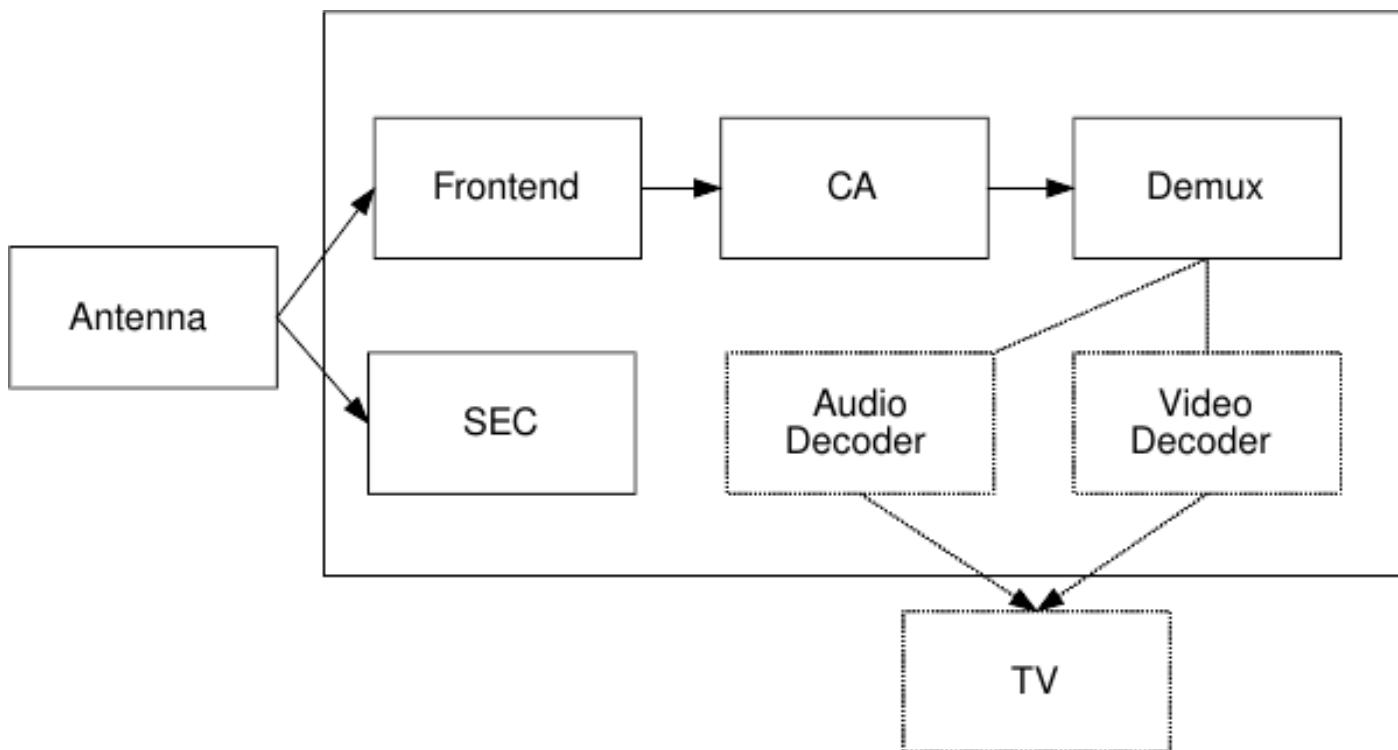


Fig. 19: Components of a Digital TV card/STB

A Digital TV card or set-top-box (STB) usually consists of the following main hardware components:

### Frontend consisting of tuner and digital TV demodulator

Here the raw signal reaches the digital TV hardware from a satellite dish or antenna or directly from cable. The frontend down-converts and demodulates this signal into an MPEG transport stream (TS). In case of a satellite frontend, this includes a facility for satellite equipment control (SEC), which allows control of LNB polarization, multi feed switches or dish rotors.

### Conditional Access (CA) hardware like CI adapters and smartcard slots

The complete TS is passed through the CA hardware. Programs to which the user has access (controlled by the smart card) are decoded in real time and re-inserted into the TS.

---

**Note:** Not every digital TV hardware provides conditional access hardware.

---

### Demultiplexer which filters the incoming Digital TV MPEG-TS stream

The demultiplexer splits the TS into its components like audio and video streams. Besides usually several of such audio and video streams it also contains data streams with information about the programs offered in this or other streams of the same provider.

### Audio and video decoder

The main targets of the demultiplexer are audio and video decoders. After decoding, they pass on the uncompressed audio and video to the computer screen or to a TV set.

---

**Note:** Modern hardware usually doesn't have a separate decoder hardware, as such functionality can be provided by the main CPU, by the graphics adapter of the system or by a signal processing hardware embedded on a Systems on a Chip (SoC) integrated circuit.

It may also not be needed for certain usages (e.g. for data-only uses like "internet over satellite").

---

*Components of a Digital TV card/STB* shows a crude schematic of the control and data flow between those components.

## Linux Digital TV Devices

The Linux Digital TV API lets you control these hardware components through currently six Unix-style character devices for video, audio, frontend, demux, CA and IP-over-DVB networking. The video and audio devices control the MPEG2 decoder hardware, the frontend device the tuner and the Digital TV demodulator. The demux device gives you control over the PES and section filters of the hardware. If the hardware does not support filtering these filters can be implemented in software. Finally, the CA device controls all the conditional access capabilities of the hardware. It can depend on the individual security requirements of the platform, if and how many of the CA functions are made available to the application through this device.

All devices can be found in the /dev tree under /dev/dvb. The individual devices are called:

- /dev/dvb/adapterN/audioM,
- /dev/dvb/adapterN/videoM,
- /dev/dvb/adapterN/frontendM,
- /dev/dvb/adapterN/netM,
- /dev/dvb/adapterN/demuxM,
- /dev/dvb/adapterN/dvrM,
- /dev/dvb/adapterN/caM,

where N enumerates the Digital TV cards in a system starting from 0, and M enumerates the devices of each type within each adapter, starting from 0, too. We will omit the "/dev/dvb/adapterN/" in the further discussion of these devices.

More details about the data structures and function calls of all the devices are described in the following chapters.

## API include files

For each of the Digital TV devices a corresponding include file exists. The Digital TV API include files should be included in application sources with a partial path like:

```
#include <linux/dvb/ca.h>
#include <linux/dvb/dmx.h>
#include <linux/dvb/frontend.h>
#include <linux/dvb/net.h>
```

To enable applications to support different API version, an additional include file `linux/dvb/version.h` exists, which defines the constant `DVB_API_VERSION`. This document describes `DVB_API_VERSION 5.10`.

### 13.3.2 Digital TV Frontend API

The Digital TV frontend API was designed to support three groups of delivery systems: Terrestrial, cable and Satellite. Currently, the following delivery systems are supported:

- Terrestrial systems: DVB-T, DVB-T2, ATSC, ATSC M/H, ISDB-T, DVB-H, DTMB, CMMB
- Cable systems: DVB-C Annex A/C, ClearQAM (DVB-C Annex B)
- Satellite systems: DVB-S, DVB-S2, DVB Turbo, ISDB-S, DSS

The Digital TV frontend controls several sub-devices including:

- Tuner
- Digital TV demodulator
- Low noise amplifier (LNA)
- Satellite Equipment Control (SEC)<sup>1</sup>.

The frontend can be accessed through `/dev/dvb/adapter?/frontend?`. Data types and ioctl definitions can be accessed by including `linux/dvb/frontend.h` in your application.

---

**Note:** Transmission via the internet (DVB-IP) and MMT (MPEG Media Transport) is not yet handled by this API but a future extension is possible.

---

<sup>1</sup> On Satellite systems, the API support for the Satellite Equipment Control (SEC) allows to power control and to send/receive signals to control the antenna subsystem, selecting the polarization and choosing the Intermediate Frequency (IF) of the Low Noise Block Converter Feed Horn (LNBf). It supports the DiSEqC and V-SEC protocols. The DiSEqC (digital SEC) specification is available at [Eutelsat](#).

## Querying frontend information

Usually, the first thing to do when the frontend is opened is to check the frontend capabilities. This is done using *ioctl FE\_GET\_INFO*. This ioctl will enumerate the Digital TV API version and other characteristics about the frontend, and can be opened either in read only or read/write mode.

## Querying frontend status and statistics

Once *FE\_SET\_PROPERTY* is called, the frontend will run a kernel thread that will periodically check for the tuner lock status and provide statistics about the quality of the signal.

The information about the frontend tuner locking status can be queried using *ioctl FE\_READ\_STATUS*.

Signal statistics are provided via *ioctl FE\_SET\_PROPERTY, FE\_GET\_PROPERTY*.

---

**Note:** Most statistics require the demodulator to be fully locked (e. g. with *FE\_HAS\_LOCK* bit set). See *Frontend statistics indicators* for more details.

---

## Property types

Tuning into a Digital TV physical channel and starting decoding it requires changing a set of parameters, in order to control the tuner, the demodulator, the Linear Low-noise Amplifier (LNA) and to set the antenna subsystem via Satellite Equipment Control - SEC (on satellite systems). The actual parameters are specific to each particular digital TV standards, and may change as the digital TV specs evolves.

In the past (up to DVB API version 3 - DVBy3), the strategy used was to have a union with the parameters needed to tune for DVB-S, DVB-C, DVB-T and ATSC delivery systems grouped there. The problem is that, as the second generation standards appeared, the size of such union was not big enough to group the structs that would be required for those new standards. Also, extending it would break userspace.

So, the legacy union/struct based approach was deprecated, in favor of a properties set approach. On such approach, *FE\_GET\_PROPERTY* and *FE\_SET\_PROPERTY* are used to setup the frontend and read its status.

The actual action is determined by a set of *dtv\_property* cmd/data pairs. With one single ioctl, is possible to get/set up to 64 properties.

This section describes the new and recommended way to set the frontend, with supports all digital TV delivery systems.

---

### Note:

1. On Linux DVB API version 3, setting a frontend was done via struct *dvb\_frontend\_parameters*.
2. Don't use DVB API version 3 calls on hardware with supports newer standards. Such API provides no support or a very limited support to new standards and/or new hardware.

3. Nowadays, most frontends support multiple delivery systems. Only with DVB API version 5 calls it is possible to switch between the multiple delivery systems supported by a frontend.
4. DVB API version 5 is also called *S2API*, as the first new standard added to it was DVB-S2.

**Example:** in order to set the hardware to tune into a DVB-C channel at 651 kHz, modulated with 256-QAM, FEC 3/4 and symbol rate of 5.217 Mbauds, those properties should be sent to *FE\_SET\_PROPERTY* ioctl:

```
DTV_DELIVERY_SYSTEM = SYS_DVBC_ANNEX_A
DTV_FREQUENCY = 651000000
DTV_MODULATION = QAM_256
DTV_INVERSION = INVERSION_AUTO
DTV_SYMBOL_RATE = 5217000
DTV_INNER_FEC = FEC_3_4
DTV_TUNE
```

The code that would do the above is shown in *Example: Setting digital TV frontend properties*.

Listing 1: Example: Setting digital TV frontend properties

```
#include <stdio.h>
#include <fcntl.h>
#include <sys/ioctl.h>
#include <linux/dvb/frontend.h>

static struct dtv_property props[] = {
    { .cmd = DTV_DELIVERY_SYSTEM, .u.data = SYS_DVBC_ANNEX_A },
    { .cmd = DTV_FREQUENCY, .u.data = 651000000 },
    { .cmd = DTV_MODULATION, .u.data = QAM_256 },
    { .cmd = DTV_INVERSION, .u.data = INVERSION_AUTO },
    { .cmd = DTV_SYMBOL_RATE, .u.data = 5217000 },
    { .cmd = DTV_INNER_FEC, .u.data = FEC_3_4 },
    { .cmd = DTV_TUNE }};

static struct dtv_properties dtv_prop = {
    .num = 6, .props = props
};

int main(void)
{
    int fd = open("/dev/dvb/adapter0/frontend0", O_RDWR);

    if (!fd) {
        perror("open");
        return -1;
    }
```

```
if (ioctl(fd, FE_SET_PROPERTY, &dtv_prop) == -1) {
    perror("ioctl");
    return -1;
}
printf("Frontend set\\n");
return 0;
}
```

**Attention:** While it is possible to directly call the Kernel code like the above example, it is strongly recommended to use `libdvbv5`, as it provides abstraction to work with the supported digital TV standards and provides methods for usual operations like program scanning and to read/write channel descriptor files.

## Digital TV property parameters

There are several different Digital TV parameters that can be used by *FE\_SET\_PROPERTY* and *FE\_GET\_PROPERTY* ioctls. This section describes each of them. Please notice, however, that only a subset of them are needed to setup a frontend.

### DTV\_UNDEFINED

Used internally. A GET/SET operation for it won't change or return anything.

### DTV\_TUNE

Interpret the cache of data, build either a traditional frontend tunerequest so we can pass validation in the `FE_SET_FRONTEND` ioctl.

### DTV\_CLEAR

Reset a cache of data specific to the frontend here. This does not effect hardware.

### DTV\_FREQUENCY

Frequency of the digital TV transponder/channel.

---

#### Note:

1. For satellite delivery systems, the frequency is in kHz.
2. For cable and terrestrial delivery systems, the frequency is in Hz.
3. On most delivery systems, the frequency is the center frequency of the transponder/channel. The exception is for ISDB-T, where the main carrier has a 1/7 offset from the center.

- 
4. For ISDB-T, the channels are usually transmitted with an offset of about 143kHz. E.g. a valid frequency could be 474,143 kHz. The stepping is bound to the bandwidth of the channel which is typically 6MHz.
  5. In ISDB-Tsb, the channel consists of only one or three segments the frequency step is 429kHz, 3\*429 respectively.
- 

## DTV\_MODULATION

Specifies the frontend modulation type for delivery systems that supports more multiple modulations.

The modulation can be one of the types defined by enum *fe\_modulation*.

Most of the digital TV standards offers more than one possible modulation type.

The table below presents a summary of the types of modulation types supported by each delivery system, as currently defined by specs.

Standard	Modulation types
ATSC (version 1)	8-VSB and 16-VSB.
DMTB	4-QAM, 16-QAM, 32-QAM, 64-QAM and 4-QAM-NR.
DVB-C Annex A/C	16-QAM, 32-QAM, 64-QAM and 256-QAM.
DVB-C Annex B	64-QAM.
DVB-C2	QPSK, 16-QAM, 64-QAM, 256-QAM, 1024-QAM and 4096-QAM.
DVB-T	QPSK, 16-QAM and 64-QAM.
DVB-T2	QPSK, 16-QAM, 64-QAM and 256-QAM.
DVB-S	No need to set. It supports only QPSK.
DVB-S2	QPSK, 8-PSK, 16-APSK and 32-APSK.
DVB-S2X	8-APSK-L, 16-APSK-L, 32-APSK-L, 64-APSK and 64-APSK-L.
ISDB-T	QPSK, DQPSK, 16-QAM and 64-QAM.
ISDB-S	8-PSK, QPSK and BPSK.

---

**Note:** As DVB-S2X specifies extensions to the DVB-S2 standard, the same delivery system enum value is used (SYS\_DVBS2).

Please notice that some of the above modulation types may not be defined currently at the Kernel. The reason is simple: no driver needed such definition yet.

---

## DTV\_BANDWIDTH\_HZ

Bandwidth for the channel, in Hz.

Should be set only for terrestrial delivery systems.

Possible values: 1712000, 5000000, 6000000, 7000000, 8000000, 10000000.

Terrestrial Standard	Possible values for bandwidth
ATSC (version 1)	No need to set. It is always 6MHz.
DMTB	No need to set. It is always 8MHz.
DVB-T	6MHz, 7MHz and 8MHz.
DVB-T2	1.172 MHz, 5MHz, 6MHz, 7MHz, 8MHz and 10MHz
ISDB-T	5MHz, 6MHz, 7MHz and 8MHz, although most places use 6MHz.

---

#### Note:

- For ISDB-Tsb, the bandwidth can vary depending on the number of connected segments. It can be easily derived from other parameters (`DTV_ISDBT_SB_SEGMENT_IDX`, `DTV_ISDBT_SB_SEGMENT_COUNT`).
  - On Satellite and Cable delivery systems, the bandwidth depends on the symbol rate. So, the Kernel will silently ignore any setting `DTV_BANDWIDTH_HZ`. I will however fill it back with a bandwidth estimation.  
Such bandwidth estimation takes into account the symbol rate set with `DTV_SYMBOL_RATE`, and the rolloff factor, which is fixed for DVB-C and DVB-S.  
For DVB-S2, the rolloff should also be set via `DTV_ROLLOFF`.
- 

## **`DTV_INVERSION`**

Specifies if the frontend should do spectral inversion or not.

The acceptable values are defined by `fe_spectral_inversion`.

## **`DTV_DISEQC_MASTER`**

Currently not implemented.

## **`DTV_SYMBOL_RATE`**

Used on cable and satellite delivery systems.

Digital TV symbol rate, in bauds (symbols/second).

## **`DTV_INNER_FEC`**

Used on cable and satellite delivery systems.

The acceptable values are defined by `fe_code_rate`.

## **DTV\_VOLTAGE**

Used on satellite delivery systems.

The voltage is usually used with non-DiSEqC capable LNBs to switch the polarization (horizontal/vertical). When using DiSEqC equipment this voltage has to be switched consistently to the DiSEqC commands as described in the DiSEqC spec.

The acceptable values are defined by *fe\_sec\_voltage*.

## **DTV\_TONE**

Currently not used.

## **DTV\_PILOT**

Used on DVB-S2.

Sets DVB-S2 pilot.

The acceptable values are defined by *fe\_pilot*.

## **DTV\_ROLLOFF**

Used on DVB-S2.

Sets DVB-S2 rolloff.

The acceptable values are defined by *fe\_rolloff*.

## **DTV\_DISEQC\_SLAVE\_REPLY**

Currently not implemented.

## **DTV\_FE\_CAPABILITY\_COUNT**

Currently not implemented.

## **DTV\_FE\_CAPABILITY**

Currently not implemented.

## **DTV\_DELIVERY\_SYSTEM**

Specifies the type of the delivery system.

The acceptable values are defined by *fe\_delivery\_system*.

## **DTV\_ISDBT\_PARTIAL\_RECEPTION**

Used only on ISDB.

If DTV\_ISDBT\_SOUND\_BROADCASTING is '0' this bit-field represents whether the channel is in partial reception mode or not.

If '1' DTV\_ISDBT\_LAYERA\_\* values are assigned to the center segment and DTV\_ISDBT\_LAYERA\_SEGMENT\_COUNT has to be '1'.

If in addition DTV\_ISDBT\_SOUND\_BROADCASTING is '1' DTV\_ISDBT\_PARTIAL\_RECEPTION represents whether this ISDB-Tsb channel is consisting of one segment and layer or three segments and two layers.

Possible values: 0, 1, -1 (AUTO)

## **DTV\_ISDBT\_SOUND\_BROADCASTING**

Used only on ISDB.

This field represents whether the other DTV\_ISDBT\_\*-parameters are referring to an ISDB-T and an ISDB-Tsb channel. (See also DTV\_ISDBT\_PARTIAL\_RECEPTION).

Possible values: 0, 1, -1 (AUTO)

## **DTV\_ISDBT\_SB\_SUBCHANNEL\_ID**

Used only on ISDB.

This field only applies if DTV\_ISDBT\_SOUND\_BROADCASTING is '1'.

(Note of the author: This might not be the correct description of the SUBCHANNEL-ID in all details, but it is my understanding of the technical background needed to program a device)

An ISDB-Tsb channel (1 or 3 segments) can be broadcasted alone or in a set of connected ISDB-Tsb channels. In this set of channels every channel can be received independently. The number of connected ISDB-Tsb segment can vary, e.g. depending on the frequency spectrum bandwidth available.

Example: Assume 8 ISDB-Tsb connected segments are broadcasted. The broadcaster has several possibilities to put those channels in the air: Assuming a normal 13-segment ISDB-T spectrum he can align the 8 segments from position 1-8 to 5-13 or anything in between.

The underlying layer of segments are subchannels: each segment is consisting of several sub-channels with a predefined IDs. A sub-channel is used to help the demodulator to synchronize on the channel.

An ISDB-T channel is always centered over all sub-channels. As for the example above, in ISDB-Tsb it is no longer as simple as that.

The `DTV_ISDBT_SB_SUBCHANNEL_ID` parameter is used to give the sub-channel ID of the segment to be demodulated.

Possible values: 0 .. 41, -1 (AUTO)

### **`DTV_ISDBT_SB_SEGMENT_IDX`**

Used only on ISDB.

This field only applies if `DTV_ISDBT_SOUND_BROADCASTING` is '1'.

`DTV_ISDBT_SB_SEGMENT_IDX` gives the index of the segment to be demodulated for an ISDB-Tsb channel where several of them are transmitted in the connected manner.

Possible values: 0 .. `DTV_ISDBT_SB_SEGMENT_COUNT` - 1

Note: This value cannot be determined by an automatic channel search.

### **`DTV_ISDBT_SB_SEGMENT_COUNT`**

Used only on ISDB.

This field only applies if `DTV_ISDBT_SOUND_BROADCASTING` is '1'.

`DTV_ISDBT_SB_SEGMENT_COUNT` gives the total count of connected ISDB-Tsb channels.

Possible values: 1 .. 13

Note: This value cannot be determined by an automatic channel search.

### **DTV-ISDBT-LAYER[A-C] parameters**

Used only on ISDB.

ISDB-T channels can be coded hierarchically. As opposed to DVB-T in ISDB-T hierarchical layers can be decoded simultaneously. For that reason a ISDB-T demodulator has 3 Viterbi and 3 Reed-Solomon decoders.

ISDB-T has 3 hierarchical layers which each can use a part of the available segments. The total number of segments over all layers has to 13 in ISDB-T.

There are 3 parameter sets, for Layers A, B and C.

### **`DTV_ISDBT_LAYER_ENABLED`**

Used only on ISDB.

Hierarchical reception in ISDB-T is achieved by enabling or disabling layers in the decoding process. Setting all bits of `DTV_ISDBT_LAYER_ENABLED` to '1' forces all layers (if applicable) to be demodulated. This is the default.

If the channel is in the partial reception mode (`DTV_ISDBT_PARTIAL_RECEPTION` = 1) the central segment can be decoded independently of the other 12 segments. In that mode layer A has to have a `SEGMENT_COUNT` of 1.

In ISDB-Tsb only layer A is used, it can be 1 or 3 in ISDB-Tsb according to DTV\_ISDBT\_PARTIAL\_RECEPTION. SEGMENT\_COUNT must be filled accordingly.

Only the values of the first 3 bits are used. Other bits will be silently ignored:

DTV\_ISDBT\_LAYER\_ENABLED bit 0: layer A enabled

DTV\_ISDBT\_LAYER\_ENABLED bit 1: layer B enabled

DTV\_ISDBT\_LAYER\_ENABLED bit 2: layer C enabled

DTV\_ISDBT\_LAYER\_ENABLED bits 3-31: unused

### **DTV\_ISDBT\_LAYER[A-C]\_FEC**

Used only on ISDB.

The Forward Error Correction mechanism used by a given ISDB Layer, as defined by *fe\_code\_rate*.

Possible values are: FEC\_AUTO, FEC\_1\_2, FEC\_2\_3, FEC\_3\_4, FEC\_5\_6, FEC\_7\_8

### **DTV\_ISDBT\_LAYER[A-C]\_MODULATION**

Used only on ISDB.

The modulation used by a given ISDB Layer, as defined by *fe\_modulation*.

Possible values are: QAM\_AUTO, QPSK, QAM\_16, QAM\_64, DQPSK

---

#### **Note:**

1. If layer C is DQPSK, then layer B has to be DQPSK.
  2. If layer B is DQPSK and DTV\_ISDBT\_PARTIAL\_RECEPTION= 0, then layer has to be DQPSK.
- 

### **DTV\_ISDBT\_LAYER[A-C]\_SEGMENT\_COUNT**

Used only on ISDB.

Possible values: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, -1 (AUTO)

Note: Truth table for DTV\_ISDBT\_SOUND\_BROADCASTING and DTV\_ISDBT\_PARTIAL\_RECEPTION and LAYER[A-C]\_SEGMENT\_COUNT

Table 281: Truth table for ISDB-T Sound Broadcasting

Partial Reception	Sound Broadcasting	Broad- casting	Layer A width	Layer B width	Layer C width	total width
0	0		1 .. 13	1 .. 13	1 .. 13	13
1	0		1	1 .. 13	1 .. 13	13
0	1		1	0	0	1
1	1		1	2	0	13

**DTV\_ISDBT\_LAYER[A-C]\_TIME\_INTERLEAVING**

Used only on ISDB.

Valid values: 0, 1, 2, 4, -1 (AUTO)

when DTV\_ISDBT\_SOUND\_BROADCASTING is active, value 8 is also valid.

Note: The real time interleaving length depends on the mode (fft-size). The values here are referring to what can be found in the TMCC-structure, as shown in the table below.

type **isdbt\_layer\_interleaving\_table**

Table 282: ISDB-T time interleaving modes

DTV_ISDBT_LAYER[A-C]_TIME_INTERLEAVING	Mode 1 (2K FFT)	Mode 2 (4K FFT)	Mode 3 (8K FFT)
0	0	0	0
1	4	2	1
2	8	4	2
4	16	8	4

**DTV\_ATSCMH\_FIC\_VER**

Used only on ATSC-MH.

Version number of the FIC (Fast Information Channel) signaling data.

FIC is used for relaying information to allow rapid service acquisition by the receiver.

Possible values: 0, 1, 2, 3, ..., 30, 31

**DTV\_ATSCMH\_PARADE\_ID**

Used only on ATSC-MH.

Parade identification number

A parade is a collection of up to eight MH groups, conveying one or two ensembles.

Possible values: 0, 1, 2, 3, ..., 126, 127

**DTV\_ATSCMH\_NOG**

Used only on ATSC-MH.

Number of MH groups per MH subframe for a designated parade.

Possible values: 1, 2, 3, 4, 5, 6, 7, 8

## **DTV\_ATSCMH\_TNOG**

Used only on ATSC-MH.

Total number of MH groups including all MH groups belonging to all MH parades in one MH subframe.

Possible values: 0, 1, 2, 3, ..., 30, 31

## **DTV\_ATSCMH\_SGN**

Used only on ATSC-MH.

Start group number.

Possible values: 0, 1, 2, 3, ..., 14, 15

## **DTV\_ATSCMH\_PRC**

Used only on ATSC-MH.

Parade repetition cycle.

Possible values: 1, 2, 3, 4, 5, 6, 7, 8

## **DTV\_ATSCMH\_RS\_FRAME\_MODE**

Used only on ATSC-MH.

Reed Solomon (RS) frame mode.

The acceptable values are defined by [\*atscmh\\_rs\\_frame\\_mode\*](#).

## **DTV\_ATSCMH\_RS\_FRAME\_ENSEMBLE**

Used only on ATSC-MH.

Reed Solomon(RS) frame ensemble.

The acceptable values are defined by [\*atscmh\\_rs\\_frame\\_ensemble\*](#).

## **DTV\_ATSCMH\_RS\_CODE\_MODE\_PRI**

Used only on ATSC-MH.

Reed Solomon (RS) code mode (primary).

The acceptable values are defined by [\*atscmh\\_rs\\_code\\_mode\*](#).

## **DTV\_ATSCMH\_RS\_CODE\_MODE\_SEC**

Used only on ATSC-MH.

Reed Solomon (RS) code mode (secondary).

The acceptable values are defined by [\*atscmh\\_rs\\_code\\_mode\*](#).

## **DTV\_ATSCMH\_SCCC\_BLOCK\_MODE**

Used only on ATSC-MH.

Series Concatenated Convolutional Code Block Mode.

The acceptable values are defined by [\*atscmh\\_sccc\\_block\\_mode\*](#).

## **DTV\_ATSCMH\_SCCC\_CODE\_MODE\_A**

Used only on ATSC-MH.

Series Concatenated Convolutional Code Rate.

The acceptable values are defined by [\*atscmh\\_sccc\\_code\\_mode\*](#).

## **DTV\_ATSCMH\_SCCC\_CODE\_MODE\_B**

Used only on ATSC-MH.

Series Concatenated Convolutional Code Rate.

Possible values are the same as documented on enum [\*atscmh\\_sccc\\_code\\_mode\*](#).

## **DTV\_ATSCMH\_SCCC\_CODE\_MODE\_C**

Used only on ATSC-MH.

Series Concatenated Convolutional Code Rate.

Possible values are the same as documented on enum [\*atscmh\\_sccc\\_code\\_mode\*](#).

## **DTV\_ATSCMH\_SCCC\_CODE\_MODE\_D**

Used only on ATSC-MH.

Series Concatenated Convolutional Code Rate.

Possible values are the same as documented on enum [\*atscmh\\_sccc\\_code\\_mode\*](#).

## **DTV\_API\_VERSION**

Returns the major/minor version of the Digital TV API

## **DTV\_CODE\_RATE\_HP**

Used on terrestrial transmissions.

The acceptable values are defined by *fe\_transmit\_mode*.

## **DTV\_CODE\_RATE\_LP**

Used on terrestrial transmissions.

The acceptable values are defined by *fe\_transmit\_mode*.

## **DTV\_GUARD\_INTERVAL**

The acceptable values are defined by *fe\_guard\_interval*.

---

### **Note:**

1. If DTV\_GUARD\_INTERVAL is set the GUARD\_INTERVAL\_AUTO the hardware will try to find the correct guard interval (if capable) and will use TMCC to fill in the missing parameters.
  2. Interval GUARD\_INTERVAL\_1\_64 is used only for DVB-C2.
  3. Interval GUARD\_INTERVAL\_1\_128 is used for both DVB-C2 and DVB\_T2.
  4. Intervals GUARD\_INTERVAL\_19\_128 and GUARD\_INTERVAL\_19\_256 are used only for DVB-T2.
  5. Intervals GUARD\_INTERVAL\_PN420, GUARD\_INTERVAL\_PN595 and GUARD\_INTERVAL\_PN945 are used only for DMTB at the present. On such standard, only those intervals and GUARD\_INTERVAL\_AUTO are valid.
- 

## **DTV\_TRANSMISSION\_MODE**

Used only on OFTM-based standards, e. g. DVB-T/T2, ISDB-T, DTMB.

Specifies the FFT size (with corresponds to the approximate number of carriers) used by the standard.

The acceptable values are defined by *fe\_transmit\_mode*.

---

### **Note:**

1. ISDB-T supports three carrier/symbol-size: 8K, 4K, 2K. It is called **mode** on such standard, and are numbered from 1 to 3:

Mode	FFT size	Transmission mode
1	2K	TRANSMISSION_MODE_2K
2	4K	TRANSMISSION_MODE_4K
3	8K	TRANSMISSION_MODE_8K

2. If DTV\_TRANSMISSION\_MODE is set the TRANSMISSION\_MODE\_AUTO the hardware will try to find the correct FFT-size (if capable) and will use TMCC to fill in the missing parameters.
  3. DVB-T specifies 2K and 8K as valid sizes.
  4. DVB-T2 specifies 1K, 2K, 4K, 8K, 16K and 32K.
  5. DTMB specifies C1 and C3780.
- 

## DTV\_HIERARCHY

Used only on DVB-T and DVB-T2.

Frontend hierarchy.

The acceptable values are defined by *fe\_hierarchy*.

## DTV\_STREAM\_ID

Used on DVB-C2, DVB-S2, DVB-T2 and ISDB-S.

DVB-C2, DVB-S2, DVB-T2 and ISDB-S support the transmission of several streams on a single transport stream. This property enables the digital TV driver to handle substream filtering, when supported by the hardware. By default, substream filtering is disabled.

For DVB-C2, DVB-S2 and DVB-T2, the valid substream id range is from 0 to 255.

For ISDB, the valid substream id range is from 1 to 65535.

To disable it, you should use the special macro NO\_STREAM\_ID\_FILTER.

Note: any value outside the id range also disables filtering.

## DTV\_DVBT2\_PLP\_ID\_LEGACY

Obsolete, replaced with DTV\_STREAM\_ID.

## **DTV\_ENUM\_DELSYS**

A Multi standard frontend needs to advertise the delivery systems provided. Applications need to enumerate the provided delivery systems, before using any other operation with the frontend. Prior to its introduction, FE\_GET\_INFO was used to determine a frontend type. A frontend which provides more than a single delivery system, FE\_GET\_INFO doesn't help much. Applications which intend to use a multistandard frontend must enumerate the delivery systems associated with it, rather than trying to use FE\_GET\_INFO. In the case of a legacy frontend, the result is just the same as with FE\_GET\_INFO, but in a more structured format

The acceptable values are defined by *fe\_delivery\_system*.

## **DTV\_INTERLEAVING**

Time interleaving to be used.

The acceptable values are defined by *fe\_interleaving*.

## **DTV\_LNA**

Low-noise amplifier.

Hardware might offer controllable LNA which can be set manually using that parameter. Usually LNA could be found only from terrestrial devices if at all.

Possible values: 0, 1, LNA\_AUTO

0, LNA off

1, LNA on

use the special macro LNA\_AUTO to set LNA auto

## **DTV\_SCRAMBLING\_SEQUENCE\_INDEX**

Used on DVB-S2.

This 18 bit field, when present, carries the index of the DVB-S2 physical layer scrambling sequence as defined in clause 5.5.4 of EN 302 307. There is no explicit signalling method to convey scrambling sequence index to the receiver. If S2 satellite delivery system descriptor is available it can be used to read the scrambling sequence index (EN 300 468 table 41).

By default, gold scrambling sequence index 0 is used.

The valid scrambling sequence index range is from 0 to 262142.

## Frontend statistics indicators

The values are returned via `dtv_property.stat`. If the property is supported, `dtv_property.stat.len` is bigger than zero.

For most delivery systems, `dtv_property.stat.len` will be 1 if the stats is supported, and the properties will return a single value for each parameter.

It should be noted, however, that new OFDM delivery systems like ISDB can use different modulation types for each group of carriers. On such standards, up to 3 groups of statistics can be provided, and `dtv_property.stat.len` is updated to reflect the "global" metrics, plus one metric per each carrier group (called "layer" on ISDB).

So, in order to be consistent with other delivery systems, the first value at `dtv_property.stat.dtv_stats` array refers to the global metric. The other elements of the array represent each layer, starting from layer A(index 1), layer B (index 2) and so on.

The number of filled elements are stored at `dtv_property.stat.len`.

Each element of the `dtv_property.stat.dtv_stats` array consists on two elements:

- `svalue` or `uvalue`, where `svalue` is for signed values of the measure (dB measures) and `uvalue` is for unsigned values (counters, relative scale)
- `scale` - Scale for the value. It can be:
  - `FE_SCALE_NOT_AVAILABLE` - The parameter is supported by the frontend, but it was not possible to collect it (could be a transitory or permanent condition)
  - `FE_SCALE_DECIBEL` - parameter is a signed value, measured in 1/1000 dB
  - `FE_SCALE_RELATIVE` - parameter is a unsigned value, where 0 means 0% and 65535 means 100%.
  - `FE_SCALE_COUNTER` - parameter is a unsigned value that counts the occurrence of an event, like bit error, block error, or lapsed time.

## `DTV_STAT_SIGNAL_STRENGTH`

Indicates the signal strength level at the analog part of the tuner or of the demod.

Possible scales for this metric are:

- `FE_SCALE_NOT_AVAILABLE` - it failed to measure it, or the measurement was not complete yet.
- `FE_SCALE_DECIBEL` - signal strength is in 0.001 dBm units, power measured in miliwatts. This value is generally negative.
- `FE_SCALE_RELATIVE` - The frontend provides a 0% to 100% measurement for power (actually, 0 to 65535).

## **DTV\_STAT\_CNR**

Indicates the Signal to Noise ratio for the main carrier.

Possible scales for this metric are:

- `FE_SCALE_NOT_AVAILABLE` - it failed to measure it, or the measurement was not complete yet.
- `FE_SCALE_DECIBEL` - Signal/Noise ratio is in 0.001 dB units.
- `FE_SCALE_RELATIVE` - The frontend provides a 0% to 100% measurement for Signal/Noise (actually, 0 to 65535).

## **DTV\_STAT\_PRE\_ERROR\_BIT\_COUNT**

Measures the number of bit errors before the forward error correction (FEC) on the inner coding block (before Viterbi, LDPC or other inner code).

This measure is taken during the same interval as `DTV_STAT_PRE_TOTAL_BIT_COUNT`.

In order to get the BER (Bit Error Rate) measurement, it should be divided by `DTV_STAT_PRE_TOTAL_BIT_COUNT`.

This measurement is monotonically increased, as the frontend gets more bit count measurements. The frontend may reset it when a channel/transponder is tuned.

Possible scales for this metric are:

- `FE_SCALE_NOT_AVAILABLE` - it failed to measure it, or the measurement was not complete yet.
- `FE_SCALE_COUNTER` - Number of error bits counted before the inner coding.

## **DTV\_STAT\_PRE\_TOTAL\_BIT\_COUNT**

Measures the amount of bits received before the inner code block, during the same period as `DTV_STAT_PRE_ERROR_BIT_COUNT` measurement was taken.

It should be noted that this measurement can be smaller than the total amount of bits on the transport stream, as the frontend may need to manually restart the measurement, losing some data between each measurement interval.

This measurement is monotonically increased, as the frontend gets more bit count measurements. The frontend may reset it when a channel/transponder is tuned.

Possible scales for this metric are:

- `FE_SCALE_NOT_AVAILABLE` - it failed to measure it, or the measurement was not complete yet.
- `FE_SCALE_COUNTER` - Number of bits counted while measuring `DTV_STAT_PRE_ERROR_BIT_COUNT`.

## **DTV\_STAT\_POST\_ERROR\_BIT\_COUNT**

Measures the number of bit errors after the forward error correction (FEC) done by inner code block (after Viterbi, LDPC or other inner code).

This measure is taken during the same interval as `DTV_STAT_POST_TOTAL_BIT_COUNT`.

In order to get the BER (Bit Error Rate) measurement, it should be divided by `DTV_STAT_POST_TOTAL_BIT_COUNT`.

This measurement is monotonically increased, as the frontend gets more bit count measurements. The frontend may reset it when a channel/transponder is tuned.

Possible scales for this metric are:

- `FE_SCALE_NOT_AVAILABLE` - it failed to measure it, or the measurement was not complete yet.
- `FE_SCALE_COUNTER` - Number of error bits counted after the inner coding.

## **DTV\_STAT\_POST\_TOTAL\_BIT\_COUNT**

Measures the amount of bits received after the inner coding, during the same period as `DTV_STAT_POST_ERROR_BIT_COUNT` measurement was taken.

It should be noted that this measurement can be smaller than the total amount of bits on the transport stream, as the frontend may need to manually restart the measurement, losing some data between each measurement interval.

This measurement is monotonically increased, as the frontend gets more bit count measurements. The frontend may reset it when a channel/transponder is tuned.

Possible scales for this metric are:

- `FE_SCALE_NOT_AVAILABLE` - it failed to measure it, or the measurement was not complete yet.
- `FE_SCALE_COUNTER` - Number of bits counted while measuring `DTV_STAT_POST_ERROR_BIT_COUNT`.

## **DTV\_STAT\_ERROR\_BLOCK\_COUNT**

Measures the number of block errors after the outer forward error correction coding (after Reed-Solomon or other outer code).

This measurement is monotonically increased, as the frontend gets more bit count measurements. The frontend may reset it when a channel/transponder is tuned.

Possible scales for this metric are:

- `FE_SCALE_NOT_AVAILABLE` - it failed to measure it, or the measurement was not complete yet.
- `FE_SCALE_COUNTER` - Number of error blocks counted after the outer coding.

## **DTV-STAT\_TOTAL\_BLOCK\_COUNT**

Measures the total number of blocks received during the same period as *DTV\_STAT\_ERROR\_BLOCK\_COUNT* measurement was taken.

It can be used to calculate the PER indicator, by dividing *DTV\_STAT\_ERROR\_BLOCK\_COUNT* by *DTV-STAT\_TOTAL\_BLOCK\_COUNT*.

Possible scales for this metric are:

- *FE\_SCALE\_NOT\_AVAILABLE* - it failed to measure it, or the measurement was not complete yet.
- *FE\_SCALE\_COUNTER* - Number of blocks counted while measuring *DTV\_STAT\_ERROR\_BLOCK\_COUNT*.

## **Properties used on terrestrial delivery systems**

### **DVB-T delivery system**

The following parameters are valid for DVB-T:

- *DTV\_API\_VERSION*
- *DTV\_DELIVERY\_SYSTEM*
- *DTV\_TUNE*
- *DTV\_CLEAR*
- *DTV\_FREQUENCY*
- *DTV\_MODULATION*
- *DTV\_BANDWIDTH\_HZ*
- *DTV\_INVERSION*
- *DTV\_CODE\_RATE\_HP*
- *DTV\_CODE\_RATE\_LP*
- *DTV\_GUARD\_INTERVAL*
- *DTV\_TRANSMISSION\_MODE*
- *DTV\_HIERARCHY*
- *DTV\_LNA*

In addition, the *DTV QoS statistics* are also valid.

## DVB-T2 delivery system

DVB-T2 support is currently in the early stages of development, so expect that this section may grow and become more detailed with time.

The following parameters are valid for DVB-T2:

- *DTV\_API\_VERSION*
- *DTV\_DELIVERY\_SYSTEM*
- *DTV\_TUNE*
- *DTV\_CLEAR*
- *DTV\_FREQUENCY*
- *DTV\_MODULATION*
- *DTV\_BANDWIDTH\_HZ*
- *DTV\_INVERSION*
- *DTV\_CODE\_RATE\_HP*
- *DTV\_CODE\_RATE\_LP*
- *DTV\_GUARD\_INTERVAL*
- *DTV\_TRANSMISSION\_MODE*
- *DTV\_HIERARCHY*
- *DTV\_STREAM\_ID*
- *DTV\_LNA*

In addition, the *DTV QoS statistics* are also valid.

## ISDB-T delivery system

This ISDB-T/ISDB-Tsb API extension should reflect all information needed to tune any ISDB-T/ISDB-Tsb hardware. Of course it is possible that some very sophisticated devices won't need certain parameters to tune.

The information given here should help application writers to know how to handle ISDB-T and ISDB-Tsb hardware using the Linux Digital TV API.

The details given here about ISDB-T and ISDB-Tsb are just enough to basically show the dependencies between the needed parameter values, but surely some information is left out. For more detailed information see the following documents:

ARIB STD-B31 - "Transmission System for Digital Terrestrial Television Broadcasting" and ARIB TR-B14 - "Operational Guidelines for Digital Terrestrial Television Broadcasting".

In order to understand the ISDB specific parameters, one has to have some knowledge the channel structure in ISDB-T and ISDB-Tsb. I.e. it has to be known to the reader that an ISDB-T channel consists of 13 segments, that it can have up to 3 layer sharing those segments, and things like that.

The following parameters are valid for ISDB-T:

- `DTV_API_VERSION`
- `DTV_DELIVERY_SYSTEM`
- `DTV_TUNE`
- `DTV_CLEAR`
- `DTV_FREQUENCY`
- `DTV_BANDWIDTH_HZ`
- `DTV_INVERSION`
- `DTV_GUARD_INTERVAL`
- `DTV_TRANSMISSION_MODE`
- `DTV_ISDBT_LAYER_ENABLED`
- `DTV_ISDBT_PARTIAL_RECEPTION`
- `DTV_ISDBT_SOUND_BROADCASTING`
- `DTV_ISDBT_SB_SUBCHANNEL_ID`
- `DTV_ISDBT_SB_SEGMENT_IDX`
- `DTV_ISDBT_SB_SEGMENT_COUNT`
- `DTV_ISDBT_LAYERA_FEC`
- `DTV_ISDBT_LAYERA_MODULATION`
- `DTV_ISDBT_LAYERA_SEGMENT_COUNT`
- `DTV_ISDBT_LAYERA_TIME_INTERLEAVING`
- `DTV_ISDBT_LAYERB_FEC`
- `DTV_ISDBT_LAYERB_MODULATION`
- `DTV_ISDBT_LAYERB_SEGMENT_COUNT`
- `DTV_ISDBT_LAYERB_TIME_INTERLEAVING`
- `DTV_ISDBT_LAYERC_FEC`
- `DTV_ISDBT_LAYERC_MODULATION`
- `DTV_ISDBT_LAYERC_SEGMENT_COUNT`
- `DTV_ISDBT_LAYERC_TIME_INTERLEAVING`

In addition, the *DTV QoS statistics* are also valid.

## ATSC delivery system

The following parameters are valid for ATSC:

- *DTV\_API\_VERSION*
- *DTV\_DELIVERY\_SYSTEM*
- *DTV\_TUNE*
- *DTV\_CLEAR*
- *DTV\_FREQUENCY*
- *DTV\_MODULATION*
- *DTV\_BANDWIDTH\_HZ*

In addition, the *DTV QoS statistics* are also valid.

## ATSC-MH delivery system

The following parameters are valid for ATSC-MH:

- *DTV\_API\_VERSION*
- *DTV\_DELIVERY\_SYSTEM*
- *DTV\_TUNE*
- *DTV\_CLEAR*
- *DTV\_FREQUENCY*
- *DTV\_BANDWIDTH\_HZ*
- *DTV\_ATSCMH\_FIC\_VER*
- *DTV\_ATSCMH\_PARADE\_ID*
- *DTV\_ATSCMH\_NOG*
- *DTV\_ATSCMH\_TNOG*
- *DTV\_ATSCMH\_SGN*
- *DTV\_ATSCMH\_PRC*
- *DTV\_ATSCMH\_RS\_FRAME\_MODE*
- *DTV\_ATSCMH\_RS\_FRAME\_ENSEMBLE*
- *DTV\_ATSCMH\_RS\_CODE\_MODE\_PRI*
- *DTV\_ATSCMH\_RS\_CODE\_MODE\_SEC*
- *DTV\_ATSCMH\_SCCC\_BLOCK\_MODE*
- *DTV\_ATSCMH\_SCCC\_CODE\_MODE\_A*
- *DTV\_ATSCMH\_SCCC\_CODE\_MODE\_B*
- *DTV\_ATSCMH\_SCCC\_CODE\_MODE\_C*

- *DTV\_ATSCMH\_SCCC\_CODE\_MODE\_D*

In addition, the *DTV QoS statistics* are also valid.

### DTMB delivery system

The following parameters are valid for DTMB:

- *DTV\_API\_VERSION*
- *DTV\_DELIVERY\_SYSTEM*
- *DTV\_TUNE*
- *DTV\_CLEAR*
- *DTV\_FREQUENCY*
- *DTV\_MODULATION*
- *DTV\_BANDWIDTH\_HZ*
- *DTV\_INVERSION*
- *DTV\_INNER\_FEC*
- *DTV\_GUARD\_INTERVAL*
- *DTV\_TRANSMISSION\_MODE*
- *DTV\_INTERLEAVING*
- *DTV\_LNA*

In addition, the *DTV QoS statistics* are also valid.

### Properties used on cable delivery systems

#### DVB-C delivery system

The DVB-C Annex-A is the widely used cable standard. Transmission uses QAM modulation.

The DVB-C Annex-C is optimized for 6MHz, and is used in Japan. It supports a subset of the Annex A modulation types, and a roll-off of 0.13, instead of 0.15

The following parameters are valid for DVB-C Annex A/C:

- *DTV\_API\_VERSION*
- *DTV\_DELIVERY\_SYSTEM*
- *DTV\_TUNE*
- *DTV\_CLEAR*
- *DTV\_FREQUENCY*
- *DTV\_MODULATION*
- *DTV\_INVERSION*
- *DTV\_SYMBOL\_RATE*

- *DTV\_INNER\_FEC*
- *DTV\_LNA*

In addition, the *DTV QoS statistics* are also valid.

## DVB-C Annex B delivery system

The DVB-C Annex-B is only used on a few Countries like the United States.

The following parameters are valid for DVB-C Annex B:

- *DTV\_API\_VERSION*
- *DTV\_DELIVERY\_SYSTEM*
- *DTV\_TUNE*
- *DTV\_CLEAR*
- *DTV\_FREQUENCY*
- *DTV\_MODULATION*
- *DTV\_INVERSION*
- *DTV\_LNA*

In addition, the *DTV QoS statistics* are also valid.

## Properties used on satellite delivery systems

### DVB-S delivery system

The following parameters are valid for DVB-S:

- *DTV\_API\_VERSION*
- *DTV\_DELIVERY\_SYSTEM*
- *DTV\_TUNE*
- *DTV\_CLEAR*
- *DTV\_FREQUENCY*
- *DTV\_INVERSION*
- *DTV\_SYMBOL\_RATE*
- *DTV\_INNER\_FEC*
- *DTV\_VOLTAGE*
- *DTV\_TONE*

In addition, the *DTV QoS statistics* are also valid.

Future implementations might add those two missing parameters:

- *DTV\_DISEQC\_MASTER*

- *DTV\_DISEQC\_SLAVE\_REPLY*

## DVB-S2 delivery system

In addition to all parameters valid for DVB-S, DVB-S2 supports the following parameters:

- *DTV\_MODULATION*
- *DTV\_PILOT*
- *DTV\_ROLOFF*
- *DTV\_STREAM\_ID*
- *DTV\_SCRAMBLING\_SEQUENCE\_INDEX*

In addition, the *DTV QoS statistics* are also valid.

## Turbo code delivery system

In addition to all parameters valid for DVB-S, turbo code supports the following parameters:

- *DTV\_MODULATION*

## ISDB-S delivery system

The following parameters are valid for ISDB-S:

- *DTV\_API\_VERSION*
- *DTV\_DELIVERY\_SYSTEM*
- *DTV\_TUNE*
- *DTV\_CLEAR*
- *DTV\_FREQUENCY*
- *DTV\_INVERSION*
- *DTV\_SYMBOL\_RATE*
- *DTV\_INNER\_FEC*
- *DTV\_VOLTAGE*
- *DTV\_STREAM\_ID*

## Frontend uAPI data types

### enum **fe\_caps**

Frontend capabilities

### Constants

#### **FE\_IS\_STUPID**

There's something wrong at the frontend, and it can't report its capabilities.

#### **FE\_CAN\_INVERSION\_AUTO**

Can auto-detect frequency spectral band inversion

#### **FE\_CAN\_FEC\_1\_2**

Supports FEC 1/2

#### **FE\_CAN\_FEC\_2\_3**

Supports FEC 2/3

#### **FE\_CAN\_FEC\_3\_4**

Supports FEC 3/4

#### **FE\_CAN\_FEC\_4\_5**

Supports FEC 4/5

#### **FE\_CAN\_FEC\_5\_6**

Supports FEC 5/6

#### **FE\_CAN\_FEC\_6\_7**

Supports FEC 6/7

#### **FE\_CAN\_FEC\_7\_8**

Supports FEC 7/8

#### **FE\_CAN\_FEC\_8\_9**

Supports FEC 8/9

#### **FE\_CAN\_FEC\_AUTO**

Can auto-detect FEC

#### **FE\_CAN\_QPSK**

Supports QPSK modulation

#### **FE\_CAN\_QAM\_16**

Supports 16-QAM modulation

#### **FE\_CAN\_QAM\_32**

Supports 32-QAM modulation

#### **FE\_CAN\_QAM\_64**

Supports 64-QAM modulation

#### **FE\_CAN\_QAM\_128**

Supports 128-QAM modulation

#### **FE\_CAN\_QAM\_256**

Supports 256-QAM modulation

#### **FE\_CAN\_QAM\_AUTO**

Can auto-detect QAM modulation

**FE\_CAN\_TRANSMISSION\_MODE\_AUTO**

Can auto-detect transmission mode

**FE\_CAN\_BANDWIDTH\_AUTO**

Can auto-detect bandwidth

**FE\_CAN\_GUARD\_INTERVAL\_AUTO**

Can auto-detect guard interval

**FE\_CAN\_HIERARCHY\_AUTO**

Can auto-detect hierarchy

**FE\_CAN\_8VSB**

Supports 8-VSB modulation

**FE\_CAN\_16VSB**

Supports 16-VSB modulation

**FE\_HAS\_EXTENDED\_CAPS**

Unused

**FE\_CAN\_MULTISTREAM**

Supports multistream filtering

**FE\_CAN\_TURBO FEC**

Supports "turbo FEC" modulation

**FE\_CAN\_2G\_MODULATION**

Supports "2nd generation" modulation, e. g. DVB-S2, DVB-T2, DVB-C2

**FE\_NEEDS\_BENDING**

Unused

**FE\_CAN\_RECOVER**

Can recover from a cable unplug automatically

**FE\_CAN\_MUTE\_TS**

Can stop spurious TS data output

**struct dvb\_frontend\_info**

Frontend properties and capabilities

**Definition:**

```
struct dvb_frontend_info {
    char name[128];
    enum fe_type type;
    __u32 frequency_min;
    __u32 frequency_max;
    __u32 frequency_stepsize;
    __u32 frequency_tolerance;
    __u32 symbol_rate_min;
    __u32 symbol_rate_max;
    __u32 symbol_rate_tolerance;
    __u32 notifier_delay;
    enum fe_caps caps;
};
```

## Members

### **name**

Name of the frontend

### **type**

**DEPRECATED.** Should not be used on modern programs, as a frontend may have more than one type. In order to get the support types of a given frontend, use `DTV_ENUM_DELSYS` instead.

### **frequency\_min**

Minimal frequency supported by the frontend.

### **frequency\_max**

Minimal frequency supported by the frontend.

### **frequency\_stepsize**

All frequencies are multiple of this value.

### **frequency\_tolerance**

Frequency tolerance.

### **symbol\_rate\_min**

Minimal symbol rate, in bauds (for Cable/Satellite systems).

### **symbol\_rate\_max**

Maximal symbol rate, in bauds (for Cable/Satellite systems).

### **symbol\_rate\_tolerance**

Maximal symbol rate tolerance, in ppm (for Cable/Satellite systems).

### **notifier\_delay**

**DEPRECATED.** Not used by any driver.

### **caps**

Capabilities supported by the frontend, as specified in [enum fe\\_caps](#).

## Description

### struct `dvb_diseqc_master_cmd`

DiSEqC master command

### Definition:

```
struct dvb_diseqc_master_cmd {
    __u8 msg[6];
    __u8 msg_len;
};
```

## Members

### **msg**

DiSEqC message to be sent. It contains a 3 bytes header with: framing + address + command, and an optional argument of up to 3 bytes of data.

### **msg\_len**

Length of the DiSEqC message. Valid values are 3 to 6.

## Description

Check out the DiSEqC bus spec available on <http://www.eutelsat.org/> for the possible messages that can be used.

**struct dvb\_diseqc\_slave\_reply**

DiSEqC received data

## Definition:

```
struct dvb_diseqc_slave_reply {  
    __u8 msg[4];  
    __u8 msg_len;  
    int timeout;  
};
```

## Members

**msg**

DiSEqC message buffer to store a message received via DiSEqC. It contains one byte header with: framing and an optional argument of up to 3 bytes of data.

**msg\_len**

Length of the DiSEqC message. Valid values are 0 to 4, where 0 means no message.

**timeout**

Return from ioctl after timeout ms with errorcode when no message was received.

## Description

Check out the DiSEqC bus spec available on <http://www.eutelsat.org/> for the possible messages that can be used.

**enum fe\_sec\_voltage**

DC Voltage used to feed the LNBf

## Constants

**SEC\_VOLTAGE\_13**

Output 13V to the LNBf

**SEC\_VOLTAGE\_18**

Output 18V to the LNBf

**SEC\_VOLTAGE\_OFF**

Don't feed the LNBf with a DC voltage

**enum fe\_sec\_tone\_mode**

Type of tone to be send to the LNBf.

## Constants

**SEC\_TONE\_ON**

Sends a 22kHz tone burst to the antenna.

**SEC\_TONE\_OFF**

Don't send a 22kHz tone to the antenna (except if the FE\_DISEQC\_\* ioctls are called).

**enum fe\_sec\_mini\_cmd**  
 Type of mini burst to be sent

## Constants

**SEC\_MINI\_A**  
 Sends a mini-DiSEqC 22kHz '0' Tone Burst to select satellite-A

**SEC\_MINI\_B**  
 Sends a mini-DiSEqC 22kHz '1' Data Burst to select satellite-B

**enum fe\_status**  
 Enumerates the possible frontend status.

## Constants

**FE\_NONE**  
 The frontend doesn't have any kind of lock. That's the initial frontend status

**FE\_HAS\_SIGNAL**  
 Has found something above the noise level.

**FE\_HAS\_CARRIER**  
 Has found a signal.

**FE\_HAS\_VITERBI**  
 FEC inner coding (Viterbi, LDPC or other inner code). is stable.

**FE\_HAS\_SYNC**  
 Synchronization bytes was found.

**FE\_HAS\_LOCK**  
 Digital TV were locked and everything is working.

**FE\_TIMEOUT**  
 Fo lock within the last about 2 seconds.

**FE\_REINIT**  
 Frontend was reinitialized, application is recommended to reset DiSEqC, tone and parameters.

**enum fe\_spectral\_inversion**  
 Type of inversion band

## Constants

**INVERSION\_OFF**  
 Don't do spectral band inversion.

**INVERSION\_ON**  
 Do spectral band inversion.

**INVERSION\_AUTO**  
 Autodetect spectral band inversion.

## Description

This parameter indicates if spectral inversion should be presumed or not. In the automatic setting (INVERSION\_AUTO) the hardware will try to figure out the correct setting by itself. If the hardware doesn't support, the dvb\_frontend will try to lock at the carrier first with inversion off. If it fails, it will try to enable inversion.

## enum **fe\_code\_rate**

Type of Forward Error Correction (FEC)

### Constants

#### **FEC\_NONE**

No Forward Error Correction Code

#### **FEC\_1\_2**

Forward Error Correction Code 1/2

#### **FEC\_2\_3**

Forward Error Correction Code 2/3

#### **FEC\_3\_4**

Forward Error Correction Code 3/4

#### **FEC\_4\_5**

Forward Error Correction Code 4/5

#### **FEC\_5\_6**

Forward Error Correction Code 5/6

#### **FEC\_6\_7**

Forward Error Correction Code 6/7

#### **FEC\_7\_8**

Forward Error Correction Code 7/8

#### **FEC\_8\_9**

Forward Error Correction Code 8/9

#### **FEC\_AUTO**

Autodetect Error Correction Code

#### **FEC\_3\_5**

Forward Error Correction Code 3/5

#### **FEC\_9\_10**

Forward Error Correction Code 9/10

#### **FEC\_2\_5**

Forward Error Correction Code 2/5

#### **FEC\_1\_3**

Forward Error Correction Code 1/3

#### **FEC\_1\_4**

Forward Error Correction Code 1/4

#### **FEC\_5\_9**

Forward Error Correction Code 5/9

#### **FEC\_7\_9**

Forward Error Correction Code 7/9

#### **FEC\_8\_15**

Forward Error Correction Code 8/15

#### **FEC\_11\_15**

Forward Error Correction Code 11/15

**FEC\_13\_18**

Forward Error Correction Code 13/18

**FEC\_9\_20**

Forward Error Correction Code 9/20

**FEC\_11\_20**

Forward Error Correction Code 11/20

**FEC\_23\_36**

Forward Error Correction Code 23/36

**FEC\_25\_36**

Forward Error Correction Code 25/36

**FEC\_13\_45**

Forward Error Correction Code 13/45

**FEC\_26\_45**

Forward Error Correction Code 26/45

**FEC\_28\_45**

Forward Error Correction Code 28/45

**FEC\_32\_45**

Forward Error Correction Code 32/45

**FEC\_77\_90**

Forward Error Correction Code 77/90

**FEC\_11\_45**

Forward Error Correction Code 11/45

**FEC\_4\_15**

Forward Error Correction Code 4/15

**FEC\_14\_45**

Forward Error Correction Code 14/45

**FEC\_7\_15**

Forward Error Correction Code 7/15

**Description**

Please note that not all FEC types are supported by a given standard.

**enum fe\_modulation**

Type of modulation/constellation

**Constants****QPSK**

QPSK modulation

**QAM\_16**

16-QAM modulation

**QAM\_32**

32-QAM modulation

**QAM\_64**

64-QAM modulation

**QAM\_128**

128-QAM modulation

**QAM\_256**

256-QAM modulation

**QAM\_AUTO**

Autodetect QAM modulation

**VSB\_8**

8-VSB modulation

**VSB\_16**

16-VSB modulation

**PSK\_8**

8-PSK modulation

**APSK\_16**

16-APSK modulation

**APSK\_32**

32-APSK modulation

**DQPSK**

DQPSK modulation

**QAM\_4\_NR**

4-QAM-NR modulation

**QAM\_1024**

1024-QAM modulation

**QAM\_4096**

4096-QAM modulation

**APSK\_8\_L**

8APSK-L modulation

**APSK\_16\_L**

16APSK-L modulation

**APSK\_32\_L**

32APSK-L modulation

**APSK\_64**

64APSK modulation

**APSK\_64\_L**

64APSK-L modulation

**Description**

Please note that not all modulations are supported by a given standard.

**enum fe\_transmit\_mode**

Transmission mode

**Constants**

TRANSMISSION\_MODE\_2K

Transmission mode 2K

#### **TRANSMISSION\_MODE\_8K**

Transmission mode 8K

#### **TRANSMISSION\_MODE\_AUTO**

Autodetect transmission mode. The hardware will try to find the correct FFT-size (if capable) to fill in the missing parameters.

#### **TRANSMISSION\_MODE\_4K**

Transmission mode 4K

#### **TRANSMISSION\_MODE\_1K**

Transmission mode 1K

#### **TRANSMISSION\_MODE\_16K**

Transmission mode 16K

#### **TRANSMISSION\_MODE\_32K**

Transmission mode 32K

#### **TRANSMISSION\_MODE\_C1**

Single Carrier (C=1) transmission mode (DTMB only)

#### **TRANSMISSION\_MODE\_C3780**

Multi Carrier (C=3780) transmission mode (DTMB only)

### **Description**

Please note that not all transmission modes are supported by a given standard.

#### **enum fe\_guard\_interval**

Guard interval

### **Constants**

#### **GUARD\_INTERVAL\_1\_32**

Guard interval 1/32

#### **GUARD\_INTERVAL\_1\_16**

Guard interval 1/16

#### **GUARD\_INTERVAL\_1\_8**

Guard interval 1/8

#### **GUARD\_INTERVAL\_1\_4**

Guard interval 1/4

#### **GUARD\_INTERVAL\_AUTO**

Autodetect the guard interval

#### **GUARD\_INTERVAL\_1\_128**

Guard interval 1/128

#### **GUARD\_INTERVAL\_19\_128**

Guard interval 19/128

**GUARD\_INTERVAL\_19\_256**

Guard interval 19/256

**GUARD\_INTERVAL\_PN420**

PN length 420 (1/4)

**GUARD\_INTERVAL\_PN595**

PN length 595 (1/6)

**GUARD\_INTERVAL\_PN945**

PN length 945 (1/9)

**GUARD\_INTERVAL\_1\_64**

Guard interval 1/64

**Description**

Please note that not all guard intervals are supported by a given standard.

**enum fe\_hierarchy**

Hierarchy

**Constants**

**HIERARCHY\_NONE**

No hierarchy

**HIERARCHY\_1**

Hierarchy 1

**HIERARCHY\_2**

Hierarchy 2

**HIERARCHY\_4**

Hierarchy 4

**HIERARCHY\_AUTO**

Autodetect hierarchy (if supported)

**Description**

Please note that not all hierarchy types are supported by a given standard.

**enum fe\_interleaving**

Interleaving

**Constants**

**INTERLEAVING\_NONE**

No interleaving.

**INTERLEAVING\_AUTO**

Auto-detect interleaving.

**INTERLEAVING\_240**

Interleaving of 240 symbols.

**INTERLEAVING\_720**

Interleaving of 720 symbols.

**Description**

Please note that, currently, only DTMB uses it.

#### enum **fe\_pilot**

Type of pilot tone

#### Constants

##### **PILOT\_ON**

Pilot tones enabled

##### **PILOT\_OFF**

Pilot tones disabled

##### **PILOT\_AUTO**

Autodetect pilot tones

#### enum **fe\_rolloff**

Rolloff factor

#### Constants

##### **ROLLOFF\_35**

Rolloff factor:  $\alpha=35\%$

##### **ROLLOFF\_20**

Rolloff factor:  $\alpha=20\%$

##### **ROLLOFF\_25**

Rolloff factor:  $\alpha=25\%$

##### **ROLLOFF\_AUTO**

Auto-detect the rolloff factor.

##### **ROLLOFF\_15**

Rolloff factor:  $\alpha=15\%$

##### **ROLLOFF\_10**

Rolloff factor:  $\alpha=10\%$

##### **ROLLOFF\_5**

Rolloff factor:  $\alpha=5\%$

#### Description

#### enum **fe\_delivery\_system**

Type of the delivery system

#### Constants

##### **SYS\_UNDEFINED**

Undefined standard. Generally, indicates an error

##### **SYS\_DVBC ANNEX\_A**

Cable TV: DVB-C following ITU-T J.83 Annex A spec

##### **SYS\_DVBC ANNEX\_B**

Cable TV: DVB-C following ITU-T J.83 Annex B spec (ClearQAM)

##### **SYS\_DVBT**

Terrestrial TV: DVB-T

**SYS\_DSS**

Satellite TV: DSS (not fully supported)

**SYS\_DVBS**

Satellite TV: DVB-S

**SYS\_DVBS2**

Satellite TV: DVB-S2 and DVB-S2X

**SYS\_DVBH**

Terrestrial TV (mobile): DVB-H (standard deprecated)

**SYS\_ISDBT**

Terrestrial TV: ISDB-T

**SYS\_ISDBS**

Satellite TV: ISDB-S

**SYS\_ISDBC**

Cable TV: ISDB-C (no drivers yet)

**SYS\_ATSC**

Terrestrial TV: ATSC

**SYS\_ATSCMH**

Terrestrial TV (mobile): ATSC-M/H

**SYS\_DTMB**

Terrestrial TV: DTMB

**SYS\_CMMB**

Terrestrial TV (mobile): CMMB (not fully supported)

**SYS\_DAB**

Digital audio: DAB (not fully supported)

**SYS\_DVBT2**

Terrestrial TV: DVB-T2

**SYS\_TURBO**

Satellite TV: DVB-S Turbo

**SYS\_DVBC\_ANNEC\_C**

Cable TV: DVB-C following ITU-T J.83 Annex C spec

**SYS\_DVBC2**

Cable TV: DVB-C2

**enum `atscmh_sccc_block_mode`**

Type of Series Concatenated Convolutional Code Block Mode.

**Constants****ATSCMH\_SCCC\_BLK\_SEP**

Separate SCCC: the SCCC outer code mode shall be set independently for each Group Region (A, B, C, D)

**ATSCMH\_SCCC\_BLK\_COMB**

Combined SCCC: all four Regions shall have the same SCCC outer code mode.

**ATSCMH\_SCCC\_BLK\_RES**

Reserved. Shouldn't be used.

**enum `atscmh_sccc_code_mode`**

Type of Series Concatenated Convolutional Code Rate.

**Constants****ATSCMH\_SCCC\_CODE\_HLF**

The outer code rate of a SCCC Block is 1/2 rate.

**ATSCMH\_SCCC\_CODE\_QTR**

The outer code rate of a SCCC Block is 1/4 rate.

**ATSCMH\_SCCC\_CODE\_RES**

Reserved. Should not be used.

**enum `atscmh_rs_frame_ensemble`**

Reed Solomon(RS) frame ensemble.

**Constants****ATSCMH\_RSFRAME\_ENS\_PRI**

Primary Ensemble.

**ATSCMH\_RSFRAME\_ENS\_SEC**

Secondary Ensemble.

**enum `atscmh_rs_frame_mode`**

Reed Solomon (RS) frame mode.

**Constants****ATSCMH\_RSFRAME\_PRI\_ONLY**

Single Frame: There is only a primary RS Frame for all Group Regions.

**ATSCMH\_RSFRAME\_PRI\_SEC**

Dual Frame: There are two separate RS Frames: Primary RS Frame for Group Region A and B and Secondary RS Frame for Group Region C and D.

**ATSCMH\_RSFRAME\_RES**

Reserved. Shouldn't be used.

## enum **atscmh\_rs\_code\_mode**

ATSC-M/H Reed Solomon modes

## Constants

### **ATSCMH\_RSCODE\_211\_187**

Reed Solomon code (211,187).

### **ATSCMH\_RSCODE\_223\_187**

Reed Solomon code (223,187).

### **ATSCMH\_RSCODE\_235\_187**

Reed Solomon code (235,187).

### **ATSCMH\_RSCODE\_RES**

Reserved. Shouldn't be used.

## enum **fecap\_scale\_params**

scale types for the quality parameters.

## Constants

### **FE\_SCALE\_NOT\_AVAILABLE**

That QoS measure is not available. That could indicate a temporary or a permanent condition.

### **FE\_SCALE\_DECIBEL**

The scale is measured in 0.001 dB steps, typically used on signal measures.

### **FE\_SCALE\_RELATIVE**

The scale is a relative percentual measure, ranging from 0 (0%) to 0xffff (100%).

### **FE\_SCALE\_COUNTER**

The scale counts the occurrence of an event, like bit error, block error, lapsed time.

## struct **dtv\_stats**

Used for reading a DTV status property

## Definition:

```
struct dtv_stats {  
    __u8 scale;  
    union {  
        __u64 uvalue;  
        __s64 svalue;  
    };  
};
```

## Members

### **scale**

Filled with *enum fecap\_scale\_params* - the scale in usage for that parameter

### **{unnamed\_union}**

anonymous

### **uvalue**

unsigned integer value of the measure, used when **scale** is either **FE\_SCALE\_RELATIVE** or **FE\_SCALE\_COUNTER**.

### svalue

integer value of the measure, for **FE\_SCALE\_DECIBEL**, used for dB measures. The unit is 0.001 dB.

### Description

For most delivery systems, this will return a single value for each parameter.

It should be noticed, however, that new OFDM delivery systems like ISDB can use different modulation types for each group of carriers. On such standards, up to 8 groups of statistics can be provided, one for each carrier group (called "layer" on ISDB).

In order to be consistent with other delivery systems, the first value refers to the entire set of carriers ("global").

**scale** should use the value **FE\_SCALE\_NOT\_AVAILABLE** when the value for the entire group of carriers or from one specific layer is not provided by the hardware.

**len** should be filled with the latest filled status + 1.

In other words, for ISDB, those values should be filled like:

```
u.st.stat.svalue[0] = global statistics;
u.st.stat.scale[0] = FE_SCALE_DECIBEL;
u.st.stat.value[1] = layer A statistics;
u.st.stat.scale[1] = FE_SCALE_NOT_AVAILABLE (if not available);
u.st.stat.svalue[2] = layer B statistics;
u.st.stat.scale[2] = FE_SCALE_DECIBEL;
u.st.stat.svalue[3] = layer C statistics;
u.st.stat.scale[3] = FE_SCALE_DECIBEL;
u.st.len = 4;
```

## struct **dtv\_fe\_stats**

store Digital TV frontend statistics

### Definition:

```
struct dtv_fe_stats {
    __u8 len;
    struct dtv_stats stat[MAX_DTV_STATS];
};
```

### Members

#### **len**

length of the statistics - if zero, stats is disabled.

#### **stat**

array with digital TV statistics.

### Description

On most standards, **len** can either be 0 or 1. However, for ISDB, each layer is modulated in separate. So, each layer may have its own set of statistics. If so, stat[0] carries on a global value for the property. Indexes 1 to 3 means layer A to B.

**struct dtv\_property**  
 store one of frontend command and its value

**Definition:**

```
struct dtv_property {
    __u32 cmd;
    __u32 reserved[3];
    union {
        __u32 data;
        struct dtv_fe_stats st;
        struct {
            __u8 data[32];
            __u32 len;
            __u32 reserved1[3];
            void *reserved2;
        } buffer;
    } u;
    int result;
};
```

**Members****cmd**

Digital TV command.

**reserved**

Not used.

**u**

Union with the values for the command.

**u.data**

A unsigned 32 bits integer with command value.

**u.st**

a *struct dtv\_fe\_stats* array of statistics.

**u.buffer**

Struct to store bigger properties. Currently unused.

**u.buffer.data**

an unsigned 32-bits array.

**u.buffer.len**

number of elements of the buffer.

**u.buffer.reserved1**

Reserved.

**u.buffer.reserved2**

Reserved.

**result**

Currently unused.

**struct dtv\_properties**

a set of command/value pairs.

**Definition:**

```
struct dtv_properties {
    __u32 num;
    struct dtv_property *props;
};
```

**Members****num**

amount of commands stored at the struct.

**props**

a pointer to *struct dtv\_property*.

**Frontend Function Calls****Digital TV frontend open()****Name**

fe-open - Open a frontend device

**Synopsis**

```
#include <fcntl.h>
```

```
int open(const char *device_name, int flags)
```

**Arguments****device\_name**

Device to be opened.

**flags**

Open flags. Access can either be O\_RDWR or O\_RDONLY.

Multiple opens are allowed with O\_RDONLY. In this mode, only query and read ioctls are allowed.

Only one open is allowed in O\_RDWR. In this mode, all ioctls are allowed.

When the O\_NONBLOCK flag is given, the system calls may return EAGAIN error code when no data is available or when the device driver is temporarily busy.

Other flags have no effect.

## Description

This system call opens a named frontend device (`/dev/dvb/adapter?/frontend?`) for subsequent use. Usually the first thing to do after a successful open is to find out the frontend type with [`ioctl FE\_GET\_INFO`](#).

The device can be opened in read-only mode, which only allows monitoring of device status and statistics, or read/write mode, which allows any kind of use (e.g. performing tuning operations.)

In a system with multiple front-ends, it is usually the case that multiple devices cannot be open in read/write mode simultaneously. As long as a front-end device is opened in read/write mode, other `open()` calls in read/write mode will either fail or block, depending on whether non-blocking or blocking mode was specified. A front-end device opened in blocking mode can later be put into non-blocking mode (and vice versa) using the `F_SETFL` command of the `fcntl` system call. This is a standard system call, documented in the Linux manual page for `fcntl`. When an `open()` call has succeeded, the device will be ready for use in the specified mode. This implies that the corresponding hardware is powered up, and that other front-ends may have been powered down to make that possible.

## Return Value

On success `open()` returns the new file descriptor. On error, -1 is returned, and the `errno` variable is set appropriately.

Possible error codes are:

On success 0 is returned, and `ca_slot_info` is filled.

On error -1 is returned, and the `errno` variable is set appropriately.

<code>EPERM</code>	The caller has no permission to access the device.
<code>EBUSY</code>	The the device driver is already in use.
<code>EMFILE</code>	The process already has the maximum number of files open.
<code>ENFILE</code>	The limit on the total number of files open on the system has been reached.

The generic error codes are described at the [\*Generic Error Codes\*](#) chapter.

## Digital TV frontend close()

### Name

`fe-close` - Close a frontend device

## Synopsis

```
#include <unistd.h>
```

```
int close(int fd)
```

## Arguments

### fd

File descriptor returned by *open()*.

## Description

This system call closes a previously opened front-end device. After closing a front-end device, its corresponding hardware might be powered down automatically.

## Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

Generic error codes are described at the *Generic Error Codes* chapter.

## ioctl FE\_GET\_INFO

### Name

`FE_GET_INFO` - Query Digital TV frontend capabilities and returns information about the - frontend. This call only requires read-only access to the device.

## Synopsis

### FE\_GET\_INFO

```
int ioctl(int fd, FE_GET_INFO, struct dvb_frontend_info *argp)
```

## Arguments

### fd

File descriptor returned by *open()*.

### argp

pointer to struct *dvb\_frontend\_info*

### Description

All Digital TV frontend devices support the `ioctl FE_GET_INFO` ioctl. It is used to identify kernel devices compatible with this specification and to obtain information about driver and hardware capabilities. The ioctl takes a pointer to `dvb_frontend_info` which is filled by the driver. When the driver is not compatible with this specification the ioctl returns an error.

### frontend capabilities

Capabilities describe what a frontend can do. Some capabilities are supported only on some specific frontend types.

The frontend capabilities are described at [`fe\_caps`](#).

### Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

Generic error codes are described at the [\*Generic Error Codes\*](#) chapter.

## ioctl FE\_READ\_STATUS

### Name

`FE_READ_STATUS` - Returns status information about the front-end. This call only requires - read-only access to the device

### Synopsis

#### `FE_READ_STATUS`

```
int ioctl(int fd, FE_READ_STATUS, unsigned int *status)
```

### Arguments

#### `fd`

File descriptor returned by [`open\(\)`](#).

#### `status`

pointer to a bitmask integer filled with the values defined by enum [`fe\_status`](#).

## Description

All Digital TV frontend devices support the `FE_READ_STATUS` ioctl. It is used to check about the locking status of the frontend after being tuned. The ioctl takes a pointer to an integer where the status will be written.

---

**Note:** The size of status is actually `sizeof(enum fe_status)`, with varies according with the architecture. This needs to be fixed in the future.

---

### `int fe_status`

The `fe_status` parameter is used to indicate the current state and/or state changes of the frontend hardware. It is produced using the enum `fe_status` values on a bitmask

### Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

Generic error codes are described at the *Generic Error Codes* chapter.

## ioctl FE\_SET\_PROPERTY, FE\_GET\_PROPERTY

### Name

`FE_SET_PROPERTY` - `FE_GET_PROPERTY` - `FE_SET_PROPERTY` sets one or more frontend properties. - `FE_GET_PROPERTY` returns one or more frontend properties.

### Synopsis

#### `FE_GET_PROPERTY`

```
int ioctl(int fd, FE_GET_PROPERTY, struct dtv_properties *argp)
```

#### `FE_SET_PROPERTY`

```
int ioctl(int fd, FE_SET_PROPERTY, struct dtv_properties *argp)
```

### Arguments

#### fd

File descriptor returned by `open()`.

#### argp

Pointer to struct `dtv_properties`.

### Description

All Digital TV frontend devices support the FE\_SET\_PROPERTY and FE\_GET\_PROPERTY ioctls. The supported properties and statistics depends on the delivery system and on the device:

- FE\_SET\_PROPERTY:
  - This ioctl is used to set one or more frontend properties.
  - This is the basic command to request the frontend to tune into some frequency and to start decoding the digital TV signal.
  - This call requires read/write access to the device.

---

**Note:** At return, the values aren't updated to reflect the actual parameters used. If the actual parameters are needed, an explicit call to FE\_GET\_PROPERTY is needed.

---

- FE\_GET\_PROPERTY:
  - This ioctl is used to get properties and statistics from the frontend.
  - No properties are changed, and statistics aren't reset.
  - This call only requires read-only access to the device.

### Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

Generic error codes are described at the [Generic Error Codes](#) chapter.

## ioctl FE\_DISEQC\_RESET\_OVERLOAD

### Name

FE\_DISEQC\_RESET\_OVERLOAD - Restores the power to the antenna subsystem, if it was powered off due to power overload.

## Synopsis

### **FE\_DISEQC\_RESET\_OVERLOAD**

```
int ioctl(int fd, FE_DISEQC_RESET_OVERLOAD, NULL)
```

## Arguments

### **fd**

File descriptor returned by *open()*.

## Description

If the bus has been automatically powered off due to power overload, this ioctl call restores the power to the bus. The call requires read/write access to the device. This call has no effect if the device is manually powered off. Not all Digital TV adapters support this ioctl.

## Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

Generic error codes are described at the *Generic Error Codes* chapter.

### **ioctl FE\_DISEQC\_SEND\_MASTER\_CMD**

## Name

FE\_DISEQC\_SEND\_MASTER\_CMD - Sends a DiSEqC command

## Synopsis

### **FE\_DISEQC\_SEND\_MASTER\_CMD**

```
int ioctl(int fd, FE_DISEQC_SEND_MASTER_CMD, struct dvb_diseqc_master_cmd
*argp)
```

### Arguments

**fd**

File descriptor returned by *open()*.

**argp**

pointer to struct *dvb\_diseqc\_master\_cmd*

### Description

Sends the DiSEqC command pointed by *dvb\_diseqc\_master\_cmd* to the antenna subsystem.

### Return Value

On success 0 is returned.

On error -1 is returned, and the *errno* variable is set appropriately.

Generic error codes are described at the *Generic Error Codes* chapter.

## ioctl FE\_DISEQC\_RECV\_SLAVE\_REPLY

### Name

FE\_DISEQC\_RECV\_SLAVE\_REPLY - Receives reply from a DiSEqC 2.0 command

### Synopsis

#### FE\_DISEQC\_RECV\_SLAVE\_REPLY

```
int ioctl(int fd, FE_DISEQC_RECV_SLAVE_REPLY, struct dvb_diseqc_slave_reply
*argp)
```

### Arguments

**fd**

File descriptor returned by *open()*.

**argp**

pointer to struct *dvb\_diseqc\_slave\_reply*.

## Description

Receives reply from a DiSEqC 2.0 command.

The received message is stored at the buffer pointed by `argp`.

## Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

Generic error codes are described at the [Generic Error Codes](#) chapter.

## ioctl FE\_DISEQC\_SEND\_BURST

### Name

`FE_DISEQC_SEND_BURST` - Sends a 22KHz tone burst for 2x1 mini DiSEqC satellite selection.

### Synopsis

#### `FE_DISEQC_SEND_BURST`

```
int ioctl(int fd, FE_DISEQC_SEND_BURST, enum fe_sec_mini_cmd tone)
```

### Arguments

#### `fd`

File descriptor returned by [`open\(\)`](#).

#### `tone`

An integer enumerated value described at [`fe\_sec\_mini\_cmd`](#).

## Description

This ioctl is used to set the generation of a 22kHz tone burst for mini DiSEqC satellite selection for 2x1 switches. This call requires read/write permissions.

It provides support for what's specified at [Digital Satellite Equipment Control \(DiSEqC\) - Simple "ToneBurst" Detection Circuit specification](#).

## Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

Generic error codes are described at the [Generic Error Codes](#) chapter.

## ioctl FE\_SET\_TONE

### Name

`FE_SET_TONE` - Sets/resets the generation of the continuous 22kHz tone.

### Synopsis

#### `FE_SET_TONE`

```
int ioctl(int fd, FE_SET_TONE, enum fe_sec_tone_mode tone)
```

### Arguments

#### `fd`

File descriptor returned by [`open\(\)`](#).

#### `tone`

an integer enumerated value described at [`fe\_sec\_tone\_mode`](#)

### Description

This ioctl is used to set the generation of the continuous 22kHz tone. This call requires read/write permissions.

Usually, satellite antenna subsystems require that the digital TV device to send a 22kHz tone in order to select between high/low band on some dual-band LNBf. It is also used to send signals to DiSEqC equipment, but this is done using the DiSEqC ioctls.

**Attention:** If more than one device is connected to the same antenna, setting a tone may interfere on other devices, as they may lose the capability of selecting the band. So, it is recommended that applications would change to `SEC_TONE_OFF` when the device is not used.

## Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

Generic error codes are described at the [Generic Error Codes](#) chapter.

## `ioctl FE_SET_VOLTAGE`

### Name

`FE_SET_VOLTAGE` - Allow setting the DC level sent to the antenna subsystem.

### Synopsis

#### `FE_SET_VOLTAGE`

```
int ioctl(int fd, FE_SET_VOLTAGE, enum fe_sec_voltage voltage)
```

### Arguments

#### `fd`

File descriptor returned by [`open\(\)`](#).

#### `voltage`

an integer enumerated value described at [`fe\_sec\_voltage`](#)

### Description

This ioctl allows to set the DC voltage level sent through the antenna cable to 13V, 18V or off.

Usually, a satellite antenna subsystems require that the digital TV device to send a DC voltage to feed power to the LNBf. Depending on the LNBf type, the polarization or the intermediate frequency (IF) of the LNBf can be controlled by the voltage level. Other devices (for example, the ones that implement DISEqC and multipoint LNBf's don't need to control the voltage level, provided that either 13V or 18V is sent to power up the LNBf.

**Attention:** if more than one device is connected to the same antenna, setting a voltage level may interfere on other devices, as they may lose the capability of setting polarization or IF. So, on those cases, setting the voltage to `SEC_VOLTAGE_OFF` while the device is not used is recommended.

### Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

Generic error codes are described at the [Generic Error Codes](#) chapter.

## **ioctl FE\_ENABLE\_HIGH\_LNB\_VOLTAGE**

### Name

`FE_ENABLE_HIGH_LNB_VOLTAGE` - Select output DC level between normal LNBf voltages or higher LNBf - voltages.

### Synopsis

#### `FE_ENABLE_HIGH_LNB_VOLTAGE`

```
int ioctl(int fd, FE_ENABLE_HIGH_LNB_VOLTAGE, unsigned int high)
```

### Arguments

#### `fd`

File descriptor returned by [`open\(\)`](#).

#### `high`

Valid flags:

- 0 - normal 13V and 18V.
- >0 - enables slightly higher voltages instead of 13/18V, in order to compensate for long antenna cables.

### Description

Select output DC level between normal LNBf voltages or higher LNBf voltages between 0 (normal) or a value grater than 0 for higher voltages.

### Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

Generic error codes are described at the [Generic Error Codes](#) chapter.

## ioctl FE\_SET\_FRONTEND\_TUNE\_MODE

### Name

FE\_SET\_FRONTEND\_TUNE\_MODE - Allow setting tuner mode flags to the frontend.

### Synopsis

#### FE\_SET\_FRONTEND\_TUNE\_MODE

```
int ioctl(int fd, FE_SET_FRONTEND_TUNE_MODE, unsigned int flags)
```

### Arguments

#### fd

File descriptor returned by [open\(\)](#).

#### flags

Valid flags:

- 0 - normal tune mode
- FE\_TUNE\_MODE\_ONESHOT - When set, this flag will disable any zigzagging or other "normal" tuning behaviour. Additionally, there will be no automatic monitoring of the lock status, and hence no frontend events will be generated. If a frontend device is closed, this flag will be automatically turned off when the device is reopened read-write.

### Description

Allow setting tuner mode flags to the frontend, between 0 (normal) or FE\_TUNE\_MODE\_ONESHOT mode

### Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

Generic error codes are described at the [Generic Error Codes](#) chapter.

### 13.3.3 Digital TV Demux Device

The Digital TV demux device controls the MPEG-TS filters for the digital TV. If the driver and hardware supports, those filters are implemented at the hardware. Otherwise, the Kernel provides a software emulation.

It can be accessed through `/dev/adapter?/demux?`. Data types and ioctl definitions can be accessed by including `linux/dvb/dmx.h` in your application.

#### Demux Data Types

##### enum **dmx\_output**

Output for the demux.

#### Constants

##### **DMX\_OUT\_DECODER**

Streaming directly to decoder.

##### **DMX\_OUT\_TAP**

Output going to a memory buffer (to be retrieved via the read command). Delivers the stream output to the demux device on which the ioctl is called.

##### **DMX\_OUT\_TS\_TAP**

Output multiplexed into a new TS (to be retrieved by reading from the logical DVR device). Routes output to the logical DVR device `/dev/dvb/adapter?/dvr?`, which delivers a TS multiplexed from all filters for which **DMX\_OUT\_TS\_TAP** was specified.

##### **DMX\_OUT\_TSDEMUX\_TAP**

Like **DMX\_OUT\_TS\_TAP** but retrieved from the DMX device.

##### enum **dmx\_input**

Input from the demux.

#### Constants

##### **DMX\_IN\_FRONTEND**

Input from a front-end device.

##### **DMX\_IN\_DVR**

Input from the logical DVR device.

##### enum **dmx\_ts\_pes**

type of the PES filter.

#### Constants

##### **DMX\_PES\_AUDIO0**

first audio PID. Also referred as **DMX\_PES\_AUDIO**.

##### **DMX\_PES\_VIDEO0**

first video PID. Also referred as **DMX\_PES\_VIDEO**.

##### **DMX\_PES\_TELETEXT0**

first teletext PID. Also referred as **DMX\_PES\_TELETEXT**.

**DMX\_PES\_SUBTITLE0**

first subtitle PID. Also referred as **DMX\_PES\_SUBTITLE**.

**DMX\_PES\_PCR0**

first Program Clock Reference PID. Also referred as **DMX\_PES\_PCR**.

**DMX\_PES\_AUDIO01**

second audio PID.

**DMX\_PES\_VIDEO01**

second video PID.

**DMX\_PES\_TELETEXT1**

second teletext PID.

**DMX\_PES\_SUBTITLE1**

second subtitle PID.

**DMX\_PES\_PCR1**

second Program Clock Reference PID.

**DMX\_PES\_AUDIO02**

third audio PID.

**DMX\_PES\_VIDEO02**

third video PID.

**DMX\_PES\_TELETEXT2**

third teletext PID.

**DMX\_PES\_SUBTITLE2**

third subtitle PID.

**DMX\_PES\_PCR2**

third Program Clock Reference PID.

**DMX\_PES\_AUDIO03**

fourth audio PID.

**DMX\_PES\_VIDEO03**

fourth video PID.

**DMX\_PES\_TELETEXT3**

fourth teletext PID.

**DMX\_PES\_SUBTITLE3**

fourth subtitle PID.

**DMX\_PES\_PCR3**

fourth Program Clock Reference PID.

**DMX\_PES\_OTHER**

any other PID.

**struct dmx\_filter**

Specifies a section header filter.

**Definition:**

```
struct dmx_filter {
    __u8 filter[DMX_FILTER_SIZE];
    __u8 mask[DMX_FILTER_SIZE];
    __u8 mode[DMX_FILTER_SIZE];
};
```

## Members

### **filter**

bit array with bits to be matched at the section header.

### **mask**

bits that are valid at the filter bit array.

### **mode**

mode of match: if bit is zero, it will match if equal (positive match); if bit is one, it will match if the bit is negated.

## Note

All arrays in this struct have a size of DMX\_FILTER\_SIZE (16 bytes).

### **struct dmx\_sct\_filter\_params**

Specifies a section filter.

## Definition:

```
struct dmx_sct_filter_params {
    __u16 pid;
    struct dmx_filter filter;
    __u32 timeout;
    __u32 flags;
#define DMX_CHECK_CRC      1;
#define DMX_ONESHOT        2;
#define DMX_IMMEDIATE_START 4;
};
```

## Members

### **pid**

PID to be filtered.

### **filter**

section header filter, as defined by *struct dmx\_filter*.

### **timeout**

maximum time to filter, in milliseconds.

### **flags**

extra flags for the section filter.

## Description

Carries the configuration for a MPEG-TS section filter.

The **flags** can be:

- DMX\_CHECK\_CRC - only deliver sections where the CRC check succeeded;

- DMX\_ONESHOT - disable the section filter after one section has been delivered;
- DMX\_IMMEDIATE\_START - Start filter immediately without requiring a *DMX\_START*.

**struct dmx\_pes\_filter\_params**

Specifies Packetized Elementary Stream (PES) filter parameters.

**Definition:**

```
struct dmx_pes_filter_params {
    __u16 pid;
    enum dmx_input input;
    enum dmx_output output;
    enum dmx_ts_pes pes_type;
    __u32 flags;
};
```

**Members****pid**

PID to be filtered.

**input**

Demux input, as specified by *enum dmx\_input*.

**output**

Demux output, as specified by *enum dmx\_output*.

**pes\_type**

Type of the pes filter, as specified by *enum dmx\_pes\_type*.

**flags**

Demux PES flags.

**struct dmx\_stc**

Stores System Time Counter (STC) information.

**Definition:**

```
struct dmx_stc {
    unsigned int num;
    unsigned int base;
    __u64 stc;
};
```

**Members****num**

input data: number of the STC, from 0 to N.

**base**

output: divisor for STC to get 90 kHz clock.

**stc**

output: stc in **base** \* 90 kHz units.

**enum dmx\_buffer\_flags**

DMX memory-mapped buffer flags

## Constants

**DMX\_BUFFER\_FLAG\_HAD\_CRC32\_DISCARD**

Indicates that the Kernel discarded one or more frames due to wrong CRC32 checksum.

**DMX\_BUFFER\_FLAG\_TEI**

Indicates that the Kernel has detected a Transport Error indicator (TEI) on a filtered pid.

**DMX\_BUFFER\_PKT\_COUNTER\_MISMATCH**

Indicates that the Kernel has detected a packet counter mismatch on a filtered pid.

**DMX\_BUFFER\_FLAG\_DISCONTINUITY\_DETECTED**

Indicates that the Kernel has detected one or more frame discontinuity.

**DMX\_BUFFER\_FLAG\_DISCONTINUITY\_INDICATOR**

Received at least one packet with a frame discontinuity indicator.

**struct dmx\_buffer**

dmx buffer info

### Definition:

```
struct dmx_buffer {  
    __u32 index;  
    __u32 bytesused;  
    __u32 offset;  
    __u32 length;  
    __u32 flags;  
    __u32 count;  
};
```

## Members

### **index**

id number of the buffer

### **bytesused**

number of bytes occupied by data in the buffer (payload);

### **offset**

for buffers with memory == DMX\_MEMORY\_MMAP; offset from the start of the device memory for this plane, (or a "cookie" that should be passed to mmap() as offset)

### **length**

size in bytes of the buffer

### **flags**

bit array of buffer flags as defined by [enum dmx\\_buffer\\_flags](#). Filled only at DMX\_DQBUF.

### **count**

monotonic counter for filled buffers. Helps to identify data stream loses. Filled only at DMX\_DQBUF.

## Description

Contains data exchanged by application and driver using one of the streaming I/O methods.

Please notice that, for DMX\_QBUF, only **index** should be filled. On DMX\_DQBUF calls, all fields will be filled by the Kernel.

```
struct dmx_requestbuffers
    request dmx buffer information
```

### Definition:

```
struct dmx_requestbuffers {
    __u32 count;
    __u32 size;
};
```

## Members

### **count**

number of requested buffers,

### **size**

size in bytes of the requested buffer

## Description

Contains data used for requesting a dmx buffer. All reserved fields must be set to zero.

```
struct dmx_exportbuffer
```

export of dmx buffer as DMABUF file descriptor

### Definition:

```
struct dmx_exportbuffer {
    __u32 index;
    __u32 flags;
    __s32 fd;
};
```

## Members

### **index**

id number of the buffer

### **flags**

flags for newly created file, currently only O\_CLOEXEC is supported, refer to manual of open syscall for more details

### **fd**

file descriptor associated with DMABUF (set by driver)

## Description

Contains data used for exporting a dmx buffer as DMABUF file descriptor. The buffer is identified by a 'cookie' returned by DMX\_QUERYBUF (identical to the cookie used to mmap() the buffer to userspace). All reserved fields must be set to zero. The field reserved0 is expected to become a structure 'type' allowing an alternative layout of the structure content. Therefore this field should not be used for any other extensions.

## Demux Function Calls

### Digital TV demux open()

#### Name

Digital TV demux open()

#### Synopsis

```
int open(const char *deviceName, int flags)
```

#### Arguments

##### **name**

Name of specific Digital TV demux device.

##### **flags**

A bit-wise OR of the following flags:

<code>O_RDONLY</code>	read-only access
<code>O_RDWR</code>	read/write access
<code>O_NONBLOCK</code>	open in non-blocking mode (blocking mode is the default)

#### Description

This system call, used with a device name of `/dev/dvb/adapter?/demux?`, allocates a new filter and returns a handle which can be used for subsequent control of that filter. This call has to be made for each filter to be used, i.e. every returned file descriptor is a reference to a single filter. `/dev/dvb/adapter?/dvr?` is a logical device to be used for retrieving Transport Streams for digital video recording. When reading from this device a transport stream containing the packets from all PES filters set in the corresponding demux device (`/dev/dvb/adapter?/demux?`) having the output set to `DMX_OUT_TS_TAP`. A recorded Transport Stream is replayed by writing to this device.

The significance of blocking or non-blocking mode is described in the documentation for functions where there is a difference. It does not affect the semantics of the `open()` call itself. A device opened in blocking mode can later be put into non-blocking mode (and vice versa) using the `F_SETFL` command of the `fcntl` system call.

## Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

<code>EMFILE</code>	"Too many open files", i.e. no more filters available.
---------------------	--

The generic error codes are described at the [Generic Error Codes](#) chapter.

## Digital TV demux close()

### Name

Digital TV demux close()

### Synopsis

```
int close(int fd)
```

### Arguments

#### fd

File descriptor returned by a previous call to [`open\(\)`](#).

### Description

This system call deactivates and deallocates a filter that was previously allocated via the [`open\(\)`](#) call.

## Return Value

On success 0 is returned.

On error, -1 is returned and the `errno` variable is set appropriately.

The generic error codes are described at the [Generic Error Codes](#) chapter.

## Digital TV demux read()

### Name

Digital TV demux read()

### Synopsis

```
size_t read(int fd, void *buf, size_t count)
```

### Arguments

#### fd

File descriptor returned by a previous call to [\*open\(\)\*](#).

#### buf

Buffer to be filled

#### count

Max number of bytes to read

### Description

This system call returns filtered data, which might be section or Packetized Elementary Stream (PES) data. The filtered data is transferred from the driver's internal circular buffer to buf. The maximum amount of data to be transferred is implied by count.

---

**Note:** if a section filter created with [\*DMX\\_CHECK\\_CRC\*](#) flag set, data that fails on CRC check will be silently ignored.

---

### Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

<code>EWOULDBLOCK</code>	No data to return and <code>O_NONBLOCK</code> was specified.
<code>EOVERFLOW</code>	The filtered data was not read from the buffer in due time, resulting in non-read data being lost. The buffer is flushed.
<code>ETIMEDOUT</code>	The section was not loaded within the stated timeout period. See ioctl <a href="#"><i>DMX_SET_FILTER</i></a> for how to set a timeout.
<code>EFAULT</code>	The driver failed to write to the callers buffer due to an invalid <code>*buf</code> pointer.

The generic error codes are described at the [\*Generic Error Codes\*](#) chapter.

## Digital TV demux write()

### Name

Digital TV demux write()

### Synopsis

```
ssize_t write(int fd, const void *buf, size_t count)
```

### Arguments

#### fd

File descriptor returned by a previous call to [open\(\)](#).

#### buf

Buffer with data to be written

#### count

Number of bytes at the buffer

### Description

This system call is only provided by the logical device `/dev/dvb/adapter?/dvr?`, associated with the physical demux device that provides the actual DVR functionality. It is used for replay of a digitally recorded Transport Stream. Matching filters have to be defined in the corresponding physical demux device, `/dev/dvb/adapter?/demux?`. The amount of data to be transferred is implied by count.

### Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

<code>EWOULDBLOCK</code>	No data was written. This might happen if <code>O_NONBLOCK</code> was specified and there is no more buffer space available (if <code>O_NONBLOCK</code> is not specified the function will block until buffer space is available).
<code>EBUSY</code>	This error code indicates that there are conflicting requests. The corresponding demux device is setup to receive data from the front- end. Make sure that these filters are stopped and that the filters with input set to <code>DMX_IN_DVR</code> are started.

The generic error codes are described at the [Generic Error Codes](#) chapter.

## Digital TV mmap()

### Name

dmx-mmap - Map device memory into application address space

**Warning:** this API is still experimental

### Synopsis

```
#include <unistd.h>
#include <sys/mman.h>
```

```
void *mmap(void *start, size_t length, int prot, int flags, int fd, off_t offset)
```

### Arguments

#### start

Map the buffer to this address in the application's address space. When the MAP\_FIXED flag is specified, start must be a multiple of the pagesize and mmap will fail when the specified address cannot be used. Use of this option is discouraged; applications should just specify a NULL pointer here.

#### length

Length of the memory area to map. This must be a multiple of the DVB packet length (188, on most drivers).

#### prot

The prot argument describes the desired memory protection. Regardless of the device type and the direction of data exchange it should be set to PROT\_READ | PROT\_WRITE, permitting read and write access to image buffers. Drivers should support at least this combination of flags.

#### flags

The flags parameter specifies the type of the mapped object, mapping options and whether modifications made to the mapped copy of the page are private to the process or are to be shared with other references.

MAP\_FIXED requests that the driver selects no other address than the one specified. If the specified address cannot be used, [mmap\(\)](#) will fail. If MAP\_FIXED is specified, start must be a multiple of the pagesize. Use of this option is discouraged.

One of the MAP\_SHARED or MAP\_PRIVATE flags must be set. MAP\_SHARED allows applications to share the mapped memory with other (e. g. child-) processes.

---

**Note:** The Linux Digital TV applications should not set the MAP\_PRIVATE, MAP\_DENYWRITE, MAP\_EXECUTABLE or MAP\_ANON flags.

---

**fd**

File descriptor returned by [open\(\)](#).

**offset**

Offset of the buffer in device memory, as returned by [ioctl DMX\\_QUERYBUF](#) ioctl.

**Description**

The [mmap\(\)](#) function asks to map `length` bytes starting at `offset` in the memory of the device specified by `fd` into the application address space, preferably at address `start`. This latter address is a hint only, and is usually specified as 0.

Suitable length and offset parameters are queried with the [ioctl DMX\\_QUERYBUF](#) ioctl. Buffers must be allocated with the [ioctl DMX\\_REQBUFS](#) ioctl before they can be queried.

To unmap buffers the [munmap\(\)](#) function is used.

**Return Value**

On success [mmap\(\)](#) returns a pointer to the mapped buffer. On error `MAP_FAILED` (-1) is returned, and the `errno` variable is set appropriately. Possible error codes are:

**EBADF**

`fd` is not a valid file descriptor.

**EACCES**

`fd` is not open for reading and writing.

**EINVAL**

The `start` or `length` or `offset` are not suitable. (E. g. they are too large, or not aligned on a `PAGESIZE` boundary.)

The `flags` or `prot` value is not supported.

No buffers have been allocated with the [ioctl DMX\\_REQBUFS](#) ioctl.

**ENOMEM**

Not enough physical or virtual memory was available to complete the request.

**DVB munmap()****Name**

`dmx-munmap` - Unmap device memory

<b>Warning:</b> This API is still experimental.
---

## Synopsis

```
#include <unistd.h>
#include <sys/mman.h>
```

```
int munmap(void *start, size_t length)
```

## Arguments

### **start**

Address of the mapped buffer as returned by the [mmap\(\)](#) function.

### **length**

Length of the mapped buffer. This must be the same value as given to [mmap\(\)](#).

## Description

Unmaps a previously with the [mmap\(\)](#) function mapped buffer and frees it, if possible.

## Return Value

On success [munmap\(\)](#) returns 0, on failure -1 and the `errno` variable is set appropriately:

### **EINVAL**

The `start` or `length` is incorrect, or no buffers have been mapped yet.

## DMX\_START

### Name

DMX\_START

## Synopsis

### **DMX\_START**

```
int ioctl(int fd, DMX_START)
```

## Arguments

### fd

File descriptor returned by `open()`.

## Description

This ioctl call is used to start the actual filtering operation defined via the ioctl calls `DMX_SET_FILTER` or `DMX_SET_PES_FILTER`.

## Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

EINVAL	Invalid argument, i.e. no filtering parameters provided via the <code>DMX_SET_FILTER</code> or <code>DMX_SET_PES_FILTER</code> ioctls.
EBUSY	This error code indicates that there are conflicting requests. There are active filters filtering data from another input source. Make sure that these filters are stopped before starting this filter.

The generic error codes are described at the [Generic Error Codes](#) chapter.

## DMX\_STOP

### Name

`DMX_STOP`

### Synopsis

#### DMX\_STOP

```
int ioctl(int fd, DMX_STOP)
```

## Arguments

### fd

File descriptor returned by `open()`.

## Description

This ioctl call is used to stop the actual filtering operation defined via the ioctl calls `DMX_SET_FILTER` or `DMX_SET_PES_FILTER` and started via the `DMX_START` command.

## Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

The generic error codes are described at the [Generic Error Codes](#) chapter.

## DMX\_SET\_FILTER

### Name

`DMX_SET_FILTER`

### Synopsis

#### DMX\_SET\_FILTER

```
int ioctl(int fd, DMX_SET_FILTER, struct dmx_sct_filter_params *params)
```

### Arguments

#### fd

File descriptor returned by [`open\(\)`](#).

#### params

Pointer to structure containing filter parameters.

## Description

This ioctl call sets up a filter according to the filter and mask parameters provided. A timeout may be defined stating number of seconds to wait for a section to be loaded. A value of 0 means that no timeout should be applied. Finally there is a flag field where it is possible to state whether a section should be CRC-checked, whether the filter should be a "one-shot" filter, i.e. if the filtering operation should be stopped after the first section is received, and whether the filtering operation should be started immediately (without waiting for a `DMX_START` ioctl call). If a filter was previously set-up, this filter will be canceled, and the receive buffer will be flushed.

## Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

The generic error codes are described at the [Generic Error Codes](#) chapter.

## `DMX_SET_PES_FILTER`

### Name

`DMX_SET_PES_FILTER`

### Synopsis

#### `DMX_SET_PES_FILTER`

```
int ioctl(int fd, DMX_SET_PES_FILTER, struct dmx_pes_filter_params *params)
```

### Arguments

#### `fd`

File descriptor returned by [`open\(\)`](#).

#### `params`

Pointer to structure containing filter parameters.

### Description

This ioctl call sets up a PES filter according to the parameters provided. By a PES filter is meant a filter that is based just on the packet identifier (PID), i.e. no PES header or payload filtering capability is supported.

## Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

<code>EBUSY</code>	This error code indicates that there are conflicting requests. There are active filters filtering data from another input source. Make sure that these filters are stopped before starting this filter.
--------------------	---

The generic error codes are described at the [Generic Error Codes](#) chapter.

## **DMX\_SET\_BUFFER\_SIZE**

### **Name**

DMX\_SET\_BUFFER\_SIZE

### **Synopsis**

#### **DMX\_SET\_BUFFER\_SIZE**

```
int ioctl(int fd, DMX_SET_BUFFER_SIZE, unsigned long size)
```

### **Arguments**

#### **fd**

File descriptor returned by [open\(\)](#).

#### **size**

Unsigned long size

### **Description**

This ioctl call is used to set the size of the circular buffer used for filtered data. The default size is two maximum sized sections, i.e. if this function is not called a buffer size of  $2 * 4096$  bytes will be used.

### **Return Value**

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

The generic error codes are described at the [Generic Error Codes](#) chapter.

## **DMX\_GET\_STC**

### **Name**

DMX\_GET\_STC

## Synopsis

### **DMX\_GET\_STC**

```
int ioctl(int fd, DMX_GET_STC, struct dmx_stc *stc)
```

## Arguments

### **fd**

File descriptor returned by [open\(\)](#).

### **stc**

Pointer to [\*dmx\\_stc\*](#) where the stc data is to be stored.

## Description

This ioctl call returns the current value of the system time counter (which is driven by a PES filter of type [\*DMX\\_PES\\_PCR\*](#)). Some hardware supports more than one STC, so you must specify which one by setting the [\*num\*](#) field of stc before the ioctl (range 0...n). The result is returned in form of a ratio with a 64 bit numerator and a 32 bit denominator, so the real 90kHz STC value is `stc->stc / stc->base`.

## Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

EINVAL	Invalid stc number.
--------	---------------------

The generic error codes are described at the [Generic Error Codes](#) chapter.

### **DMX\_GET\_PES\_PIDS**

## Name

`DMX_GET_PES_PIDS`

## Synopsis

### **DMX\_GET\_PES\_PIDS**

```
int ioctl(fd, DMX_GET_PES_PIDS, __u16 pids[5])
```

## Arguments

### fd

File descriptor returned by `open()`.

### pids

Array used to store 5 Program IDs.

## Description

This ioctl allows to query a DVB device to return the first PID used by audio, video, teletext, subtitle and PCR programs on a given service. They're stored as:

PID element	position	content
pids[DMX_PES_AUDIO]	0	first audio PID
pids[DMX_PES_VIDEO]	1	first video PID
pids[DMX_PES_TELETEXT]	2	first teletext PID
pids[DMX_PES_SUBTITLE]	3	first subtitle PID
pids[DMX_PES_PCR]	4	first Program Clock Reference PID

---

**Note:** A value equal to 0xffff means that the PID was not filled by the Kernel.

---

## Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

The generic error codes are described at the [Generic Error Codes](#) chapter.

## DMX\_ADD\_PID

### Name

`DMX_ADD_PID`

### Synopsis

#### DMX\_ADD\_PID

```
int ioctl(fd, DMX_ADD_PID, __u16 *pid)
```

## Arguments

### fd

File descriptor returned by `open()`.

### pid

PID number to be filtered.

## Description

This ioctl call allows to add multiple PIDs to a transport stream filter previously set up with `DMX_SET_PES_FILTER` and output equal to `DMX_OUT_TSDEMUX_TAP`.

## Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

Generic error codes are described at the [Generic Error Codes](#) chapter.

## DMX\_REMOVE\_PID

### Name

`DMX_REMOVE_PID`

### Synopsis

#### DMX\_REMOVE\_PID

```
int ioctl(fd, DMX_REMOVE_PID, __u16 *pid)
```

## Arguments

### fd

File descriptor returned by `open()`.

### pid

PID of the PES filter to be removed.

## Description

This ioctl call allows to remove a PID when multiple PIDs are set on a transport stream filter, e. g. a filter previously set up with output equal to `DMX_OUT_TSDEMUX_TAP`, created via either `DMX_SET_PES_FILTER` or `DMX_ADD_PID`.

## Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

The generic error codes are described at the [Generic Error Codes](#) chapter.

## ioctl DMX\_REQBUFS

### Name

`DMX_REQBUFS` - Initiate Memory Mapping and/or DMA buffer I/O

**Warning:** this API is still experimental

### Synopsis

#### `DMX_REQBUFS`

```
int ioctl(int fd, DMX_REQBUFS, struct dmx_requestbuffers *argp)
```

### Arguments

#### `fd`

File descriptor returned by `open()`.

#### `argp`

Pointer to struct `dmx_requestbuffers`.

## Description

This ioctl is used to initiate a memory mapped or DMABUF based demux I/O.

Memory mapped buffers are located in device memory and must be allocated with this ioctl before they can be mapped into the application's address space. User buffers are allocated by applications themselves, and this ioctl is merely used to switch the driver into user pointer I/O mode and to setup some internal structures. Similarly, DMABUF buffers are allocated by applications through a device driver, and this ioctl only configures the driver into DMABUF I/O mode without performing any direct allocation.

To allocate device buffers applications initialize all fields of the struct `dmx_requestbuffers` structure. They set the `count` field to the desired number of buffers, and `size` to the size of each buffer.

When the ioctl is called with a pointer to this structure, the driver will attempt to allocate the requested number of buffers and it stores the actual number allocated in the `count` field. The `count` can be smaller than the number requested, even zero, when the driver runs out of free memory. A larger number is also possible when the driver requires more buffers to function correctly. The actual allocated buffer size can be returned at `size`, and can be smaller than what's requested.

When this I/O method is not supported, the ioctl returns an `EOPNOTSUPP` error code.

Applications can call `ioctl DMX_REQBUFS` again to change the number of buffers, however this cannot succeed when any buffers are still mapped. A `count` value of zero frees all buffers, after aborting or finishing any DMA in progress.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## **EOPNOTSUPP**

The requested I/O method is not supported.

## ioctl DMX\_QUERYBUF

### Name

`DMX_QUERYBUF` - Query the status of a buffer

**Warning:** this API is still experimental

### Synopsis

#### `DMX_QUERYBUF`

```
int ioctl(int fd, DMX_QUERYBUF, struct dvb_buffer *argp)
```

### Arguments

#### `fd`

File descriptor returned by `open()`.

#### `argp`

Pointer to struct `dvb_buffer`.

## Description

This ioctl is part of the mmap streaming I/O method. It can be used to query the status of a buffer at any time after buffers have been allocated with the [\*ioctl DMX\\_REQBUFS\*](#) ioctl.

Applications set the `index` field. Valid index numbers range from zero to the number of buffers allocated with [\*ioctl DMX\\_REQBUFS\*](#) (struct `dvb_requestbuffers` count) minus one.

After calling [\*ioctl DMX\\_QUERYBUF\*](#) with a pointer to this structure, drivers return an error code or fill the rest of the structure.

On success, the `offset` will contain the offset of the buffer from the start of the device memory, the `length` field its size, and the `bytesused` the number of bytes occupied by data in the buffer (payload).

## Return Value

On success 0 is returned, the `offset` will contain the offset of the buffer from the start of the device memory, the `length` field its size, and the `bytesused` the number of bytes occupied by data in the buffer (payload).

On error it returns -1 and the `errno` variable is set appropriately. The generic error codes are described at the [\*Generic Error Codes\*](#) chapter.

### EINVAL

The `index` is out of bounds.

## [\*\*ioctl DMX\\_EXPBUF\*\*](#)

### Name

`DMX_EXPBUF` - Export a buffer as a DMABUF file descriptor.

**Warning:** this API is still experimental

### Synopsis

#### `DMX_EXPBUF`

```
int ioctl(int fd, DMX_EXPBUF, struct dmx_exportbuffer *argp)
```

## Arguments

### fd

File descriptor returned by `open()`.

### argp

Pointer to struct `dmx_exportbuffer`.

## Description

This ioctl is an extension to the memory mapping I/O method. It can be used to export a buffer as a DMABUF file at any time after buffers have been allocated with the `ioctl DMX_REQBUFS` ioctl.

To export a buffer, applications fill struct `dmx_exportbuffer`. Applications must set the `index` field. Valid index numbers range from zero to the number of buffers allocated with `ioctl DMX_REQBUFS` (struct `dmx_requestbuffers` count) minus one. Additional flags may be posted in the `flags` field. Refer to a manual for `open()` for details. Currently only `O_CLOEXEC`, `O_RDONLY`, `O_WRONLY`, and `O_RDWR` are supported. All other fields must be set to zero. In the case of multi-planar API, every plane is exported separately using multiple `ioctl DMX_EXPBUF` calls.

After calling `ioctl DMX_EXPBUF` the `fd` field will be set by a driver, on success. This is a DMABUF file descriptor. The application may pass it to other DMABUF-aware devices. It is recommended to close a DMABUF file when it is no longer used to allow the associated memory to be reclaimed.

## Examples

```
int buffer_export(int v4lfd, enum dmx_buf_type bt, int index, int *dmafd)
{
    struct dmx_exportbuffer expbuf;

    memset(&expbuf, 0, sizeof(expbuf));
    expbuf.type = bt;
    expbuf.index = index;
    if (ioctl(v4lfd, DMX_EXPBUF, &expbuf) == -1) {
        perror("DMX_EXPBUF");
        return -1;
    }
    *dmafd = expbuf.fd;
    return 0;
}
```

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## EINVAL

A queue is not in MMAP mode or DMABUF exporting is not supported or `flags` or `index` fields are invalid.

## ioctl DMX\_QBUF, DMX\_DQBUF

### Name

`DMX_QBUF` - `DMX_DQBUF` - Exchange a buffer with the driver

**Warning:** this API is still experimental

### Synopsis

#### DMX\_QBUF

```
int ioctl(int fd, DMX_QBUF, struct dmx_buffer *argp)
```

#### DMX\_DQBUF

```
int ioctl(int fd, DMX_DQBUF, struct dmx_buffer *argp)
```

### Arguments

#### fd

File descriptor returned by [`open\(\)`](#).

#### argp

Pointer to struct [`dmx\_buffer`](#).

### Description

Applications call the `DMX_QBUF` ioctl to enqueue an empty (capturing) or filled (output) buffer in the driver's incoming queue. The semantics depend on the selected I/O method.

To enqueue a buffer applications set the `index` field. Valid index numbers range from zero to the number of buffers allocated with [`ioctl DMX\_REQBUFS`](#) (struct [`dmx\_requestbuffers`](#) count) minus one. The contents of the struct [`dmx\_buffer`](#) returned by a [`ioctl DMX\_QUERYBUF`](#) ioctl will do as well.

When `DMX_QBUF` is called with a pointer to this structure, it locks the memory pages of the buffer in physical memory, so they cannot be swapped out to disk. Buffers remain locked until dequeued, until the device is closed.

Applications call the `DMX_DQBUF` ioctl to dequeue a filled (capturing) buffer from the driver's outgoing queue. They just set the `index` field with the buffer ID to be queued. When `DMX_DQBUF` is called with a pointer to struct `dmx_buffer`, the driver fills the remaining fields or returns an error code.

By default `DMX_DQBUF` blocks when no buffer is in the outgoing queue. When the `O_NONBLOCK` flag was given to the `open()` function, `DMX_DQBUF` returns immediately with an `EAGAIN` error code when no buffer is available.

The struct `dmx_buffer` structure is specified in *Buffers*.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the *Generic Error Codes* chapter.

### **EAGAIN**

Non-blocking I/O has been selected using `O_NONBLOCK` and no buffer was in the outgoing queue.

### **EINVAL**

The `index` is out of bounds, or no buffers have been allocated yet.

### **EIO**

`DMX_DQBUF` failed due to an internal error. Can also indicate temporary problems like signal loss or CRC errors.

## 13.3.4 Digital TV CA Device

The Digital TV CA device controls the conditional access hardware. It can be accessed through `/dev/dvb/adapter?/ca?`. Data types and ioctl definitions can be accessed by including `linux/dvb/ca.h` in your application.

---

**Note:** There are three ioctls at this API that aren't documented: `CA_GET_MSG`, `CA_SEND_MSG` and `CA_SET_DESCR`. Documentation for them are welcome.

---

## CA Data Types

### `struct ca_slot_info`

CA slot interface types and info.

#### **Definition:**

```
struct ca_slot_info {
    int num;
    int type;
#define CA_CI          1;
#define CA_CI_LINK    2;
#define CA_CI_PHYS    4;
#define CA_DESCR       8;
```

```
#define CA_SC          128;
    unsigned int flags;
#define CA_CI_MODULE_PRESENT 1;
#define CA_CI_MODULE_READY   2;
};
```

### Members

**num**  
slot number.

**type**  
slot type.

**flags**  
flags applicable to the slot.

### Description

This struct stores the CA slot information.

**type** can be:

- CA\_CI - CI high level interface;
- CA\_CI\_LINK - CI link layer level interface;
- CA\_CI\_PHYS - CI physical layer level interface;
- CA\_DESCR - built-in descrambler;
- CA\_SC -simple smart card interface.

**flags** can be:

- CA\_CI\_MODULE\_PRESENT - module (or card) inserted;
- CA\_CI\_MODULE\_READY - module is ready for usage.

### struct ca\_descr\_info

descrambler types and info.

### Definition:

```
struct ca_descr_info {
    unsigned int num;
    unsigned int type;
#define CA_ECD          1;
#define CA_NDS          2;
#define CA_DSS          4;
};
```

### Members

**num**  
number of available descramblers (keys).

**type**  
type of supported scrambling system.

## Description

Identifies the number of descramblers and their type.

**type** can be:

- CA\_ECD - European Common Descrambler (ECD) hardware;
- CA\_NDS - Videoguard (NDS) hardware;
- CA\_DSS - Distributed Sample Scrambling (DSS) hardware.

### struct ca\_caps

CA slot interface capabilities.

#### Definition:

```
struct ca_caps {
    unsigned int slot_num;
    unsigned int slot_type;
    unsigned int descr_num;
    unsigned int descr_type;
};
```

## Members

### slot\_num

total number of CA card and module slots.

### slot\_type

bitmap with all supported types as defined at *struct ca\_slot\_info* (e. g. CA\_CI, CA\_CI\_LINK, etc).

### descr\_num

total number of descrambler slots (keys)

### descr\_type

bitmap with all supported types as defined at *struct ca\_descr\_info* (e. g. CA\_ECD, CA\_NDS, etc).

### struct ca\_msg

a message to/from a CI-CAM

#### Definition:

```
struct ca_msg {
    unsigned int index;
    unsigned int type;
    unsigned int length;
    unsigned char msg[256];
};
```

## Members

### index

unused

### type

unused

### **length**

length of the message

### **msg**

message

### **Description**

This struct carries a message to be send/received from a CI CA module.

### **struct ca\_descr**

CA descrambler control words info

### **Definition:**

```
struct ca_descr {  
    unsigned int index;  
    unsigned int parity;  
    unsigned char cw[8];  
};
```

### **Members**

#### **index**

CA Descrambler slot

#### **parity**

control words parity, where 0 means even and 1 means odd

#### **cw**

CA Descrambler control words

## **CA Function Calls**

### **Digital TV CA open()**

#### **Name**

Digital TV CA open()

#### **Synopsis**

```
int open(const char *name, int flags)
```

## Arguments

### **name**

Name of specific Digital TV CA device.

### **flags**

A bit-wise OR of the following flags:

O_RDONLY	read-only access
O_RDWR	read/write access
O_NONBLOCK	open in non-blocking mode (blocking mode is the default)

## Description

This system call opens a named ca device (e.g. /dev/dvb/adapter?/ca?) for subsequent use.

When an open() call has succeeded, the device will be ready for use. The significance of blocking or non-blocking mode is described in the documentation for functions where there is a difference. It does not affect the semantics of the open() call itself. A device opened in blocking mode can later be put into non-blocking mode (and vice versa) using the F\_SETFL command of the fcntl system call. This is a standard system call, documented in the Linux manual page for fcntl. Only one user can open the CA Device in O\_RDWR mode. All other attempts to open the device in this mode will fail, and an error code will be returned.

## Return Value

On success 0 is returned.

On error -1 is returned, and the errno variable is set appropriately.

Generic error codes are described at the [Generic Error Codes](#) chapter.

## Digital TV CA close()

### **Name**

Digital TV CA close()

### **Synopsis**

```
int close(int fd)
```

### Arguments

#### fd

File descriptor returned by a previous call to [open\(\)](#).

### Description

This system call closes a previously opened CA device.

### Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

Generic error codes are described at the [Generic Error Codes](#) chapter.

## CA\_RESET

### Name

CA\_RESET

### Synopsis

#### CA\_RESET

```
int ioctl(fd, CA_RESET)
```

### Arguments

#### fd

File descriptor returned by a previous call to [open\(\)](#).

### Description

Puts the Conditional Access hardware on its initial state. It should be called before start using the CA hardware.

## Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

Generic error codes are described at the [Generic Error Codes](#) chapter.

## CA\_GET\_CAP

### Name

`CA_GET_CAP`

### Synopsis

#### `CA_GET_CAP`

```
int ioctl(fd, CA_GET_CAP, struct ca_caps *caps)
```

### Arguments

#### `fd`

File descriptor returned by a previous call to [`open\(\)`](#).

#### `caps`

Pointer to struct `ca_caps`.

### Description

Queries the Kernel for information about the available CA and descrambler slots, and their types.

## Return Value

On success 0 is returned and `ca_caps` is filled.

On error, -1 is returned and the `errno` variable is set appropriately.

The generic error codes are described at the [Generic Error Codes](#) chapter.

## CA\_GET\_SLOT\_INFO

### Name

CA\_GET\_SLOT\_INFO

### Synopsis

#### CA\_GET\_SLOT\_INFO

```
int ioctl(fd, CA_GET_SLOT_INFO, struct ca_slot_info *info)
```

### Arguments

#### fd

File descriptor returned by a previous call to [open\(\)](#).

#### info

Pointer to struct [\*ca\\_slot\\_info\*](#).

### Description

Returns information about a CA slot identified by [\*ca\\_slot\\_info\*.slot\\_num](#).

### Return Value

On success 0 is returned, and [\*ca\\_slot\\_info\*](#) is filled.

On error -1 is returned, and the `errno` variable is set appropriately.

ENODEV	the slot is not available.
--------	----------------------------

The generic error codes are described at the [Generic Error Codes](#) chapter.

## CA\_GET\_DESCR\_INFO

### Name

CA\_GET\_DESCR\_INFO

## Synopsis

### CA\_GET\_DESCR\_INFO

```
int ioctl(fd, CA_GET_DESCR_INFO, struct ca_descr_info *desc)
```

## Arguments

### fd

File descriptor returned by a previous call to [open\(\)](#).

### desc

Pointer to struct [\*ca\\_descr\\_info\*](#).

## Description

Returns information about all descrambler slots.

## Return Value

On success 0 is returned, and [\*ca\\_descr\\_info\*](#) is filled.

On error -1 is returned, and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### CA\_GET\_MSG

## Name

CA\_GET\_MSG

## Synopsis

### CA\_GET\_MSG

```
int ioctl(fd, CA_GET_MSG, struct ca_msg *msg)
```

## Arguments

### fd

File descriptor returned by a previous call to [open\(\)](#).

### msg

Pointer to struct [\*ca\\_msg\*](#).

### Description

Receives a message via a CI CA module.

---

**Note:** Please notice that, on most drivers, this is done by reading from the /dev/adapter?/ca? device node.

---

### Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

Generic error codes are described at the [Generic Error Codes](#) chapter.

## CA\_SEND\_MSG

### Name

`CA_SEND_MSG`

### Synopsis

#### CA\_SEND\_MSG

```
int ioctl(fd, CA_SEND_MSG, struct ca_msg *msg)
```

### Arguments

#### fd

File descriptor returned by a previous call to [`open\(\)`](#).

#### msg

Pointer to struct `ca_msg`.

### Description

Sends a message via a CI CA module.

---

**Note:** Please notice that, on most drivers, this is done by writing to the /dev/adapter?/ca? device node.

---

## Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

Generic error codes are described at the [Generic Error Codes](#) chapter.

## `CA_SET_DESCR`

### Name

`CA_SET_DESCR`

### Synopsis

#### `CA_SET_DESCR`

```
int ioctl(fd, CA_SET_DESCR, struct ca_descr *desc)
```

### Arguments

#### `fd`

File descriptor returned by a previous call to [`open\(\)`](#).

#### `msg`

Pointer to struct `ca_descr`.

### Description

`CA_SET_DESCR` is used for feeding descrambler CA slots with descrambling keys (referred as control words).

## Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

Generic error codes are described at the [Generic Error Codes](#) chapter.

## The High level CI API

---

**Note:** This documentation is outdated.

---

This document describes the high level CI API as in accordance to the Linux DVB API.

With the High Level CI approach any new card with almost any random architecture can be implemented with this style, the definitions inside the switch statement can be easily adapted for any card, thereby eliminating the need for any additional ioctls.

The disadvantage is that the driver/hardware has to manage the rest. For the application programmer it would be as simple as sending/receiving an array to/from the CI ioctls as defined in the Linux DVB API. No changes have been made in the API to accommodate this feature.

### Why the need for another CI interface?

This is one of the most commonly asked question. Well a nice question. Strictly speaking this is not a new interface.

The CI interface is defined in the DVB API in ca.h as:

```
typedef struct ca_slot_info {
    int num;                      /* slot number */

    int type;                     /* CA interface this slot supports */
#define CA_CI           1          /* CI high level interface */
#define CA_CI_LINK     2          /* CI link layer level interface */
#define CA_CI_PHYS     4          /* CI physical layer level interface */
#define CA_DESCR        8          /* built-in descrambler */
#define CA_SC          128         /* simple smart card interface */

    unsigned int flags;
#define CA_CI_MODULE_PRESENT 1 /* module (or card) inserted */
#define CA_CI_MODULE_READY   2
} ca_slot_info_t;
```

This CI interface follows the CI high level interface, which is not implemented by most applications. Hence this area is revisited.

This CI interface is quite different in the case that it tries to accommodate all other CI based devices, that fall into the other categories.

This means that this CI interface handles the EN50221 style tags in the Application layer only and no session management is taken care of by the application. The driver/hardware will take care of all that.

This interface is purely an EN50221 interface exchanging APDU's. This means that no session management, link layer or a transport layer do exist in this case in the application to driver communication. It is as simple as that. The driver/hardware has to take care of that.

With this High Level CI interface, the interface can be defined with the regular ioctls.

All these ioctls are also valid for the High level CI interface

```
#define CA_RESET_IOR('o', 128) #define CA_GET_CAP_IOR('o', 129, ca_caps_t) #define
CA_GET_SLOT_INFO_IOR('o', 130, ca_slot_info_t) #define CA_GET_DESCR_INFO_IOR('o',
131, ca_descr_info_t) #define CA_GET_MSG_IOR('o', 132, ca_msg_t) #define CA_SEND_MSG
_IOW('o', 133, ca_msg_t) #define CA_SET_DESCR_IOW('o', 134, ca_descr_t)
```

On querying the device, the device yields information thus:

```
CA_GET_SLOT_INFO
-----
Command = [info]
APP: Number=[1]
APP: Type=[1]
APP: flags=[1]
APP: CI High level interface
APP: CA/CI Module Present

CA_GET_CAP
-----
Command = [caps]
APP: Slots=[1]
APP: Type=[1]
APP: Descrambler keys=[16]
APP: Type=[1]

CA_SEND_MSG
-----
Descriptors(Program Level)=[ 09 06 06 04 05 50 ff f1]
Found CA descriptor @ program level

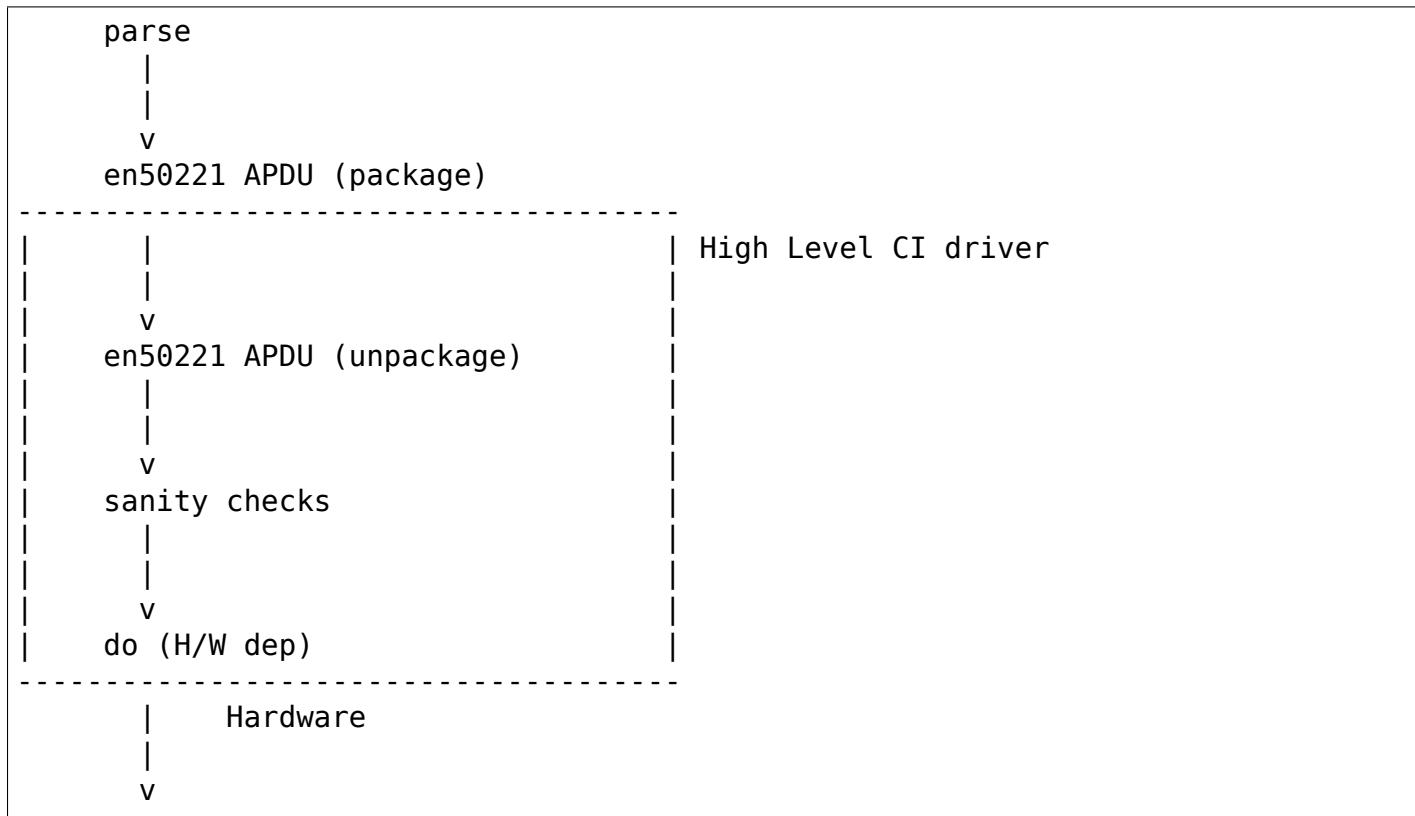
(20) ES type=[2] ES pid=[201] ES length =[0 (0x0)]
(25) ES type=[4] ES pid=[301] ES length =[0 (0x0)]
ca_message length is 25 (0x19) bytes
EN50221 CA MSG=[ 9f 80 32 19 03 01 2d d1 f0 08 01 09 06 06 04 05 50 ff f1 02
-e0 c9 00 00 04 e1 2d 00 00 ]
```

Not all ioctl's are implemented in the driver from the API, the other features of the hardware that cannot be implemented by the API are achieved using the CA\_GET\_MSG and CA\_SEND\_MSG ioctls. An EN50221 style wrapper is used to exchange the data to maintain compatibility with other hardware.

```
/* a message to/from a CI-CAM */
typedef struct ca_msg {
    unsigned int index;
    unsigned int type;
    unsigned int length;
    unsigned char msg[256];
} ca_msg_t;
```

The flow of data can be described thus,

```
App (User)
-----
```



The High Level CI interface uses the EN50221 DVB standard, following a standard ensures futureproofness.

### 13.3.5 Digital TV Network API

The Digital TV net device controls the mapping of data packages that are part of a transport stream to be mapped into a virtual network interface, visible through the standard Linux network protocol stack.

Currently, two encapsulations are supported:

- [Multi Protocol Encapsulation \(MPE\)](#)
- [Ultra Lightweight Encapsulation \(ULE\)](#)

In order to create the Linux virtual network interfaces, an application needs to tell to the Kernel what are the PIDs and the encapsulation types that are present on the transport stream. This is done through `/dev/dvb/adapter?/net?` device node. The data will be available via virtual `dvb?_?` network interfaces, and will be controlled/routed via the standard ip tools (like `ip`, `route`, `netstat`, `ifconfig`, etc).

Data types and ioctl definitions are defined via `linux/dvb/net.h` header.

## Digital TV net Function Calls

### Net Data Types

#### struct dvb\_net\_if

describes a DVB network interface

#### Definition:

```
struct dvb_net_if {
    __u16 pid;
    __u16 if_num;
    __u8 feedtype;
#define DVB_NET_FEEDTYPE_MPE 0  ;
#define DVB_NET_FEEDTYPE_ULE 1  ;
};
```

### Members

#### pid

Packet ID (PID) of the MPEG-TS that contains data

#### if\_num

number of the Digital TV interface.

#### feedtype

Encapsulation type of the feed.

### Description

A MPEG-TS stream may contain packet IDs with IP packages on it. This struct describes it, and the type of encoding.

**feedtype** can be:

- DVB\_NET\_FEEDTYPE\_MPE for MPE encoding
- DVB\_NET\_FEEDTYPE\_ULE for ULE encoding.

## ioctl NET\_ADD\_IF

### Name

NET\_ADD\_IF - Creates a new network interface for a given Packet ID.

### Synopsis

#### NET\_ADD\_IF

```
int ioctl(int fd, NET_ADD_IF, struct dvb_net_if *net_if)
```

### Arguments

#### fd

File descriptor returned by `open()`.

#### net\_if

pointer to struct `dvb_net_if`

### Description

The NET\_ADD\_IF ioctl system call selects the Packet ID (PID) that contains a TCP/IP traffic, the type of encapsulation to be used (MPE or ULE) and the interface number for the new interface to be created. When the system call successfully returns, a new virtual network interface is created.

The struct `dvb_net_if`::ifnum field will be filled with the number of the created interface.

### Return Value

On success 0 is returned, and `ca_slot_info` is filled.

On error -1 is returned, and the `errno` variable is set appropriately.

The generic error codes are described at the [Generic Error Codes](#) chapter.

## ioctl NET\_REMOVE\_IF

### Name

NET\_REMOVE\_IF - Removes a network interface.

### Synopsis

#### NET\_REMOVE\_IF

```
int ioctl(int fd, NET_REMOVE_IF, int ifnum)
```

## Arguments

### fd

File descriptor returned by `open()`.

### net\_if

number of the interface to be removed

## Description

The `NET_REMOVE_IF` ioctl deletes an interface previously created via `NET_ADD_IF`.

## Return Value

On success 0 is returned, and `ca_slot_info` is filled.

On error -1 is returned, and the `errno` variable is set appropriately.

The generic error codes are described at the *Generic Error Codes* chapter.

## ioctl NET\_GET\_IF

## Name

`NET_GET_IF` - Read the configuration data of an interface created via - `NET_ADD_IF`.

## Synopsis

### `NET_GET_IF`

```
int ioctl(int fd, NET_GET_IF, struct dvb_net_if *net_if)
```

## Arguments

### fd

File descriptor returned by `open()`.

### net\_if

pointer to struct `dvb_net_if`

### Description

The NET\_GET\_IF ioctl uses the interface number given by the struct `dvb_net_if`::ifnum field and fills the content of struct `dvb_net_if` with the packet ID and encapsulation type used on such interface. If the interface was not created yet with `NET_ADD_IF`, it will return -1 and fill the `errno` with EINVAL error code.

### Return Value

On success 0 is returned, and `ca_slot_info` is filled.

On error -1 is returned, and the `errno` variable is set appropriately.

The generic error codes are described at the [Generic Error Codes](#) chapter.

### 13.3.6 Digital TV Deprecated APIs

The APIs described here **should not** be used on new drivers or applications.

The DVBy3 frontend API has issues with new delivery systems, including DVB-S2, DVB-T2, ISDB, etc.

**Attention:** The APIs described here doesn't necessarily reflect the current code implementation, as this section of the document was written for DVB version 1, while the code reflects DVB version 3 implementation.

### Digital TV Frontend legacy API (a. k. a. DVBy3)

The usage of this API is deprecated, as it doesn't support all digital TV standards, doesn't provide good statistics measurements and provides incomplete information. This is kept only to support legacy applications.

#### Frontend Legacy Data Types

##### Frontend type

For historical reasons, frontend types are named by the type of modulation used in transmission. The fontend types are given by `fe_type_t` type, defined as:

type `fe_type`

Table 283: Frontend types

<code>fe_type</code>	Description	<code>DTV_DELIVERY_SYSTEM</code> equivalent type
<code>FE_QPSK</code>	For DVB-S standard	<code>SYS_DVBS</code>
<code>FE_QAM</code>	For DVB-C annex A standard	<code>SYS_DVBC_ANNEX_A</code>
<code>FE_OFDM</code>	For DVB-T standard	<code>SYS_DVBT</code>
<code>FE_ATSC</code>	For ATSC standard (terrestrial) or for DVB-C Annex B (cable) used in US.	<code>SYS_ATSC</code> (terrestrial) <code>SYS_DVBC_ANNEX_B</code> (cable)

Newer formats like DVB-S2, ISDB-T, ISDB-S and DVB-T2 are not described at the above, as they're supported via the new `FE_GET_PROPERTY/FE_GET_SET_PROPERTY` ioctl's, using the `DTV_DELIVERY_SYSTEM` parameter.

In the old days, struct `dvb_frontend_info` used to contain `fe_type_t` field to indicate the delivery systems, filled with either `FE_QPSK`, `FE_QAM`, `FE_OFDM` or `FE_ATSC`. While this is still filled to keep backward compatibility, the usage of this field is deprecated, as it can report just one delivery system, but some devices support multiple delivery systems. Please use `DTV_ENUM_DELSYS` instead.

On devices that support multiple delivery systems, struct `dvb_frontend_info::fe_type_t` is filled with the currently standard, as selected by the last call to `FE_SET_PROPERTY` using the `DTV_DELIVERY_SYSTEM` property.

## Frontend bandwidth

type `fe_bandwidth`

Table 284: enum fe\_bandwidth

ID	Description
<code>BANDWIDTH_AUTO</code>	Autodetect bandwidth (if supported)
<code>BANDWIDTH_1_712_MHZ</code>	1.712 MHz
<code>BANDWIDTH_5_MHZ</code>	5 MHz
<code>BANDWIDTH_6_MHZ</code>	6 MHz
<code>BANDWIDTH_7_MHZ</code>	7 MHz
<code>BANDWIDTH_8_MHZ</code>	8 MHz
<code>BANDWIDTH_10_MHZ</code>	10 MHz

type **dvb\_frontend\_parameters**

## frontend parameters

The kind of parameters passed to the frontend device for tuning depend on the kind of hardware you are using.

The struct `dvb_frontend_parameters` uses a union with specific per-system parameters. However, as newer delivery systems required more data, the structure size weren't enough to fit, and just extending its size would break the existing applications. So, those parameters were replaced by the usage of `FE_GET_PROPERTY/FE_SET_PROPERTY` ioctl's. The new API is flexible enough to add new parameters to existing delivery systems, and to add newer delivery systems.

So, newer applications should use `FE_GET_PROPERTY/FE_SET_PROPERTY` instead, in order to be able to support the newer System Delivery like DVB-S2, DVB-T2, DVB-C2, ISDB, etc.

All kinds of parameters are combined as a union in the `dvb_frontend_parameters` structure:

```
struct dvb_frontend_parameters {
    uint32_t frequency;      /* (absolute) frequency in Hz for QAM/OFDM */
                           /* intermediate frequency in kHz for QPSK */
    fe_spectral_inversion_t inversion;
    union {
        struct dvb_qpsk_parameters qpsk;
        struct dvb_qam_parameters qam;
        struct dvb_ofdm_parameters ofdm;
        struct dvb_vsb_parameters vsb;
    } u;
};
```

In the case of QPSK frontends the `frequency` field specifies the intermediate frequency, i.e. the offset which is effectively added to the local oscillator frequency (LOF) of the LNB. The intermediate frequency has to be specified in units of kHz. For QAM and OFDM frontends the `frequency` specifies the absolute frequency and is given in Hz.

type **dvb\_qpsk\_parameters**

## QPSK parameters

For satellite QPSK frontends you have to use the `dvb_qpsk_parameters` structure:

```
struct dvb_qpsk_parameters {
    uint32_t symbol_rate; /* symbol rate in Symbols per second */
    fe_code_rate_t fec_inner; /* forward error correction (see above) */
};
```

type **dvb\_qam\_parameters**

## QAM parameters

for cable QAM frontend you use the dvb\_qam\_parameters structure:

```
struct dvb_qam_parameters {
    uint32_t symbol_rate; /* symbol rate in Symbols per second */
    fe_code_rate_t fec_inner; /* forward error correction (see above) */
    fe_modulation_t modulation; /* modulation type (see above) */
};
```

type **dvb\_vsb\_parameters**

## VSB parameters

ATSC frontends are supported by the dvb\_vsb\_parameters structure:

```
struct dvb_vsb_parameters {
    fe_modulation_t modulation; /* modulation type (see above) */
};
```

type **dvb\_ofdm\_parameters**

## OFDM parameters

DVB-T frontends are supported by the dvb\_ofdm\_parameters structure:

```
struct dvb_ofdm_parameters {
    fe_bandwidth_t bandwidth;
    fe_code_rate_t code_rate_HP; /* high priority stream code rate */
    fe_code_rate_t code_rate_LP; /* low priority stream code rate */
    fe_modulation_t constellation; /* modulation type (see above) */
    fe_transmit_mode_t transmission_mode;
    fe_guard_interval_t guard_interval;
    fe_hierarchy_t hierarchy_information;
};
```

type **dvb\_frontend\_event**

## frontend events

```
struct dvb_frontend_event {
    fe_status_t status;
    struct dvb_frontend_parameters parameters;
};
```

## Frontend Legacy Function Calls

Those functions are defined at DVB version 3. The support is kept in the kernel due to compatibility issues only. Their usage is strongly not recommended

### FE\_READ\_BER

#### Name

FE\_READ\_BER

**Attention:** This ioctl is deprecated.

#### Synopsis

##### FE\_READ\_BER

```
int ioctl(int fd, FE_READ_BER, uint32_t *ber)
```

#### Arguments

##### fd

File descriptor returned by [open\(\)](#).

##### ber

The bit error rate is stored into \*ber.

#### Description

This ioctl call returns the bit error rate for the signal currently received/demodulated by the front-end. For this command, read-only access to the device is sufficient.

#### Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

Generic error codes are described at the [Generic Error Codes](#) chapter.

## FE\_READ\_SNR

### Name

FE\_READ\_SNR

**Attention:** This ioctl is deprecated.

### Synopsis

#### FE\_READ\_SNR

```
int ioctl(int fd, FE_READ_SNR, int16_t *snr)
```

### Arguments

#### fd

File descriptor returned by [open\(\)](#).

#### snr

The signal-to-noise ratio is stored into \*snr.

### Description

This ioctl call returns the signal-to-noise ratio for the signal currently received by the front-end. For this command, read-only access to the device is sufficient.

### Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

Generic error codes are described at the [Generic Error Codes](#) chapter.

## FE\_READ\_SIGNAL\_STRENGTH

### Name

FE\_READ\_SIGNAL\_STRENGTH

**Attention:** This ioctl is deprecated.

## Synopsis

### FE\_READ\_SIGNAL\_STRENGTH

```
int ioctl(int fd, FE_READ_SIGNAL_STRENGTH, uint16_t *strength)
```

## Arguments

### fd

File descriptor returned by [open\(\)](#).

### strength

The signal strength value is stored into \*strength.

## Description

This ioctl call returns the signal strength value for the signal currently received by the front-end. For this command, read-only access to the device is sufficient.

## Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

Generic error codes are described at the [Generic Error Codes](#) chapter.

## FE\_READ\_UNCORRECTED\_BLOCKS

### Name

FE\_READ\_UNCORRECTED\_BLOCKS

**Attention:** This ioctl is deprecated.

## Synopsis

### FE\_READ\_UNCORRECTED\_BLOCKS

```
int ioctl(int fd, FE_READ_UNCORRECTED_BLOCKS, uint32_t *ublocks)
```

## Arguments

### fd

File descriptor returned by `open()`.

### ublocks

The total number of uncorrected blocks seen by the driver so far.

## Description

This ioctl call returns the number of uncorrected blocks detected by the device driver during its lifetime. For meaningful measurements, the increment in block count during a specific time interval should be calculated. For this command, read-only access to the device is sufficient.

## Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

Generic error codes are described at the [Generic Error Codes](#) chapter.

## FE\_SET\_FRONTEND

**Attention:** This ioctl is deprecated.

## Name

`FE_SET_FRONTEND`

## Synopsis

### FE\_SET\_FRONTEND

```
int ioctl(int fd, FE_SET_FRONTEND, struct dvb_frontend_parameters *p)
```

## Arguments

### fd

File descriptor returned by `open()`.

### p

Points to parameters for tuning operation.

## Description

This ioctl call starts a tuning operation using specified parameters. The result of this call will be successful if the parameters were valid and the tuning could be initiated. The result of the tuning operation in itself, however, will arrive asynchronously as an event (see documentation for [FE\\_GET\\_EVENT](#) and `FrontendEvent`.) If a new [FE\\_SET\\_FRONTEND](#) operation is initiated before the previous one was completed, the previous operation will be aborted in favor of the new one. This command requires read/write access to the device.

## Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

EINVAL	Maximum supported symbol rate reached.
--------	--

Generic error codes are described at the [Generic Error Codes](#) chapter.

## FE\_GET\_FRONTEND

### Name

FE\_GET\_FRONTEND

**Attention:** This ioctl is deprecated.

### Synopsis

#### FE\_GET\_FRONTEND

```
int ioctl(int fd, FE_GET_FRONTEND, struct dvb_frontend_parameters *p)
```

### Arguments

#### fd

File descriptor returned by [open\(\)](#).

#### p

Points to parameters for tuning operation.

## Description

This ioctl call queries the currently effective frontend parameters. For this command, read-only access to the device is sufficient.

## Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

EINVAL	Maximum supported symbol rate reached.
--------	--

Generic error codes are described at the [Generic Error Codes](#) chapter.

## FE\_GET\_EVENT

### Name

`FE_GET_EVENT`

**Attention:** This ioctl is deprecated.

### Synopsis

#### FE\_GET\_EVENT

```
int ioctl(int fd, FE_GET_EVENT, struct dvb_frontend_event *ev)
```

### Arguments

#### fd

File descriptor returned by `open()`.

#### ev

Points to the location where the event, if any, is to be stored.

## Description

This ioctl call returns a frontend event if available. If an event is not available, the behavior depends on whether the device is in blocking or non-blocking mode. In the latter case, the call fails immediately with `errno` set to `EWOULDBLOCK`. In the former case, the call blocks until an event becomes available.

## Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

<code>EWOULDBLOCK</code>	There is no event pending, and the device is in non-blocking mode.
<code>EOVERFLOW</code>	Overflow in event queue - one or more events were lost.

Generic error codes are described at the [Generic Error Codes](#) chapter.

## `FE_DISHNWWORK_SEND_LEGACY_CMD`

### Name

`FE_DISHNWWORK_SEND_LEGACY_CMD`

### Synopsis

#### `FE_DISHNWWORK_SEND_LEGACY_CMD`

```
int ioctl(int fd, FE_DISHNWWORK_SEND_LEGACY_CMD, unsigned long cmd)
```

### Arguments

#### `fd`

File descriptor returned by [`open\(\)`](#).

#### `cmd`

Sends the specified raw cmd to the dish via DISEqC.

## Description

**Warning:** This is a very obscure legacy command, used only at stv0299 driver. Should not be used on newer drivers.

It provides a non-standard method for selecting Diseqc voltage on the frontend, for Dish Network legacy switches.

As support for this ioctl were added in 2004, this means that such dishes were already legacy in 2004.

## Return Value

On success 0 is returned.

On error -1 is returned, and the `errno` variable is set appropriately.

Generic error codes are described at the [Generic Error Codes](#) chapter.

### 13.3.7 Examples

In the past, we used to have a set of examples here. However, those examples got out of date and doesn't even compile nowadays.

Also, nowadays, the best is to use the libdvbv5 DVB API nowadays, with is fully documented.

Please refer to the [libdvbv5](#) for updated/recommended examples.

### 13.3.8 Digital TV uAPI header files

#### Digital TV uAPI headers

##### `frontend.h`

```
/* SPDX-License-Identifier: LGPL-2.1+ WITH Linux-syscall-note */
/*
 * frontend.h
 *
 * Copyright (C) 2000 Marcus Metzler <marcus@convergence.de>
 *                  Ralph Metzler <ralph@convergence.de>
 *                  Holger Waechtler <holger@convergence.de>
 *                  Andre Draszik <ad@convergence.de>
 *                  for convergence integrated media GmbH
 */

#ifndef _DVBFRONTEND_H_
#define _DVBFRONTEND_H_

#include <linux/types.h>

/** 
 * enum fe_caps - Frontend capabilities
 *
 * @FE_IS_STUPID:                                     There's something wrong at the
 *                                                        frontend, and it can't report its
 *                                                        capabilities.
 * @FE_CAN_INVERSION_AUTO:                            Can auto-detect frequency spectral
 *                                                        band inversion
 * @FE_CAN_FEC_1_2:                                    Supports FEC 1/2
 */
```

```

* @FE_CAN_FEC_2_3: Supports FEC 2/3
* @FE_CAN_FEC_3_4: Supports FEC 3/4
* @FE_CAN_FEC_4_5: Supports FEC 4/5
* @FE_CAN_FEC_5_6: Supports FEC 5/6
* @FE_CAN_FEC_6_7: Supports FEC 6/7
* @FE_CAN_FEC_7_8: Supports FEC 7/8
* @FE_CAN_FEC_8_9: Supports FEC 8/9
* @FE_CAN_FEC_AUTO: Can auto-detect FEC
* @FE_CAN_QPSK: Supports QPSK modulation
* @FE_CAN_QAM_16: Supports 16-QAM modulation
* @FE_CAN_QAM_32: Supports 32-QAM modulation
* @FE_CAN_QAM_64: Supports 64-QAM modulation
* @FE_CAN_QAM_128: Supports 128-QAM modulation
* @FE_CAN_QAM_256: Supports 256-QAM modulation
* @FE_CAN_QAM_AUTO: Can auto-detect QAM modulation
* @FE_CAN_TRANSMISSION_MODE_AUTO: Can auto-detect transmission mode
* @FE_CAN_BANDWIDTH_AUTO: Can auto-detect bandwidth
* @FE_CAN_GUARD_INTERVAL_AUTO: Can auto-detect guard interval
* @FE_CAN_HIERARCHY_AUTO: Can auto-detect hierarchy
* @FE_CAN_8VSB: Supports 8-VSB modulation
* @FE_CAN_16VSB: Supports 16-VSB modulation
* @FE_HAS_EXTENDED_CAPS: Unused
* @FE_CAN_MULTISTREAM: Supports multistream filtering
* @FE_CAN_TURBO_FEC: Supports "turbo FEC" modulation
* @FE_CAN_2G_MODULATION: Supports "2nd generation" modulation,
e. g. DVB-S2, DVB-T2, DVB-C2
*
* @FE_NEEDS_BENDING: Unused
* @FE_CAN_RECOVER: Can recover from a cable unplug
automatically
*/
* @FE_CAN_MUTE_TS: Can stop spurious TS data output
enum fe_caps {
    FE_IS_STUPID = 0,
    FE_CAN_INVERSION_AUTO = 0x1,
    FE_CAN_FEC_1_2 = 0x2,
    FE_CAN_FEC_2_3 = 0x4,
    FE_CAN_FEC_3_4 = 0x8,
    FE_CAN_FEC_4_5 = 0x10,
    FE_CAN_FEC_5_6 = 0x20,
    FE_CAN_FEC_6_7 = 0x40,
    FE_CAN_FEC_7_8 = 0x80,
    FE_CAN_FEC_8_9 = 0x100,
    FE_CAN_FEC_AUTO = 0x200,
    FE_CAN_QPSK = 0x400,
    FE_CAN_QAM_16 = 0x800,
    FE_CAN_QAM_32 = 0x1000,
    FE_CAN_QAM_64 = 0x2000,
    FE_CAN_QAM_128 = 0x4000,
    FE_CAN_QAM_256 = 0x8000,
    FE_CAN_QAM_AUTO = 0x10000,
    FE_CAN_TRANSMISSION_MODE_AUTO = 0x20000,

```

```

        FE_CAN_BANDWIDTH_AUTO          = 0x40000,
        FE_CAN_GUARD_INTERVAL_AUTO    = 0x80000,
        FE_CAN_HIERARCHY_AUTO         = 0x100000,
        FE_CAN_8VSB                   = 0x200000,
        FE_CAN_16VSB                  = 0x400000,
        FE_HAS_EXTENDED_CAPS          = 0x800000,
        FE_CAN_MULTISTREAM            = 0x40000000,
        FE_CAN_TURBO_FEC              = 0x80000000,
        FE_CAN_2G_MODULATION          = 0x100000000,
        FE_NEEDS_BENDING               = 0x200000000,
        FE_CAN_RECOVER                 = 0x400000000,
        FE_CAN_MUTE_TS                 = 0x800000000
};

/*
 * DEPRECATED: Should be kept just due to backward compatibility.
 */
enum fe_type {
    FE_QPSK,
    FE_QAM,
    FE_OFDM,
    FE_ATSC
};

/***
 * struct dvb_frontend_info - Frontend properties and capabilities
 *
 * @name:                      Name of the frontend
 * @type:                       ****DEPRECATED****.
 *                               Should not be used on modern programs,
 *                               as a frontend may have more than one type.
 *                               In order to get the support types of a given
 *                               frontend, use :c:type:`DTV_ENUM_DELSYS` instead.
 * @frequency_min:              Minimal frequency supported by the frontend.
 * @frequency_max:              Minimal frequency supported by the frontend.
 * @frequency_stepsize:         All frequencies are multiple of this value.
 * @frequency_tolerance:       Frequency tolerance.
 * @symbol_rate_min:           Minimal symbol rate, in bauds
 *                            (for Cable/Satellite systems).
 * @symbol_rate_max:           Maximal symbol rate, in bauds
 *                            (for Cable/Satellite systems).
 * @symbol_rate_tolerance:     Maximal symbol rate tolerance, in ppm
 *                            (for Cable/Satellite systems).
 * @notifier_delay:            ****DEPRECATED****. Not used by any driver.
 * @caps:                      Capabilities supported by the frontend,
 *                             as specified in &enum fe_caps.
 *
 * .. note:
 *
 * #. The frequencies are specified in Hz for Terrestrial and Cable

```

```
*      systems.
* #. The frequencies are specified in kHz for Satellite systems.
*/
struct dvb_frontend_info {
    char        name[128];
    enum fe_type type;          /* DEPRECATED. Use DTV_ENUM_DELSYS instead */
    __u32       frequency_min;
    __u32       frequency_max;
    __u32       frequency_stepsize;
    __u32       frequency_tolerance;
    __u32       symbol_rate_min;
    __u32       symbol_rate_max;
    __u32       symbol_rate_tolerance;
    __u32       notifier_delay;           /* DEPRECATED */
    enum fe_caps caps;
};

/***
 * struct dvb_diseqc_master_cmd - DiSEqC master command
 *
 * @msg:
 *     DiSEqC message to be sent. It contains a 3 bytes header with:
 *     framing + address + command, and an optional argument
 *     of up to 3 bytes of data.
 * @msg_len:
 *     Length of the DiSEqC message. Valid values are 3 to 6.
 *
 * Check out the DiSEqC bus spec available on http://www.eutelsat.org/ for
 * the possible messages that can be used.
 */
struct dvb_diseqc_master_cmd {
    __u8 msg[6];
    __u8 msg_len;
};

/***
 * struct dvb_diseqc_slave_reply - DiSEqC received data
 *
 * @msg:
 *     DiSEqC message buffer to store a message received via DiSEqC.
 *     It contains one byte header with: framing and
 *     an optional argument of up to 3 bytes of data.
 * @msg_len:
 *     Length of the DiSEqC message. Valid values are 0 to 4,
 *     where 0 means no message.
 * @timeout:
 *     Return from ioctl after timeout ms with errorcode when
 *     no message was received.
 *
 * Check out the DiSEqC bus spec available on http://www.eutelsat.org/ for
 * the possible messages that can be used.
*/
```

```
/*
struct dvb_diseqc_slave_reply {
    __u8 msg[4];
    __u8 msg_len;
    int timeout;
};

/** 
 * enum fe_sec_voltage - DC Voltage used to feed the LNBf
 *
 * @SEC_VOLTAGE_13:      Output 13V to the LNBf
 * @SEC_VOLTAGE_18:      Output 18V to the LNBf
 * @SEC_VOLTAGE_OFF:     Don't feed the LNBf with a DC voltage
 */
enum fe_sec_voltage {
    SEC_VOLTAGE_13,
    SEC_VOLTAGE_18,
    SEC_VOLTAGE_OFF
};

/** 
 * enum fe_sec_tone_mode - Type of tone to be send to the LNBf.
 * @SEC_TONE_ON:          Sends a 22kHz tone burst to the antenna.
 * @SEC_TONE_OFF:         Don't send a 22kHz tone to the antenna (except
 *                       if the ``FE_DISEQC_*`` ioctls are called).
 */
enum fe_sec_tone_mode {
    SEC_TONE_ON,
    SEC_TONE_OFF
};

/** 
 * enum fe_sec_mini_cmd - Type of mini burst to be sent
 *
 * @SEC_MINI_A:           Sends a mini-DiSEqC 22kHz '0' Tone Burst to select
 *                       satellite-A
 * @SEC_MINI_B:           Sends a mini-DiSEqC 22kHz '1' Data Burst to select
 *                       satellite-B
 */
enum fe_sec_mini_cmd {
    SEC_MINI_A,
    SEC_MINI_B
};

/** 
 * enum fe_status - Enumerates the possible frontend status.
 * @FE_NONE:              The frontend doesn't have any kind of lock.
 * @FE_HAS_SIGNAL:        That's the initial frontend status
 * @FE_HAS_CARRIER:       Has found something above the noise level.
 * @FE_HAS_VITERBI:       Has found a signal.
 * @FE_HAS_LDPC:          FEC inner coding (Viterbi, LDPC or other inner code).
 */
```

```
*                      is stable.
* @FE_HAS_SYNC:      Synchronization bytes was found.
* @FE_HAS_LOCK:     Digital TV were locked and everything is working.
* @FE_TIMEDOUT:    Fo lock within the last about 2 seconds.
* @FE_REINIT:       Frontend was reinitialized, application is recommended
*                   to reset DiSEqC, tone and parameters.
*/
enum fe_status {
    FE_NONE              = 0x00,
    FE_HAS_SIGNAL        = 0x01,
    FE_HAS_CARRIER       = 0x02,
    FE_HAS_VITERBI      = 0x04,
    FE_HAS_SYNC          = 0x08,
    FE_HAS_LOCK          = 0x10,
    FE_TIMEDOUT         = 0x20,
    FE_REINIT            = 0x40,
};

/***
 * enum fe_spectral_inversion - Type of inversion band
 *
 * @INVERSION_OFF:      Don't do spectral band inversion.
 * @INVERSION_ON:        Do spectral band inversion.
 * @INVERSION_AUTO:     Autodetect spectral band inversion.
 *
 * This parameter indicates if spectral inversion should be presumed or
 * not. In the automatic setting (`INVERSION_AUTO`) the hardware will try
 * to figure out the correct setting by itself. If the hardware doesn't
 * support, the %dvb_frontend will try to lock at the carrier first with
 * inversion off. If it fails, it will try to enable inversion.
 */
enum fe_spectral_inversion {
    INVERSION_OFF,
    INVERSION_ON,
    INVERSION_AUTO
};

/***
 * enum fe_code_rate - Type of Forward Error Correction (FEC)
 *
 * @FEC_NONE: No Forward Error Correction Code
 * @FEC_1_2:  Forward Error Correction Code 1/2
 * @FEC_2_3:  Forward Error Correction Code 2/3
 * @FEC_3_4:  Forward Error Correction Code 3/4
 * @FEC_4_5:  Forward Error Correction Code 4/5
 * @FEC_5_6:  Forward Error Correction Code 5/6
 * @FEC_6_7:  Forward Error Correction Code 6/7
 * @FEC_7_8:  Forward Error Correction Code 7/8
 * @FEC_8_9:  Forward Error Correction Code 8/9
 * @FEC_AUTO: Autodetect Error Correction Code
 * @FEC_3_5:  Forward Error Correction Code 3/5
```

```
* @FEC_9_10: Forward Error Correction Code 9/10
* @FEC_2_5: Forward Error Correction Code 2/5
* @FEC_1_3: Forward Error Correction Code 1/3
* @FEC_1_4: Forward Error Correction Code 1/4
* @FEC_5_9: Forward Error Correction Code 5/9
* @FEC_7_9: Forward Error Correction Code 7/9
* @FEC_8_15: Forward Error Correction Code 8/15
* @FEC_11_15: Forward Error Correction Code 11/15
* @FEC_13_18: Forward Error Correction Code 13/18
* @FEC_9_20: Forward Error Correction Code 9/20
* @FEC_11_20: Forward Error Correction Code 11/20
* @FEC_23_36: Forward Error Correction Code 23/36
* @FEC_25_36: Forward Error Correction Code 25/36
* @FEC_13_45: Forward Error Correction Code 13/45
* @FEC_26_45: Forward Error Correction Code 26/45
* @FEC_28_45: Forward Error Correction Code 28/45
* @FEC_32_45: Forward Error Correction Code 32/45
* @FEC_77_90: Forward Error Correction Code 77/90
* @FEC_11_45: Forward Error Correction Code 11/45
* @FEC_4_15: Forward Error Correction Code 4/15
* @FEC_14_45: Forward Error Correction Code 14/45
* @FEC_7_15: Forward Error Correction Code 7/15
*
* Please note that not all FEC types are supported by a given standard.
*/
enum fe_code_rate {
    FEC_NONE = 0,
    FEC_1_2,
    FEC_2_3,
    FEC_3_4,
    FEC_4_5,
    FEC_5_6,
    FEC_6_7,
    FEC_7_8,
    FEC_8_9,
    FEC_AUTO,
    FEC_3_5,
    FEC_9_10,
    FEC_2_5,
    FEC_1_3,
    FEC_1_4,
    FEC_5_9,
    FEC_7_9,
    FEC_8_15,
    FEC_11_15,
    FEC_13_18,
    FEC_9_20,
    FEC_11_20,
    FEC_23_36,
    FEC_25_36,
    FEC_13_45,
```

```
FEC_26_45,
FEC_28_45,
FEC_32_45,
FEC_77_90,
FEC_11_45,
FEC_4_15,
FEC_14_45,
FEC_7_15,
};

/**
 * enum fe_modulation - Type of modulation/constellation
 * @QPSK:          QPSK modulation
 * @QAM_16:         16-QAM modulation
 * @QAM_32:         32-QAM modulation
 * @QAM_64:         64-QAM modulation
 * @QAM_128:        128-QAM modulation
 * @QAM_256:        256-QAM modulation
 * @QAM_AUTO:       Autodetect QAM modulation
 * @VSB_8:          8-VSB modulation
 * @VSB_16:         16-VSB modulation
 * @PSK_8:          8-PSK modulation
 * @APSK_16:         16-APSK modulation
 * @APSK_32:         32-APSK modulation
 * @DQPSK:          DQPSK modulation
 * @QAM_4_NR:        4-QAM-NR modulation
 * @QAM_1024:        1024-QAM modulation
 * @QAM_4096:        4096-QAM modulation
 * @APSK_8_L:         8APSK-L modulation
 * @APSK_16_L:        16APSK-L modulation
 * @APSK_32_L:        32APSK-L modulation
 * @APSK_64:          64APSK modulation
 * @APSK_64_L:         64APSK-L modulation
 *
 * Please note that not all modulations are supported by a given standard.
 *
 */
enum fe_modulation {
    QPSK,
    QAM_16,
    QAM_32,
    QAM_64,
    QAM_128,
    QAM_256,
    QAM_AUTO,
    VSB_8,
    VSB_16,
    PSK_8,
    APSK_16,
    APSK_32,
    DQPSK,
```

```

        QAM_4_NR,
        QAM_1024,
        QAM_4096,
        APSK_8_L,
        APSK_16_L,
        APSK_32_L,
        APSK_64,
        APSK_64_L,
};

/***
 * enum fe_transmit_mode - Transmission mode
 *
 * @TRANSMISSION_MODE_AUTO:
 *     Autodetect transmission mode. The hardware will try to find the
 *     correct FFT-size (if capable) to fill in the missing parameters.
 * @TRANSMISSION_MODE_1K:
 *     Transmission mode 1K
 * @TRANSMISSION_MODE_2K:
 *     Transmission mode 2K
 * @TRANSMISSION_MODE_8K:
 *     Transmission mode 8K
 * @TRANSMISSION_MODE_4K:
 *     Transmission mode 4K
 * @TRANSMISSION_MODE_16K:
 *     Transmission mode 16K
 * @TRANSMISSION_MODE_32K:
 *     Transmission mode 32K
 * @TRANSMISSION_MODE_C1:
 *     Single Carrier (C=1) transmission mode (DTMB only)
 * @TRANSMISSION_MODE_C3780:
 *     Multi Carrier (C=3780) transmission mode (DTMB only)
 *
 * Please note that not all transmission modes are supported by a given
 * standard.
 */
enum fe_transmit_mode {
    TRANSMISSION_MODE_2K,
    TRANSMISSION_MODE_8K,
    TRANSMISSION_MODE_AUTO,
    TRANSMISSION_MODE_4K,
    TRANSMISSION_MODE_1K,
    TRANSMISSION_MODE_16K,
    TRANSMISSION_MODE_32K,
    TRANSMISSION_MODE_C1,
    TRANSMISSION_MODE_C3780,
};

/***
 * enum fe_guard_interval - Guard interval
 *

```

```
* @GUARD_INTERVAL_AUTO:           Autodetect the guard interval
* @GUARD_INTERVAL_1_128:         Guard interval 1/128
* @GUARD_INTERVAL_1_32:          Guard interval 1/32
* @GUARD_INTERVAL_1_16:          Guard interval 1/16
* @GUARD_INTERVAL_1_8:           Guard interval 1/8
* @GUARD_INTERVAL_1_4:           Guard interval 1/4
* @GUARD_INTERVAL_19_128:        Guard interval 19/128
* @GUARD_INTERVAL_19_256:        Guard interval 19/256
* @GUARD_INTERVAL_PN420:         PN length 420 (1/4)
* @GUARD_INTERVAL_PN595:         PN length 595 (1/6)
* @GUARD_INTERVAL_PN945:         PN length 945 (1/9)
* @GUARD_INTERVAL_1_64:          Guard interval 1/64
*
* Please note that not all guard intervals are supported by a given standard.
*/
enum fe_guard_interval {
    GUARD_INTERVAL_1_32,
    GUARD_INTERVAL_1_16,
    GUARD_INTERVAL_1_8,
    GUARD_INTERVAL_1_4,
    GUARD_INTERVAL_AUTO,
    GUARD_INTERVAL_1_128,
    GUARD_INTERVAL_19_128,
    GUARD_INTERVAL_19_256,
    GUARD_INTERVAL_PN420,
    GUARD_INTERVAL_PN595,
    GUARD_INTERVAL_PN945,
    GUARD_INTERVAL_1_64,
};

/***
* enum fe_hierarchy - Hierarchy
* @HIERARCHY_NONE:      No hierarchy
* @HIERARCHY_AUTO:       Autodetect hierarchy (if supported)
* @HIERARCHY_1:          Hierarchy 1
* @HIERARCHY_2:          Hierarchy 2
* @HIERARCHY_4:          Hierarchy 4
*
* Please note that not all hierarchy types are supported by a given standard.
*/
enum fe_hierarchy {
    HIERARCHY_NONE,
    HIERARCHY_1,
    HIERARCHY_2,
    HIERARCHY_4,
    HIERARCHY_AUTO
};

/***
* enum fe_interleaving - Interleaving
* @INTERLEAVING_NONE:   No interleaving.
```

```

* @INTERLEAVING_AUTO: Auto-detect interleaving.
* @INTERLEAVING_240: Interleaving of 240 symbols.
* @INTERLEAVING_720: Interleaving of 720 symbols.
*
* Please note that, currently, only DTMB uses it.
*/
enum fe_interleaving {
    INTERLEAVING_NONE,
    INTERLEAVING_AUTO,
    INTERLEAVING_240,
    INTERLEAVING_720,
};

/* DVBv5 property Commands */

#define DTV_UNDEFINED          0
#define DTV_TUNE                1
#define DTV_CLEAR               2
#define DTV_FREQUENCY           3
#define DTV_MODULATION          4
#define DTV_BANDWIDTH_HZ         5
#define DTV_INVERSION            6
#define DTV_DISEQC_MASTER        7
#define DTV_SYMBOL_RATE           8
#define DTV_INNER_FEC             9
#define DTV_VOLTAGE              10
#define DTV_TONE                  11
#define DTV_PILOT                 12
#define DTV_ROLLOFF                13
#define DTV_DISEQC_SLAVE_REPLY      14

/* Basic enumeration set for querying unlimited capabilities */
#define DTV_FE_CAPABILITY_COUNT   15
#define DTV_FE_CAPABILITY          16
#define DTV_DELIVERY_SYSTEM         17

/* ISDB-T and ISDB-Tsb */
#define DTV_ISDBT_PARTIAL_RECEPTION 18
#define DTV_ISDBT_SOUND_BROADCASTING 19

#define DTV_ISDBT_SB_SUBCHANNEL_ID    20
#define DTV_ISDBT_SB_SEGMENT_IDX      21
#define DTV_ISDBT_SB_SEGMENT_COUNT     22

#define DTV_ISDBT_LAYERA_FEC          23
#define DTV_ISDBT_LAYERA_MODULATION    24
#define DTV_ISDBT_LAYERA_SEGMENT_COUNT 25
#define DTV_ISDBT_LAYERA_TIME_INTERLEAVING 26

#define DTV_ISDBT_LAYERB_FEC          27
#define DTV_ISDBT_LAYERB_MODULATION    28

```

#define DTV_ISDBT_LAYERB_SEGMENT_COUNT	29
#define DTV_ISDBT_LAYERB_TIME_INTERLEAVING	30
#define DTV_ISDBT_LAYERC_FEC	31
#define DTV_ISDBT_LAYERC_MODULATION	32
#define DTV_ISDBT_LAYERC_SEGMENT_COUNT	33
#define DTV_ISDBT_LAYERC_TIME_INTERLEAVING	34
#define DTV_API_VERSION	35
#define DTV_CODE_RATE_HP	36
#define DTV_CODE_RATE_LP	37
#define DTV_GUARD_INTERVAL	38
#define DTV_TRANSMISSION_MODE	39
#define DTV_HIERARCHY	40
#define DTV_ISDBT_LAYER_ENABLED	41
#define DTV_STREAM_ID	42
#define DTV_ISDBS_TS_ID_LEGACY	DTV_STREAM_ID
#define DTV_DVBT2_PLP_ID_LEGACY	43
#define DTV_ENUM_DELSYS	44
/* ATSC-MH */	
#define DTV_ATSCMH_FIC_VER	45
#define DTV_ATSCMH_PARADE_ID	46
#define DTV_ATSCMH_NOG	47
#define DTV_ATSCMH_TNOG	48
#define DTV_ATSCMH_SGN	49
#define DTV_ATSCMH_PRC	50
#define DTV_ATSCMH_RS_FRAME_MODE	51
#define DTV_ATSCMH_RS_FRAME_ENSEMBLE	52
#define DTV_ATSCMH_RS_CODE_MODE_PRI	53
#define DTV_ATSCMH_RS_CODE_MODE_SEC	54
#define DTV_ATSCMH_SCCC_BLOCK_MODE	55
#define DTV_ATSCMH_SCCC_CODE_MODE_A	56
#define DTV_ATSCMH_SCCC_CODE_MODE_B	57
#define DTV_ATSCMH_SCCC_CODE_MODE_C	58
#define DTV_ATSCMH_SCCC_CODE_MODE_D	59
#define DTV_INTERLEAVING	60
#define DTV_LNA	61
/* Quality parameters */	
#define DTV_STAT_SIGNAL_STRENGTH	62
#define DTV_STAT_CNR	63
#define DTV_STAT_PRE_ERROR_BIT_COUNT	64
#define DTV_STAT_PRE_TOTAL_BIT_COUNT	65
#define DTV_STAT_POST_ERROR_BIT_COUNT	66
#define DTV_STAT_POST_TOTAL_BIT_COUNT	67

```

#define DTV_STAT_ERROR_BLOCK_COUNT      68
#define DTV_STAT_TOTAL_BLOCK_COUNT     69

/* Physical layer scrambling */
#define DTV_SCRAMBLING_SEQUENCE_INDEX 70

#define DTV_MAX_COMMAND           DTV_SCRAMBLING_SEQUENCE_INDEX

/**
 * enum fe_pilot - Type of pilot tone
 *
 * @PILOT_ON:   Pilot tones enabled
 * @PILOT_OFF:  Pilot tones disabled
 * @PILOT_AUTO: Autodetect pilot tones
 */
enum fe_pilot {
    PILOT_ON,
    PILOT_OFF,
    PILOT_AUTO,
};

/**
 * enum fe_rolloff - Rolloff factor
 * @ROLLOFF_35:          Rolloff factor:  $\alpha=35\%$ 
 * @ROLLOFF_20:          Rolloff factor:  $\alpha=20\%$ 
 * @ROLLOFF_25:          Rolloff factor:  $\alpha=25\%$ 
 * @ROLLOFF_AUTO:        Auto-detect the rolloff factor.
 * @ROLLOFF_15:          Rolloff factor:  $\alpha=15\%$ 
 * @ROLLOFF_10:          Rolloff factor:  $\alpha=10\%$ 
 * @ROLLOFF_5:           Rolloff factor:  $\alpha=5\%$ 
 *
 * .. note:
 *
 *   Rolloff factor of 35% is implied on DVB-S. On DVB-S2, it is default.
 */
enum fe_rolloff {
    ROLLOFF_35,
    ROLLOFF_20,
    ROLLOFF_25,
    ROLLOFF_AUTO,
    ROLLOFF_15,
    ROLLOFF_10,
    ROLLOFF_5,
};

/**
 * enum fe_delivery_system - Type of the delivery system
 *
 * @SYS_UNDEFINED:
 *   Undefined standard. Generally, indicates an error
 * @SYS_DVBC_ANNEX_A:

```

```
*      Cable TV: DVB-C following ITU-T J.83 Annex A spec
* @SYS_DVBC_ANNEX_B:
*      Cable TV: DVB-C following ITU-T J.83 Annex B spec (ClearQAM)
* @SYS_DVBC_ANNEX_C:
*      Cable TV: DVB-C following ITU-T J.83 Annex C spec
* @SYS_DVBC2:
*      Cable TV: DVB-C2
* @SYS_ISDBC:
*      Cable TV: ISDB-C (no drivers yet)
* @SYS_DVBT:
*      Terrestrial TV: DVB-T
* @SYS_DVBT2:
*      Terrestrial TV: DVB-T2
* @SYS_ISDBT:
*      Terrestrial TV: ISDB-T
* @SYS_ATSC:
*      Terrestrial TV: ATSC
* @SYS_ATSCMH:
*      Terrestrial TV (mobile): ATSC-M/H
* @SYS_DTMB:
*      Terrestrial TV: DTMB
* @SYS_DVBS:
*      Satellite TV: DVB-S
* @SYS_DVBS2:
*      Satellite TV: DVB-S2 and DVB-S2X
* @SYS_TURBO:
*      Satellite TV: DVB-S Turbo
* @SYS_ISDBS:
*      Satellite TV: ISDB-S
* @SYS_DAB:
*      Digital audio: DAB (not fully supported)
* @SYS_DSS:
*      Satellite TV: DSS (not fully supported)
* @SYS_CMMB:
*      Terrestrial TV (mobile): CMMB (not fully supported)
* @SYS_DVBH:
*      Terrestrial TV (mobile): DVB-H (standard deprecated)
*/
enum fe_delivery_system {
    SYS_UNDEFINED,
    SYS_DVBC_ANNEX_A,
    SYS_DVBC_ANNEX_B,
    SYS_DVBT,
    SYS_DSS,
    SYS_DVBS,
    SYS_DVBS2,
    SYS_DVBH,
    SYS_ISDBT,
    SYS_ISDBS,
    SYS_ISDBC,
    SYS_ATSC,
```

```

SYS_ATSCMH,
SYS_DTMB,
SYS_CMMB,
SYS_DAB,
SYS_DVBT2,
SYS_TURBO,
SYS_DVBC_ANNEX_C,
SYS_DVBC2,
};

/* backward compatibility definitions for delivery systems */
#define SYS_DVBC_ANNEX_AC      SYS_DVBC_ANNEX_A
#define SYS_DMBTH              SYS_DTMB /* DMB-TH is legacy name, use DTMB */

/* ATSC-MH specific parameters */

/***
 * enum atscmh_sccc_block_mode - Type of Series Concatenated Convolutional
 *                                     Code Block Mode.
 *
 * @ATSCMH_SCCC_BLK_SEP:
 *     Separate SCCC: the SCCC outer code mode shall be set independently
 *     for each Group Region (A, B, C, D)
 * @ATSCMH_SCCC_BLK_COMB:
 *     Combined SCCC: all four Regions shall have the same SCCC outer
 *     code mode.
 * @ATSCMH_SCCC_BLK_RES:
 *     Reserved. Shouldn't be used.
 */
enum atscmh_sccc_block_mode {
    ATSCMH_SCCC_BLK_SEP      = 0,
    ATSCMH_SCCC_BLK_COMB    = 1,
    ATSCMH_SCCC_BLK_RES     = 2,
};

/***
 * enum atscmh_sccc_code_mode - Type of Series Concatenated Convolutional
 *                                     Code Rate.
 *
 * @ATSCMH_SCCC_CODE_HLF:
 *     The outer code rate of a SCCC Block is 1/2 rate.
 * @ATSCMH_SCCC_CODE_QTR:
 *     The outer code rate of a SCCC Block is 1/4 rate.
 * @ATSCMH_SCCC_CODE_RES:
 *     Reserved. Should not be used.
 */
enum atscmh_sccc_code_mode {
    ATSCMH_SCCC_CODE_HLF     = 0,
    ATSCMH_SCCC_CODE_QTR     = 1,
    ATSCMH_SCCC_CODE_RES     = 2,
};

```

```
/**  
 * enum atscmh_rs_frame_ensemble - Reed Solomon(RS) frame ensemble.  
 *  
 * @ATSCMH_RSFRAME_ENS_PRI: Primary Ensemble.  
 * @ATSCMH_RSFRAME_ENS_SEC: Secondary Ensemble.  
 */  
enum atscmh_rs_frame_ensemble {  
    ATSCMH_RSFRAME_ENS_PRI = 0,  
    ATSCMH_RSFRAME_ENS_SEC = 1,  
};  
  
/**  
 * enum atscmh_rs_frame_mode - Reed Solomon (RS) frame mode.  
 *  
 * @ATSCMH_RSFRAME_PRI_ONLY:  
 *     Single Frame: There is only a primary RS Frame for all Group  
 *     Regions.  
 * @ATSCMH_RSFRAME_PRI_SEC:  
 *     Dual Frame: There are two separate RS Frames: Primary RS Frame for  
 *     Group Region A and B and Secondary RS Frame for Group Region C and  
 *     D.  
 * @ATSCMH_RSFRAME_RES:  
 *     Reserved. Shouldn't be used.  
 */  
enum atscmh_rs_frame_mode {  
    ATSCMH_RSFRAME_PRI_ONLY = 0,  
    ATSCMH_RSFRAME_PRI_SEC = 1,  
    ATSCMH_RSFRAME_RES = 2,  
};  
  
/**  
 * enum atscmh_rs_code_mode - ATSC-M/H Reed Solomon modes  
 * @ATSCMH_RSCODE_211_187: Reed Solomon code (211,187).  
 * @ATSCMH_RSCODE_223_187: Reed Solomon code (223,187).  
 * @ATSCMH_RSCODE_235_187: Reed Solomon code (235,187).  
 * @ATSCMH_RSCODE_RES: Reserved. Shouldn't be used.  
 */  
enum atscmh_rs_code_mode {  
    ATSCMH_RSCODE_211_187 = 0,  
    ATSCMH_RSCODE_223_187 = 1,  
    ATSCMH_RSCODE_235_187 = 2,  
    ATSCMH_RSCODE_RES = 3,  
};  
  
#define NO_STREAM_ID_FILTER (~0U)  
#define LNA_AUTO (~0U)  
  
/**  
 * enum fecap_scale_params - scale types for the quality parameters.  
 */
```

```

* @FE_SCALE_NOT_AVAILABLE: That QoS measure is not available. That
*                           could indicate a temporary or a permanent
*                           condition.
* @FE_SCALE_DECIBEL: The scale is measured in 0.001 dB steps, typically
*                           used on signal measures.
* @FE_SCALE_RELATIVE: The scale is a relative percentual measure,
*                           ranging from 0 (0%) to 0xffff (100%).
* @FE_SCALE_COUNTER: The scale counts the occurrence of an event, like
*                           bit error, block error, lapsed time.
*/
enum fecap_scale_params {
    FE_SCALE_NOT_AVAILABLE = 0,
    FE_SCALE_DECIBEL,
    FE_SCALE_RELATIVE,
    FE_SCALE_COUNTER
};

/***
* struct dtv_stats - Used for reading a DTV status property
*
* @scale:
*     Filled with enum fecap_scale_params - the scale in usage
*     for that parameter
*
* @svalue:
*     integer value of the measure, for %FE_SCALE_DECIBEL,
*     used for dB measures. The unit is 0.001 dB.
*
* @uvalue:
*     unsigned integer value of the measure, used when @scale is
*     either %FE_SCALE_RELATIVE or %FE_SCALE_COUNTER.
*
* For most delivery systems, this will return a single value for each
* parameter.
*
* It should be noticed, however, that new OFDM delivery systems like
* ISDB can use different modulation types for each group of carriers.
* On such standards, up to 8 groups of statistics can be provided, one
* for each carrier group (called "layer" on ISDB).
*
* In order to be consistent with other delivery systems, the first
* value refers to the entire set of carriers ("global").
*
* @scale should use the value %FE_SCALE_NOT_AVAILABLE when
* the value for the entire group of carriers or from one specific layer
* is not provided by the hardware.
*
* @len should be filled with the latest filled status + 1.
*
* In other words, for ISDB, those values should be filled like::
```

```

*      u.st.stat.svalue[0] = global statistics;
*      u.st.stat.scale[0] = FE_SCALE_DECIBEL;
*      u.st.stat.value[1] = layer A statistics;
*      u.st.stat.scale[1] = FE_SCALE_NOT_AVAILABLE (if not available);
*      u.st.stat.svalue[2] = layer B statistics;
*      u.st.stat.scale[2] = FE_SCALE_DECIBEL;
*      u.st.stat.svalue[3] = layer C statistics;
*      u.st.stat.scale[3] = FE_SCALE_DECIBEL;
*      u.st.len = 4;
*/
struct dtv_stats {
    __u8 scale;      /* enum fecap_scale_params type */
    union {
        __u64 uvalue;    /* for counters and relative scales */
        __s64 svalue;   /* for 0.001 dB measures */
    };
} __attribute__ ((packed));

#define MAX_DTV_STATS 4

/***
 * struct dtv_fe_stats - store Digital TV frontend statistics
 *
 * @len:          length of the statistics - if zero, stats is disabled.
 * @stat:         array with digital TV statistics.
 *
 * On most standards, @len can either be 0 or 1. However, for ISDB, each
 * layer is modulated in separate. So, each layer may have its own set
 * of statistics. If so, stat[0] carries on a global value for the property.
 * Indexes 1 to 3 means layer A to B.
 */
struct dtv_fe_stats {
    __u8 len;
    struct dtv_stats stat[MAX_DTV_STATS];
} __attribute__ ((packed));

/***
 * struct dtv_property - store one of frontend command and its value
 *
 * @cmd:           Digital TV command.
 * @reserved:      Not used.
 * @u:             Union with the values for the command.
 * @u.data:        A unsigned 32 bits integer with command value.
 * @u.buffer:      Struct to store bigger properties.
 *
 * @u.buffer.data: an unsigned 32-bits array.
 * @u.buffer.len:  number of elements of the buffer.
 * @u.buffer.reserved1: Reserved.
 * @u.buffer.reserved2: Reserved.
 * @u.st:          a &struct dtv_fe_stats array of statistics.
 * @result:        Currently unused.
 */

```

```

/*
 */
struct dtv_property {
    __u32 cmd;
    __u32 reserved[3];
    union {
        __u32 data;
        struct dtv_fe_stats st;
        struct {
            __u8 data[32];
            __u32 len;
            __u32 reserved1[3];
            void *reserved2;
        } buffer;
    } u;
    int result;
} __attribute__ ((packed));

/* num of properties cannot exceed DTV_IOCTL_MAX_MSGS per ioctl */
#define DTV_IOCTL_MAX_MSGS 64

/***
 * struct dtv_properties - a set of command/value pairs.
 *
 * @num:           amount of commands stored at the struct.
 * @props:         a pointer to &struct dtv_property.
 */
struct dtv_properties {
    __u32 num;
    struct dtv_property *props;
};

/*
 * When set, this flag will disable any zigzagging or other "normal" tuning
 * behavior. Additionally, there will be no automatic monitoring of the lock
 * status, and hence no frontend events will be generated. If a frontend device
 * is closed, this flag will be automatically turned off when the device is
 * reopened read-write.
 */
#define FE_TUNE_MODE_ONESHOT 0x01

/* Digital TV Frontend API calls */

#define FE_GET_INFO           _IOR('o', 61, struct dvb_frontend_info)

#define FE_DISEQC_RESET_OVERLOAD _IO('o', 62)
#define FE_DISEQC_SEND_MASTER_CMD _IOW('o', 63, struct dvb_diseqc_master_cmd)
#define FE_DISEQC_RECV_SLAVE_REPLY _IOR('o', 64, struct dvb_diseqc_slave_reply)
#define FE_DISEQC_SEND_BURST    _IO('o', 65) /* fe_sec_mini_cmd_t */

#define FE_SET_TONE             _IO('o', 66) /* fe_sec_tone_mode_t */

```

```

#define FE_SET_VOLTAGE _I0('o', 67) /* fe_sec_voltage_t */
#define FE_ENABLE_HIGH_LNB_VOLTAGE _I0('o', 68) /* int */

#define FE_READ_STATUS _IOR('o', 69, fe_status_t)
#define FE_READ_BER _IOR('o', 70, __u32)
#define FE_READ_SIGNAL_STRENGTH _IOR('o', 71, __u16)
#define FE_READ_SNR _IOR('o', 72, __u16)
#define FE_READ_UNCORRECTED_BLOCKS _IOR('o', 73, __u32)

#define FE_SET_FRONTEND_TUNE_MODE _IO('o', 81) /* unsigned int */
#define FE_GET_EVENT _IOR('o', 78, struct dvb_frontend_event)

#define FE_DISHNETHWORK_SEND_LEGACY_CMD _IO('o', 80) /* unsigned int */

#define FE_SET_PROPERTY _IOW('o', 82, struct dtv_properties)
#define FE_GET_PROPERTY _IOR('o', 83, struct dtv_properties)

#if defined(__DVB_CORE__) || !defined(__KERNEL__)

/*
 * DEPRECATED: Everything below is deprecated in favor of DVBv5 API
 *
 * The DVBv3 only ioctls, structs and enums should not be used on
 * newer programs, as it doesn't support the second generation of
 * digital TV standards, nor supports newer delivery systems.
 * They also don't support modern frontends with usually support multiple
 * delivery systems.
 *
 * Drivers shouldn't use them.
 *
 * New applications should use DVBv5 delivery system instead
 */
/* */

enum fe_bandwidth {
    BANDWIDTH_8_MHZ,
    BANDWIDTH_7_MHZ,
    BANDWIDTH_6_MHZ,
    BANDWIDTH_AUTO,
    BANDWIDTH_5_MHZ,
    BANDWIDTH_10_MHZ,
    BANDWIDTH_1_712_MHZ,
};

/* This is kept for legacy userspace support */
typedef enum fe_sec_voltage fe_sec_voltage_t;
typedef enum fe_caps fe_caps_t;
typedef enum fe_type fe_type_t;
typedef enum fe_sec_tone_mode fe_sec_tone_mode_t;

```

```

typedef enum fe_sec_mini_cmd fe_sec_mini_cmd_t;
typedef enum fe_status fe_status_t;
typedef enum fe_spectral_inversion fe_spectral_inversion_t;
typedef enum fe_code_rate fe_code_rate_t;
typedef enum fe_modulation fe_modulation_t;
typedef enum fe_transmit_mode fe_transmit_mode_t;
typedef enum fe_bandwidth fe_bandwidth_t;
typedef enum fe_guard_interval fe_guard_interval_t;
typedef enum fe_hierarchy fe_hierarchy_t;
typedef enum fe_pilot fe_pilot_t;
typedef enum fe_rolloff fe_rolloff_t;
typedef enum fe_delivery_system fe_delivery_system_t;

/* DVBv3 structs */

struct dvb_qpsk_parameters {
    __u32 symbol_rate; /* symbol rate in Symbols per second */
    fe_code_rate_t fec_inner; /* forward error correction (see above) */
};

struct dvb_qam_parameters {
    __u32 symbol_rate; /* symbol rate in Symbols per second */
    fe_code_rate_t fec_inner; /* forward error correction (see above) */
    fe_modulation_t modulation; /* modulation type (see above) */
};

struct dvb_vsb_parameters {
    fe_modulation_t modulation; /* modulation type (see above) */
};

struct dvb_ofdm_parameters {
    fe_bandwidth_t bandwidth;
    fe_code_rate_t code_rate_HP; /* high priority stream code rate */
    fe_code_rate_t code_rate_LP; /* low priority stream code rate */
    fe_modulation_t constellation; /* modulation type (see above) */
    fe_transmit_mode_t transmission_mode;
    fe_guard_interval_t guard_interval;
    fe_hierarchy_t hierarchy_information;
};

struct dvb_frontend_parameters {
    __u32 frequency; /* (absolute) frequency in Hz for DVB-C/DVB-T/ATSC */
                      /* intermediate frequency in kHz for DVB-S */
    fe_spectral_inversion_t inversion;
    union {
        struct dvb_qpsk_parameters qpsk; /* DVB-S */
        struct dvb_qam_parameters qam; /* DVB-C */
        struct dvb_ofdm_parameters ofdm; /* DVB-T */
        struct dvb_vsb_parameters vsb; /* ATSC */
    } u;
};

```

```
};

struct dvb_frontend_event {
    fe_status_t status;
    struct dvb_frontend_parameters parameters;
};

/* DVBy3 API calls */

#define FE_SET_FRONTEND           _IOW('o', 76, struct dvb_frontend_
    ~parameters)
#define FE_GET_FRONTEND           _IOR('o', 77, struct dvb_frontend_
    ~parameters)

#endif

#endif /* _DVBFRONTEND_H_ */
```

## dmx.h

```
/* SPDX-License-Identifier: LGPL-2.1+ WITH Linux-syscall-note */
/*
 * dmx.h
 *
 * Copyright (C) 2000 Marcus Metzler <marcus@convergence.de>
 *                  & Ralph Metzler <ralph@convergence.de>
 *                  for convergence integrated media GmbH
 */

#ifndef _UAPI_DVBDMX_H_
#define _UAPI_DVBDMX_H_

#include <linux/types.h>
#ifndef __KERNEL__
#include <time.h>
#endif

#define DMX_FILTER_SIZE 16

/***
 * enum dmx_output - Output for the demux.
 *
 * @c:type:DMX_OUT_DECODER <dmx_output>:
 *     Streaming directly to decoder.
 * @c:type:DMX_OUT_TAP <dmx_output>:
 *     Output going to a memory buffer (to be retrieved via the read command).
 *     Delivers the stream output to the demux device on which the ioctl
 *     is called.
 * @c:type:DMX_OUT_TS_TAP <dmx_output>:
 *     Output multiplexed into a new TS (to be retrieved by reading from the
```

```

*      logical DVR device). Routes output to the logical DVR device
*      ``/dev/dvb/adapter?/dvr?``, which delivers a TS multiplexed from all
*      filters for which @:c:type:DMX_OUT_TS_TAP <dmx_output> was specified.
* @:c:type:DMX_OUT_TSDEMUX_TAP <dmx_output>:
*      Like @:c:type:DMX_OUT_TS_TAP <dmx_output> but retrieved from the DMXdevice.
*/
enum dmx_output {
    DMX_OUT_DECODER,
    DMX_OUT_TAP,
    DMX_OUT_TS_TAP,
    DMX_OUT_TSDEMUX_TAP
};

/***
* dmx_input - Input from the demux.
*
* @:c:type:DMX_IN_FRONTEND <dmx_input>:      Input from a front-end device.
* @:c:type:DMX_IN_DVR <dmx_input>:            Input from the logical DVR device.
*/
dmx_input {
    DMX_IN_FRONTEND,
    DMX_IN_DVR
};

/***
* dmx_ts_pes - type of the PES filter.
*
* @:c:type:DMX_PES_AUDIO0 <dmx_pes_type>:      first audio PID. Also referredas @DMX_PES_AUDIO.
* @:c:type:DMX_PES_VIDEO0 <dmx_pes_type>:        first video PID. Also referredas @DMX_PES_VIDEO.
* @:c:type:DMX_PES_TELETEXT0 <dmx_pes_type>:     first teletext PID. Alsoreferred as @DMX_PES_TELETEXT.
* @:c:type:DMX_PES_SUBTITLE0 <dmx_pes_type>:     first subtitle PID. Alsoreferred as @DMX_PES_SUBTITLE.
* @:c:type:DMX_PES_PCR0 <dmx_pes_type>:          first Program Clock ReferencePID.
*                                              Also referred as @DMX_PES_PCR.
*
* @:c:type:DMX_PES_AUDIO1 <dmx_pes_type>:        second audio PID.
* @:c:type:DMX_PES_VIDEO1 <dmx_pes_type>:         second video PID.
* @:c:type:DMX_PES_TELETEXT1 <dmx_pes_type>:     second teletext PID.
* @:c:type:DMX_PES_SUBTITLE1 <dmx_pes_type>:    second subtitle PID.
* @:c:type:DMX_PES_PCR1 <dmx_pes_type>:          second Program Clock ReferencePID.
*
* @:c:type:DMX_PES_AUDIO2 <dmx_pes_type>:        third audio PID.
* @:c:type:DMX_PES_VIDEO2 <dmx_pes_type>:         third video PID.
* @:c:type:DMX_PES_TELETEXT2 <dmx_pes_type>:    third teletext PID.
* @:c:type:DMX_PES_SUBTITLE2 <dmx_pes_type>:   third subtitle PID.

```

```

* @:c:type:DMX_PES_PCR2 <dmx_pes_type>:           third Program Clock Referenceu
↳PID.
*
* @:c:type:DMX_PES_AUDIO3 <dmx_pes_type>:           fourth audio PID.
* @:c:type:DMX_PES_VIDEO3 <dmx_pes_type>:           fourth video PID.
* @:c:type:DMX_PES_TELETEXT3 <dmx_pes_type>:        fourth teletext PID.
* @:c:type:DMX_PES_SUBTITLE3 <dmx_pes_type>:        fourth subtitle PID.
* @:c:type:DMX_PES_PCR3 <dmx_pes_type>:           fourth Program Clock Referenceu
↳PID.
*
* @:c:type:DMX_PES_OTHER <dmx_pes_type>:           any other PID.
*/



dmx_ts_pes {
    DMX_PES_AUDIO0,
    DMX_PES_VIDEO0,
    DMX_PES_TELETEXT0,
    DMX_PES_SUBTITLE0,
    DMX_PES_PCR0,

    DMX_PES_AUDIO1,
    DMX_PES_VIDEO1,
    DMX_PES_TELETEXT1,
    DMX_PES_SUBTITLE1,
    DMX_PES_PCR1,

    DMX_PES_AUDIO2,
    DMX_PES_VIDEO2,
    DMX_PES_TELETEXT2,
    DMX_PES_SUBTITLE2,
    DMX_PES_PCR2,

    DMX_PES_AUDIO3,
    DMX_PES_VIDEO3,
    DMX_PES_TELETEXT3,
    DMX_PES_SUBTITLE3,
    DMX_PES_PCR3,

    DMX_PES_OTHER
};

#define DMX_PES_AUDIO    DMX_PES_AUDIO0
#define DMX_PES_VIDEO    DMX_PES_VIDEO0
#define DMX_PES_TELETEXT DMX_PES_TELETEXT0
#define DMX_PES_SUBTITLE DMX_PES_SUBTITLE0
#define DMX_PES_PCR      DMX_PES_PCR0

/***
 * struct dmx_filter - Specifies a section header filter.
 *
 * @filter: bit array with bits to be matched at the section header.
*/

```

```

* @mask: bits that are valid at the filter bit array.
* @mode: mode of match: if bit is zero, it will match if equal (positive
*         match); if bit is one, it will match if the bit is negated.
*
* Note: All arrays in this struct have a size of DMX_FILTER_SIZE (16 bytes).
*/
struct dmx_filter {
    __u8 filter[DMX_FILTER_SIZE];
    __u8 mask[DMX_FILTER_SIZE];
    __u8 mode[DMX_FILTER_SIZE];
};

/***
* struct dmx_sct_filter_params - Specifies a section filter.
*
* @pid: PID to be filtered.
* @filter: section header filter, as defined by &struct dmx_filter.
* @timeout: maximum time to filter, in milliseconds.
* @flags: extra flags for the section filter.
*
* Carries the configuration for a MPEG-TS section filter.
*
* The @flags can be:
*
*      - %DMX_CHECK_CRC - only deliver sections where the CRC check succeeded;
*      - %DMX_ONESHOT - disable the section filter after one section
*                      has been delivered;
*      - %DMX_IMMEDIATE_START - Start filter immediately without requiring a
*                                :ref:`DMX_START`.
*/
struct dmx_sct_filter_params {
    __u16 pid;
    struct dmx_filter filter;
    __u32 timeout;
    __u32 flags;
#define DMX_CHECK_CRC     1
#define DMX_ONESHOT       2
#define DMX_IMMEDIATE_START 4
};

/***
* struct dmx_pes_filter_params - Specifies Packetized Elementary Stream (PES)
*                               filter parameters.
*
* @pid:          PID to be filtered.
* @input:        Demux input, as specified by &enum dmx_input.
* @output:       Demux output, as specified by &enum dmx_output.
* @pes_type:     Type of the pes filter, as specified by &enum dmx_pes_type.
* @flags:        Demux PES flags.
*/
struct dmx_pes_filter_params {

```

```

        __u16          pid;
        dmx_input      input;
        enum dmx_output output;
        dmx_ts_pes    pes_type;
        __u32          flags;
};

/***
 * struct dmx_stc - Stores System Time Counter (STC) information.
 *
 * @num: input data: number of the STC, from 0 to N.
 * @base: output: divisor for STC to get 90 kHz clock.
 * @stc: output: stc in @base * 90 kHz units.
 */
struct dmx_stc {
        unsigned int num;
        unsigned int base;
        __u64 stc;
};

/***
 * enum dmx_buffer_flags - DMX memory-mapped buffer flags
 *
 * @:c:type:DMX_BUFFER_FLAG_HAD_CRC32_DISCARD <dmx_buffer_flags>:
 *     Indicates that the Kernel discarded one or more frames due to wrong
 *     CRC32 checksum.
 * @:c:type:DMX_BUFFER_FLAG_TEI <dmx_buffer_flags>:
 *     Indicates that the Kernel has detected a Transport Error indicator
 *     (TEI) on a filtered pid.
 * @:c:type:DMX_BUFFER_PKT_COUNTER_MISMATCH <dmx_buffer_flags>:
 *     Indicates that the Kernel has detected a packet counter mismatch
 *     on a filtered pid.
 * @:c:type:DMX_BUFFER_FLAG_DISCONTINUITY_DETECTED <dmx_buffer_flags>:
 *     Indicates that the Kernel has detected one or more frame discontinuity.
 * @:c:type:DMX_BUFFER_FLAG_DISCONTINUITY_INDICATOR <dmx_buffer_flags>:
 *     Received at least one packet with a frame discontinuity indicator.
 */
enum dmx_buffer_flags {
        DMX_BUFFER_FLAG_HAD_CRC32_DISCARD          = 1 << 0,
        DMX_BUFFER_FLAG_TEI                         = 1 << 1,
        DMX_BUFFER_PKT_COUNTER_MISMATCH           = 1 << 2,
        DMX_BUFFER_FLAG_DISCONTINUITY_DETECTED     = 1 << 3,
        DMX_BUFFER_FLAG_DISCONTINUITY_INDICATOR    = 1 << 4,
};

/***
 * struct dmx_buffer - dmx buffer info
 *
 * @index:      id number of the buffer
 * @bytesused:  number of bytes occupied by data in the buffer (payload);

```

```

* @offset:      for buffers with memory == DMX_MEMORY_MMAP;
*               offset from the start of the device memory for this plane,
*               (or a "cookie" that should be passed to mmap() as offset)
* @length:     size in bytes of the buffer
* @flags:       bit array of buffer flags as defined by &enum dmx_buffer_flags.
*               Filled only at &DMX_DQBUF.
* @count:      monotonic counter for filled buffers. Helps to identify
*               data stream loses. Filled only at &DMX_DQBUF.
*
* Contains data exchanged by application and driver using one of the streaming
* I/O methods.
*
* Please notice that, for &DMX_QBUF, only @index should be filled.
* On &DMX_DQBUF calls, all fields will be filled by the Kernel.
*/
struct dmx_buffer {
    __u32           index;
    __u32           bytesused;
    __u32           offset;
    __u32           length;
    __u32           flags;
    __u32           count;
};

/***
* struct dmx_requestbuffers - request dmx buffer information
*
* @count:        number of requested buffers,
* @size:         size in bytes of the requested buffer
*
* Contains data used for requesting a dmx buffer.
* All reserved fields must be set to zero.
*/
struct dmx_requestbuffers {
    __u32           count;
    __u32           size;
};

/***
* struct dmx_exportbuffer - export of dmx buffer as DMABUF file descriptor
*
* @index:        id number of the buffer
* @flags:        flags for newly created file, currently only O_CLOEXEC is
*               supported, refer to manual of open syscall for more details
* @fd:          file descriptor associated with DMABUF (set by driver)
*
* Contains data used for exporting a dmx buffer as DMABUF file descriptor.
* The buffer is identified by a 'cookie' returned by DMX\_QUERYBUF
* (identical to the cookie used to mmap() the buffer to userspace). All
* reserved fields must be set to zero. The field reserved0 is expected to
* become a structure 'type' allowing an alternative layout of the structure

```

```
* content. Therefore this field should not be used for any other extensions.  
*/  
struct dmx_exportbuffer {  
    __u32           index;  
    __u32           flags;  
    __s32           fd;  
};  
  
#define DMX_START           _I0('o', 41)  
#define DMX_STOP            _I0('o', 42)  
#define DMX_SET_FILTER      _IOW('o', 43, struct dmx_sct_filter_params)  
#define DMX_SET_PES_FILTER  _IOW('o', 44, struct dmx_pes_filter_params)  
#define DMX_SET_BUFFER_SIZE _I0('o', 45)  
#define DMX_GET_PES_PIDS   _IOR('o', 47, __u16[5])  
#define DMX_GET_STC         _IOWR('o', 50, struct dmx_stc)  
#define DMX_ADD_PID        _IOW('o', 51, __u16)  
#define DMX_REMOVE_PID     _IOW('o', 52, __u16)  
  
#if !defined(__KERNEL__)  
  
/* This is needed for legacy userspace support */  
typedef enum dmx_output dmx_output_t;  
typedef dmx_input dmx_input_t;  
typedef dmx_ts_pes dmx_pes_type_t;  
typedef struct dmx_filter dmx_filter_t;  
  
#endif  
  
#define DMX_REQBUFS          _IOWR('o', 60, struct dmx_requestbuffers)  
#define DMX_QUERYBUF         _IOWR('o', 61, struct dmx_buffer)  
#define DMX_EXPBUF           _IOWR('o', 62, struct dmx_exportbuffer)  
#define DMX_QBUF              _IOWR('o', 63, struct dmx_buffer)  
#define DMX_DQBUF             _IOWR('o', 64, struct dmx_buffer)  
  
#endif /* _DVBDMX_H_ */
```

## ca.h

```
/* SPDX-License-Identifier: LGPL-2.1+ WITH Linux-syscall-note */  
/*  
 * ca.h  
 *  
 * Copyright (C) 2000 Ralph Metzler <ralph@convergence.de>  
 *                  & Marcus Metzler <marcus@convergence.de>  
 *                  for convergence integrated media GmbH  
 */  
  
#ifndef _DVBCA_H_  
#define _DVBCA_H_
```

```
/**
 * struct ca_slot_info - CA slot interface types and info.
 *
 * @num:          slot number.
 * @type:         slot type.
 * @flags:        flags applicable to the slot.
 *
 * This struct stores the CA slot information.
 *
 * @type can be:
 *
 *      - %CA_CI - CI high level interface;
 *      - %CA_CI_LINK - CI link layer level interface;
 *      - %CA_CI_PHYS - CI physical layer level interface;
 *      - %CA_DESCR - built-in descrambler;
 *      - %CA_SC - simple smart card interface.
 *
 * @flags can be:
 *
 *      - %CA_CI_MODULE_PRESENT - module (or card) inserted;
 *      - %CA_CI_MODULE_READY - module is ready for usage.
 */
struct ca_slot_info {
    int num;
    int type;
#define CA_CI           1
#define CA_CI_LINK     2
#define CA_CI_PHYS     4
#define CA_DESCR        8
#define CA_SC          128

    unsigned int flags;
#define CA_CI_MODULE_PRESENT 1
#define CA_CI_MODULE_READY   2
};

/**
 * struct ca_descr_info - descrambler types and info.
 *
 * @num:          number of available descramblers (keys).
 * @type:         type of supported scrambling system.
 *
 * Identifies the number of descramblers and their type.
 *
 * @type can be:
 *
 *      - %CA_ECD - European Common Descrambler (ECD) hardware;
 *      - %CA_NDS - Videoguard (NDS) hardware;
 *      - %CA_DSS - Distributed Sample Scrambling (DSS) hardware.
*/

```

```
struct ca_descr_info {
    unsigned int num;
    unsigned int type;
#define CA_ECD          1
#define CA_NDS          2
#define CA_DSS          4
};

/***
 * struct ca_caps - CA slot interface capabilities.
 *
 * @slot_num:    total number of CA card and module slots.
 * @slot_type:   bitmap with all supported types as defined at
 *               &struct ca_slot_info (e. g. %CA_CI, %CA_CI_LINK, etc).
 * @descr_num:   total number of descrambler slots (keys)
 * @descr_type:  bitmap with all supported types as defined at
 *               &struct ca_descr_info (e. g. %CA_ECD, %CA_NDS, etc).
 */
struct ca_caps {
    unsigned int slot_num;
    unsigned int slot_type;
    unsigned int descr_num;
    unsigned int descr_type;
};

/***
 * struct ca_msg - a message to/from a CI-CAM
 *
 * @index:        unused
 * @type:         unused
 * @length:       length of the message
 * @msg:          message
 *
 * This struct carries a message to be send/received from a CI CA module.
 */
struct ca_msg {
    unsigned int index;
    unsigned int type;
    unsigned int length;
    unsigned char msg[256];
};

/***
 * struct ca_descr - CA descrambler control words info
 *
 * @index: CA Descrambler slot
 * @parity: control words parity, where 0 means even and 1 means odd
 * @cw:     CA Descrambler control words
 */
struct ca_descr {
    unsigned int index;
```

```

        unsigned int parity;
        unsigned char cw[8];
};

#define CA_RESET           _IO('o', 128)
#define CA_GET_CAP         _IOR('o', 129, struct ca_caps)
#define CA_GET_SLOT_INFO   _IOR('o', 130, struct ca_slot_info)
#define CA_GET_DESCR_INFO  _IOR('o', 131, struct ca_descr_info)
#define CA_GET_MSG          _IOR('o', 132, struct ca_msg)
#define CA_SEND_MSG         _IOW('o', 133, struct ca_msg)
#define CA_SET_DESCR        _IOW('o', 134, struct ca_descr)

#if !defined(__KERNEL__)

/* This is needed for legacy userspace support */
typedef struct ca_slot_info ca_slot_info_t;
typedef struct ca_descr_info ca_descr_info_t;
typedef struct ca_caps ca_caps_t;
typedef struct ca_msg ca_msg_t;
typedef struct ca_descr ca_descr_t;

#endif

#endif

```

**net.h**

```

/* SPDX-License-Identifier: LGPL-2.1+ WITH Linux-syscall-note */
/*
 * net.h
 *
 * Copyright (C) 2000 Marcus Metzler <marcus@convergence.de>
 *                   & Ralph Metzler <ralph@convergence.de>
 *                   for convergence integrated media GmbH
 */

#ifndef _DVBNET_H_
#define _DVBNET_H_

#include <linux/types.h>

/**
 * struct dvb_net_if - describes a DVB network interface
 *
 * @pid: Packet ID (PID) of the MPEG-TS that contains data
 * @if_num: number of the Digital TV interface.
 * @feedtype: Encapsulation type of the feed.
 *
 * A MPEG-TS stream may contain packet IDs with IP packages on it.
 * This struct describes it, and the type of encoding.
 */


```

```
*  
* @feedtype can be:  
*  
*     - %DVB_NET_FEEDTYPE_MPE for MPE encoding  
*     - %DVB_NET_FEEDTYPE_ULE for ULE encoding.  
*/  
struct dvb_net_if {  
    __u16 pid;  
    __u16 if_num;  
    __u8 feedtype;  
#define DVB_NET_FEEDTYPE_MPE 0 /* multi protocol encapsulation */  
#define DVB_NET_FEEDTYPE_ULE 1 /* ultra lightweight encapsulation */  
};  
  
#define NET_ADD_IF      _IOWR('o', 52, struct dvb_net_if)  
#define NET_REMOVE_IF   _IO('o', 53)  
#define NET_GET_IF      _IOWR('o', 54, struct dvb_net_if)  
  
/* binary compatibility cruft: */  
struct __dvb_net_if_old {  
    __u16 pid;  
    __u16 if_num;  
};  
#define __NET_ADD_IF_OLD _IOWR('o', 52, struct __dvb_net_if_old)  
#define __NET_GET_IF_OLD _IOWR('o', 54, struct __dvb_net_if_old)  
  
#endif /*_DVBNET_H_*/
```

### 13.3.9 Revision and Copyright

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- Original author of the Digital TV API documentation.
- O. C. Metzler, Marcus <[rjkm@metzlerbros.de](mailto:rjkm@metzlerbros.de)>
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- Carvalho Chehab, Mauro <[mchehab+samsung@kernel.org](mailto:mchehab+samsung@kernel.org)>
- Ported document to Docbook XML, addition of DVBy5 API, documentation gaps fix.

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### 13.3.10 Revision History

**revision**

2.2.0 / 2017-09-01 (*mcc*)

Most gaps between the uAPI document and the Kernel implementation got fixed for the non-legacy API.

**revision**

2.1.0 / 2015-05-29 (*mcc*)

DocBook improvements and cleanups, in order to document the system calls on a more standard way and provide more description about the current Digital TV API.

**revision**

2.0.4 / 2011-05-06 (*mcc*)

Add more information about DVBy5 API, better describing the frontend GET/SET props ioctl's.

**revision**

2.0.3 / 2010-07-03 (*mcc*)

Add some frontend capabilities flags, present on kernel, but missing at the specs.

**revision**

2.0.2 / 2009-10-25 (*mcc*)

documents FE\_SET\_FRONTEND\_TUNE\_MODE and FE\_DISHETWORK\_SEND\_LEGACY\_CMD ioctls.

**revision**

2.0.1 / 2009-09-16 (*mcc*)

Added ISDB-T test originally written by Patrick Boettcher

**revision**

2.0.0 / 2009-09-06 (*mcc*)

Conversion from LaTex to DocBook XML. The contents is the same as the original LaTex version.

**revision**

1.0.0 / 2003-07-24 (*rjkm*)

Initial revision on LaTEX.

## 13.4 Part III - Remote Controller API

### 13.4.1 Introduction

Currently, most analog and digital devices have a Infrared input for remote controllers. Each manufacturer has their own type of control. It is not rare for the same manufacturer to ship different types of controls, depending on the device.

A Remote Controller interface is mapped as a normal evdev/input interface, just like a keyboard or a mouse. So, it uses all ioctls already defined for any other input devices.

However, remote controllers are more flexible than a normal input device, as the IR receiver (and/or transmitter) can be used in conjunction with a wide variety of different IR remotes.

In order to allow flexibility, the Remote Controller subsystem allows controlling the RC-specific attributes via *the sysfs class nodes*.

### 13.4.2 Remote Controller's sysfs nodes

As defined at Documentation/ABI/testing/sysfs-class-rc, those are the sysfs nodes that control the Remote Controllers:

#### /sys/class/rc/

The /sys/class/rc/ class sub-directory belongs to the Remote Controller core and provides a sysfs interface for configuring infrared remote controller receivers.

#### /sys/class/rc/rcN/

A /sys/class/rc/rcN directory is created for each remote control receiver device where N is the number of the receiver.

#### /sys/class/rc/rcN/protocols

Reading this file returns a list of available protocols, something like:

```
rc5 [rc6] nec jvc [sony]
```

Enabled protocols are shown in [] brackets.

Writing "+proto" will add a protocol to the list of enabled protocols.

Writing "-proto" will remove a protocol from the list of enabled protocols.

Writing "proto" will enable only "proto".

Writing "none" will disable all protocols.

Write fails with EINVAL if an invalid protocol combination or unknown protocol name is used.

#### /sys/class/rc/rcN/filter

Sets the scancode filter expected value.

Use in combination with /sys/class/rc/rcN/filter\_mask to set the expected value of the bits set in the filter mask. If the hardware supports it then scancodes which do not match the filter will be ignored. Otherwise the write will fail with an error.

This value may be reset to 0 if the current protocol is altered.

## /sys/class/rc/rcN/filter\_mask

Sets the scancode filter mask of bits to compare. Use in combination with /sys/class/rc/rcN/filter to set the bits of the scancode which should be compared against the expected value. A value of 0 disables the filter to allow all valid scancodes to be processed.

If the hardware supports it then scancodes which do not match the filter will be ignored. Otherwise the write will fail with an error.

This value may be reset to 0 if the current protocol is altered.

## /sys/class/rc/rcN/wakeup\_protocols

Reading this file returns a list of available protocols to use for the wakeup filter, something like:

```
rc-5 nec nec-x rc-6-0 rc-6-6a-24 [rc-6-6a-32] rc-6-mce
```

Note that protocol variants are listed, so nec, sony, rc-5, rc-6 have their different bit length encodings listed if available.

Note that all protocol variants are listed.

The enabled wakeup protocol is shown in [] brackets.

Only one protocol can be selected at a time.

Writing "proto" will use "proto" for wakeup events.

Writing "none" will disable wakeup.

Write fails with EINVAL if an invalid protocol combination or unknown protocol name is used, or if wakeup is not supported by the hardware.

## /sys/class/rc/rcN/wakeup\_filter

Sets the scancode wakeup filter expected value. Use in combination with /sys/class/rc/rcN/wakeup\_filter\_mask to set the expected value of the bits set in the wakeup filter mask to trigger a system wake event.

If the hardware supports it and wakeup\_filter is not 0 then scancodes which match the filter will wake the system from e.g. suspend to RAM or power off. Otherwise the write will fail with an error.

This value may be reset to 0 if the wakeup protocol is altered.

## /sys/class/rc/rcN/wakeup\_filter\_mask

Sets the scancode wakeup filter mask of bits to compare. Use in combination with /sys/class/rc/rcN/wakeup\_filter to set the bits of the scancode which should be compared against the expected value to trigger a system wake event.

If the hardware supports it and wakeup\_filter is not 0 then scancodes which match the filter will wake the system from e.g. suspend to RAM or power off. Otherwise the write will fail with an error.

This value may be reset to 0 if the wakeup protocol is altered.

### 13.4.3 Remote Controller Protocols and Scancodes

IR is encoded as a series of pulses and spaces, using a protocol. These protocols can encode e.g. an address (which device should respond) and a command: what it should do. The values for these are not always consistent across different devices for a given protocol.

Therefore out the output of the IR decoder is a scancode; a single u32 value. Using keymap tables this can be mapped to linux key codes.

Other things can be encoded too. Some IR protocols encode a toggle bit; this is to distinguish whether the same button is being held down, or has been released and pressed again. If has been released and pressed again, the toggle bit will invert from one IR message to the next.

Some remotes have a pointer-type device which can used to control the mouse; some air conditioning systems can have their target temperature target set in IR.

The following are the protocols the kernel knows about and also lists how scancodes are encoded for each protocol.

#### rc-5 (RC\_PROTO\_RC5)

This IR protocol uses manchester encoding to encode 14 bits. There is a detailed description here <https://www.sbprojects.net/knowledge/ir/rc5.php>.

The scancode encoding is *not* consistent with the lirc daemon (lircd) rc5 protocol, or the manchester BPF decoder.

Table 285: rc5 bits scancode mapping

rc-5 bit	scancode bit	description
1	none	Start bit, always set
1	6 (inverted)	2nd start bit in rc5, re-used as 6th command bit
1	none	Toggle bit
5	8 to 13	Address
6	0 to 5	Command

There is a variant of rc5 called either rc5x or extended rc5 where there the second stop bit is the 6th command bit, but inverted. This is done so it the scancodes and encoding is compatible with existing schemes. This bit is stored in bit 6 of the scancode, inverted. This is done to keep it compatible with plain rc-5 where there are two start bits.

#### rc-5-sz (RC\_PROTO\_RC5\_SZ)

This is much like rc-5 but one bit longer. The scancode is encoded differently.

Table 286: rc-5-sz bits scancode mapping

rc-5-sz bits	scancode bit	description
1	none	Start bit, always set
1	13	Address bit
1	none	Toggle bit
6	6 to 11	Address
6	0 to 5	Command

## **rc-5x-20 (RC\_PROTO\_RC5X\_20)**

This rc-5 extended to encoded 20 bits. There is a 3555 microseconds space after the 8th bit.

Table 287: rc-5x-20 bits scancode mapping

rc-5-sz bits	scancode bit	description
1	none	Start bit, always set
1	14	Address bit
1	none	Toggle bit
5	16 to 20	Address
6	8 to 13	Address
6	0 to 5	Command

## **jvc (RC\_PROTO\_JVC)**

The jvc protocol is much like nec, without the inverted values. It is described here <https://www.sbprojects.net/knowledge/ir/jvc.php>.

The scancode is a 16 bits value, where the address is the lower 8 bits and the command the higher 8 bits; this is reversed from IR order.

## **sony-12 (RC\_PROTO\_SONY12)**

The sony protocol is a pulse-width encoding. There are three variants, which just differ in number of bits and scancode encoding.

Table 288: sony-12 bits scancode mapping

sony-12 bits	scancode bit	description
5	16 to 20	device
7	0 to 6	function

## **sony-15 (RC\_PROTO\_SONY15)**

The sony protocol is a pulse-width encoding. There are three variants, which just differ in number of bits and scancode encoding.

Table 289: sony-12 bits scancode mapping

sony-12 bits	scancode bit	description
8	16 to 23	device
7	0 to 6	function

## sony-20 (RC\_PROTO\_SONY20)

The sony protocol is a pulse-width encoding. There are three variants, which just differ in number of bits and scancode encoding.

Table 290: sony-20 bits scancode mapping

sony-20 bits	scancode bit	description
5	16 to 20	device
7	0 to 7	device
8	8 to 15	extended bits

## nec (RC\_PROTO\_NEC)

The nec protocol encodes an 8 bit address and an 8 bit command. It is described here <https://www.sbprojects.net/knowledge/ir/nec.php>. Note that the protocol sends least significant bit first.

As a check, the nec protocol sends the address and command twice; the second time it is inverted. This is done for verification.

A plain nec IR message has 16 bits; the high 8 bits are the address and the low 8 bits are the command.

## nec-x (RC\_PROTO\_NECX)

Extended nec has a 16 bit address and a 8 bit command. This is encoded as a 24 bit value as you would expect, with the lower 8 bits the command and the upper 16 bits the address.

## nec-32 (RC\_PROTO\_NECK32)

nec-32 does not send an inverted address or an inverted command; the entire message, all 32 bits, are used.

For this to be decoded correctly, the second 8 bits must not be the inverted value of the first, and also the last 8 bits must not be the inverted value of the third 8 bit value.

The scancode has a somewhat unusual encoding.

Table 291: nec-32 bits scancode mapping

nec-32 bits	scancode bit
First 8 bits	16 to 23
Second 8 bits	24 to 31
Third 8 bits	0 to 7
Fourth 8 bits	8 to 15

## **sanyo (RC\_PROTO\_SANYO)**

The sanyo protocol is like the nec protocol, but with 13 bits address rather than 8 bits. Both the address and the command are followed by their inverted versions, but these are not present in the scancodes.

Bits 8 to 20 of the scancode is the 13 bits address, and the lower 8 bits are the command.

## **mcir2-kbd (RC\_PROTO\_MCIR2\_KBD)**

This protocol is generated by the Microsoft MCE keyboard for keyboard events. Refer to the ir-mce\_kbd-decoder.c to see how it is encoded.

## **mcir2-mse (RC\_PROTO\_MCIR2\_MSE)**

This protocol is generated by the Microsoft MCE keyboard for pointer events. Refer to the ir-mce\_kbd-decoder.c to see how it is encoded.

## **rc-6-0 (RC\_PROTO\_RC6\_0)**

This is the rc-6 in mode 0. rc-6 is described here <https://www.sbprojects.net/knowledge/ir/rc6.php>. The scancode is the exact 16 bits as in the protocol. There is also a toggle bit.

## **rc-6-6a-20 (RC\_PROTO\_RC6\_6A\_20)**

This is the rc-6 in mode 6a, 20 bits. rc-6 is described here <https://www.sbprojects.net/knowledge/ir/rc6.php>. The scancode is the exact 20 bits as in the protocol. There is also a toggle bit.

## **rc-6-6a-24 (RC\_PROTO\_RC6\_6A\_24)**

This is the rc-6 in mode 6a, 24 bits. rc-6 is described here <https://www.sbprojects.net/knowledge/ir/rc6.php>. The scancode is the exact 24 bits as in the protocol. There is also a toggle bit.

## **rc-6-6a-32 (RC\_PROTO\_RC6\_6A\_32)**

This is the rc-6 in mode 6a, 32 bits. rc-6 is described here <https://www.sbprojects.net/knowledge/ir/rc6.php>. The upper 16 bits are the vendor, and the lower 16 bits are the vendor-specific bits. This protocol is for the non-Microsoft MCE variant (vendor != 0x800f).

### **rc-6-mce (RC\_PROTO\_RC6\_MCE)**

This is the rc-6 in mode 6a, 32 bits. The upper 16 bits are the vendor, and the lower 16 bits are the vendor-specific bits. This protocol is for the Microsoft MCE variant (vendor = 0x800f). The toggle bit in the protocol itself is ignored, and the 16th bit should be taken as the toggle bit.

### **sharp (RC\_PROTO\_SHARP)**

This is a protocol used by Sharp VCRs, described here <https://www.sbprojects.net/knowledge/ir/sharp.php>. There is a very long (40ms) space between the normal and inverted values, and some IR receivers cannot decode this.

There is a 5 bit address and a 8 bit command. In the scancode the address is in bits 8 to 12, and the command in bits 0 to 7.

### **xmp (RC\_PROTO\_XMP)**

This protocol has several versions and only version 1 is supported. Refer to the decoder (ir-xmp-decoder.c) to see how it is encoded.

### **cec (RC\_PROTO\_CEC)**

This is not an IR protocol, this is a protocol over CEC. The CEC infrastructure uses rc-core for handling CEC commands, so that they can easily be remapped.

### **imon (RC\_PROTO\_IMON)**

This protocol is used by Antec Veris/SoundGraph iMON remotes.

The protocol describes both button presses and pointer movements. The protocol encodes 31 bits, and the scancode is simply the 31 bits with the top bit always 0.

### **rc-mm-12 (RC\_PROTO\_RCMM12)**

The rc-mm protocol is described here <https://www.sbprojects.net/knowledge/ir/rcmm.php>. The scancode is simply the 12 bits.

### **rc-mm-24 (RC\_PROTO\_RCMM24)**

The rc-mm protocol is described here <https://www.sbprojects.net/knowledge/ir/rcmm.php>. The scancode is simply the 24 bits.

## rc-mm-32 (RC\_PROTO\_RCMM32)

The rc-mm protocol is described here <https://www.sbprojects.net/knowledge/ir/rcmm.php>. The scancode is simply the 32 bits.

## xbox-dvd (RC\_PROTO\_XBOX\_DVD)

This protocol is used by XBox DVD Remote, which was made for the original XBox. There is no in-kernel decoder or encoder for this protocol. The usb device decodes the protocol. There is a BPF decoder available in v4l-utils.

### 13.4.4 Remote controller tables

Unfortunately, for several years, there was no effort to create uniform IR keycodes for different devices. This caused the same IR keynote to be mapped completely differently on different IR devices. This resulted that the same IR keynote to be mapped completely different on different IR's. Due to that, V4L2 API now specifies a standard for mapping Media keys on IR.

This standard should be used by both V4L/DVB drivers and userspace applications

The modules register the remote as keyboard within the linux input layer. This means that the IR key strokes will look like normal keyboard key strokes (if CONFIG\_INPUT\_KEYBOARD is enabled). Using the event devices (CONFIG\_INPUT\_EVDEV) it is possible for applications to access the remote via /dev/input/event devices.

Table 292: IR default keymapping

Key code	Meaning	Key examples on IR
<b>Numeric keys</b>		
KEY_NUMERIC_0	Keyboard digit 0	0
KEY_NUMERIC_1	Keyboard digit 1	1
KEY_NUMERIC_2	Keyboard digit 2	2
KEY_NUMERIC_3	Keyboard digit 3	3
KEY_NUMERIC_4	Keyboard digit 4	4
KEY_NUMERIC_5	Keyboard digit 5	5
KEY_NUMERIC_6	Keyboard digit 6	6
KEY_NUMERIC_7	Keyboard digit 7	7
KEY_NUMERIC_8	Keyboard digit 8	8
KEY_NUMERIC_9	Keyboard digit 9	9
<b>Movie play control</b>		
KEY_FORWARD	Instantly advance in time	>> / FORWARD
KEY_BACK	Instantly go back in time	<<< / BACK
KEY_FASTFORWARD	Play movie faster	>>> / FORWARD
KEY_REWIND	Play movie back	REWIND / BACKWARD
KEY_NEXT	Select next chapter / sub-chapter / interval	NEXT / SKIP

continues on next page

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KEY_PREVIOUS	Select previous chapter / sub-chapter / interval	<< / PREV / PREVIOUS
KEY AGAIN	Repeat the video or a video interval	REPEAT / LOOP / RECALL
KEY_PAUSE	Pause stream	PAUSE / FREEZE
KEY_PLAY	Play movie at the normal timeshift	NORMAL TIMESSHIFT / LIVE / >
KEY_PLAYPAUSE	Alternate between play and pause	PLAY / PAUSE
KEY_STOP	Stop stream	STOP
KEY_RECORD	Start/stop recording stream	CAPTURE / REC / RECORD/PAUSE
KEY_CAMERA	Take a picture of the image	CAMERA ICON / CAPTURE / SNAPSHOT
KEY_SHUFFLE	Enable shuffle mode	SHUFFLE
KEY_TIME	Activate time shift mode	TIME SHIFT
KEY_TITLE	Allow changing the chapter	CHAPTER
KEY_SUBTITLE	Allow changing the subtitle	SUBTITLE
<b>Image control</b>		
KEY_BRIGHTNESSDOWN	Decrease Brightness	BRIGHTNESS DECREASE
KEY_BRIGHTNESSUP	Increase Brightness	BRIGHTNESS INCREASE
KEY_ANGLE	Switch video camera angle (on videos with more than one angle stored)	ANGLE / SWAP
KEY_EPG	Open the Elecrowonic Play Guide (EPG)	EPG / GUIDE
KEY_TEXT	Activate/change closed caption mode	CLOSED CAPTION/TELETEXT / DVD TEXT / TELETEXT / TTX
<b>Audio control</b>		
KEY_AUDIO	Change audio source	AUDIO SOURCE / AUDIO / MUSIC
KEY_MUTE	Mute/unmute audio	MUTE / DEMUTE / UNMUTE
KEY_VOLUMEDOWN	Decrease volume	VOLUME- / VOLUME DOWN
KEY_VOLUMEUP	Increase volume	VOLUME+ / VOLUME UP
KEY_MODE	Change sound mode	MONO/STEREO
KEY_LANGUAGE	Select Language	1ST / 2ND LANGUAGE / DVD LANG / MTS/SAP / MTS SEL
<b>Channel control</b>		
KEY_CHANNEL	Go to the next favorite channel	ALT / CHANNEL / CH SURFING / SURF / FAV
KEY_CHANNELDOWN	Decrease channel sequentially	CHANNEL - / CHANNEL DOWN / DOWN
KEY_CHANNELUP	Increase channel sequentially	CHANNEL + / CHANNEL UP / UP

continues on next page

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KEY_DIGITS	Use more than one digit for channel	PLUS / 100/ 1xx / xxx / -/- / Single Double Triple Digit
KEY_SEARCH	Start channel autoscans	SCAN / AUTOSCAN
<b>Colored keys</b>		
KEY_BLUE	IR Blue key	BLUE
KEY_GREEN	IR Green Key	GREEN
KEY_RED	IR Red key	RED
KEY_YELLOW	IR Yellow key	YELLOW
<b>Media selection</b>		
KEY_CD	Change input source to Compact Disc	CD
KEY_DVD	Change input to DVD	DVD / DVD MENU
KEY_EJECTCLOSECD	Open/close the CD/DVD player	-> ) / CLOSE / OPEN
KEY_MEDIA	Turn on/off Media application	PC/TV / TURN ON/OFF APP
KEY_PC	Selects from TV to PC	PC
KEY_RADIO	Put into AM/FM radio mode	RADIO / TV/FM / TV/RADIO / FM / FM/RADIO
KEY_TV	Select tv mode	TV / LIVE TV
KEY_TV2	Select Cable mode	AIR/CBL
KEY_VCR	Select VCR mode	VCR MODE / DTR
KEY_VIDEO	Alternate between input modes	SOURCE / SELECT / DISPLAY / SWITCH INPUTS / VIDEO
<b>Power control</b>		
KEY_POWER	Turn on/off computer	SYSTEM POWER / COMPUTER POWER
KEY_POWER2	Turn on/off application	TV ON/OFF / POWER
KEY_SLEEP	Activate sleep timer	SLEEP / SLEEP TIMER
KEY_SUSPEND	Put computer into suspend mode	STANDBY / SUSPEND
<b>Window control</b>		
KEY_CLEAR	Stop stream and return to default input video/audio	CLEAR / RESET / BOSS KEY
KEY_CYCLEWINDOWS	Minimize windows and move to the next one	ALT-TAB / MINIMIZE / DESKTOP
KEY_FAVORITES	Open the favorites stream window	TV WALL / Favorites
KEY_MENU	Call application menu	2ND CONTROLS (USA: MENU) / DVD/MENU / SHOW/HIDE CTRL
KEY_NEW	Open/Close Picture in Picture	PIP
KEY_OK	Send a confirmation code to application	OK / ENTER / RETURN
KEY_ASPECT_RATIO	Select screen aspect ratio	4:3 16:9 SELECT

continues on next page

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KEY_FULL_SCREEN	Put device into zoom/full screen mode	ZOOM / FULL SCREEN / ZOOM+ / HIDE PANEL / SWITCH
<b>Navigation keys</b>		
KEY_ESC	Cancel current operation	CANCEL / BACK
KEY_HELP	Open a Help window	HELP
KEY_HOMEPAGE	Navigate to Home-page	HOME
KEY_INFO	Open On Screen Display	DISPLAY INFORMATION / OSD
KEY_WWW	Open the default browser	WEB
KEY_UP	Up key	UP
KEY_DOWN	Down key	DOWN
KEY_LEFT	Left key	LEFT
KEY_RIGHT	Right key	RIGHT
<b>Miscellaneous keys</b>		
KEY_DOT	Return a dot	.
KEY_FN	Select a function	FUNCTION

It should be noted that, sometimes, there are some fundamental missing keys at some cheaper IR's. Due to that, it is recommended to:

Table 293: Notes

On simpler IR's, without separate channel keys, you need to map UP as KEY_CHANNELUP
On simpler IR's, without separate channel keys, you need to map DOWN as KEY_CHANNELDOWN
On simpler IR's, without separate volume keys, you need to map LEFT as KEY_VOLUMEDOWN
On simpler IR's, without separate volume keys, you need to map RIGHT as KEY_VOLUMEUP

### 13.4.5 Changing default Remote Controller mappings

The event interface provides two ioctls to be used against the /dev/input/event device, to allow changing the default keymapping.

This program demonstrates how to replace the keymap tables.

**file: uapi/v4l/keytable.c**

```
/* keytable.c - This program allows checking/replacing keys at IR

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```

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```
/*
#include <ctype.h>
#include <errno.h>
#include <fcntl.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <linux/input.h>
#include <sys/ioctl.h>

#include "parse.h"

void prtcode (int *codes)
{
    struct parse_key *p;

    for (p=keynames;p->name!=NULL;p++) {
        if (p->value == (unsigned)codes[1]) {
            printf("scancode 0x%04x = %s (0x%02x)\n", codes[0], p-
→>name, codes[1]);
            return;
        }
    }

    if (isprint (codes[1]))
        printf("scancode %d = '%c' (0x%02x)\n", codes[0], codes[1], ↵
→codes[1]);
    else
        printf("scancode %d = 0x%02x\n", codes[0], codes[1]);
}

int parse_code(char *string)
{
    struct parse_key *p;

    for (p=keynames;p->name!=NULL;p++) {
        if (!strcasecmp(p->name, string)) {
            return p->value;
        }
    }
    return -1;
}

int main (int argc, char *argv[])
{
    int fd;
    unsigned int i, j;
```

```

int codes[2];

if (argc<2 || argc>4) {
    printf ("usage: %s <device> to get table; or\n"
            "        %s <device> <scancode> <keycode>\n"
            "        %s <device> <keycode_file> ", *argv, *argv,
       *argv);
    return -1;
}

if ((fd = open(argv[1], O_RDONLY)) < 0) {
    perror("Couldn't open input device");
    return(-1);
}

if (argc==4) {
    int value;

    value=parse_code(argv[3]);

    if (value==-1) {
        value = strtol(argv[3], NULL, 0);
        if (errno)
            perror("value");
    }

    codes [0] = (unsigned) strtol(argv[2], NULL, 0);
    codes [1] = (unsigned) value;

    if(ioctl(fd, EVIOCSKEYCODE, codes))
        perror ("EVIOCSKEYCODE");

    if(ioctl(fd, EVIOCGKEYCODE, codes)==0)
        prtcode(codes);
    return 0;
}

if (argc==3) {
    FILE *fin;
    int value;
    char *scancode, *keycode, s[2048];

    fin=fopen(argv[2],"r");
    if (fin==NULL) {
        perror ("opening keycode file");
        return -1;
    }

    /* Clears old table */
    for (j = 0; j < 256; j++) {

```

```

        for (i = 0; i < 256; i++) {
            codes[0] = (j << 8) | i;
            codes[1] = KEY_RESERVED;
            ioctl(fd, EVIOCSKEYCODE, codes);
        }
    }

    while (fgets(s, sizeof(s), fin)) {
        scancode=strtok(s,"\\n\\t =:");
        if (!scancode) {
            perror ("parsing input file scancode");
            return -1;
        }
        if (!strcasecmp(scancode, "scancode")) {
            scancode = strtok(NULL,"\\n\\t =:");
            if (!scancode) {
                perror ("parsing input file scancode");
                return -1;
            }
        }
        keycode=strtok(NULL,"\\n\\t =(");
        if (!keycode) {
            perror ("parsing input file keycode");
            return -1;
        }

        // printf ("parsing %s=%s:", scancode, keycode);
        value=parse_code(keycode);
        // printf ("\tvalue=%d\n",value);

        if (value== -1) {
            value = strtol(keycode, NULL, 0);
            if (errno)
                perror("value");
        }

        codes [0] = (unsigned) strtol(scancode, NULL, 0);
        codes [1] = (unsigned) value;

        // printf("\t%04x=%04x\n",codes[0], codes[1]);
        if(ioctl(fd, EVIOCSKEYCODE, codes)) {
            fprintf(stderr, "Setting scancode 0x%04x with_"
        ↪0x%04x via ",codes[0], codes[1]);
            perror ("EVIOCSKEYCODE");
        }

        if(ioctl(fd, EVIOCGKEYCODE, codes)==0)
            prtcode(codes);
    }
}

```

```

        return 0;
    }

    /* Get scancode table */
    for (j = 0; j < 256; j++) {
        for (i = 0; i < 256; i++) {
            codes[0] = (j << 8) | i;
            if (!ioctl(fd, EVIOCGKEYCODE, codes) && codes[1] != u
→KEY_RESERVED)
                prtcode(codes);
        }
    }
    return 0;
}

```

### 13.4.6 LIRC Device Interface

#### Introduction

LIRC stands for Linux Infrared Remote Control. The LIRC device interface is a bi-directional interface for transporting raw IR and decoded scancodes data between userspace and kernelspace. Fundamentally, it is just a chardev (/dev/lircX, for X = 0, 1, 2, ...), with a number of standard struct file\_operations defined on it. With respect to transporting raw IR and decoded scancodes to and fro, the essential fops are read, write and ioctl.

It is also possible to attach a BPF program to a LIRC device for decoding raw IR into scancodes.

Example dmesg output upon a driver registering w/LIRC:

```
$ dmesg |grep lirc_dev
rc rc0: lirc_dev: driver mceusb registered at minor = 0, raw IR receiver, raw
→IR transmitter
```

What you should see for a chardev:

```
$ ls -l /dev/lirc*
crw-rw---- 1 root root 248, 0 Jul 2 22:20 /dev/lirc0
```

Note that the package `v4l-utils` contains tools for working with LIRC devices:

- `ir-ctl`: can receive raw IR and transmit IR, as well as query LIRC device features.
- `ir-keytable`: can load keymaps; allows you to set IR kernel protocols; load BPF IR decoders and test IR decoding. Some BPF IR decoders are also provided.

## LIRC modes

LIRC supports some modes of receiving and sending IR codes, as shown on the following table.

### LIRC\_MODE\_SCANCODE

This mode is for both sending and receiving IR.

For transmitting (aka sending), create a `struct lirc_scancode` with the desired scancode set in the `scancode` member, `rc_proto` set to the *IR protocol*, and all other members set to 0. Write this struct to the lirc device.

For receiving, you read `struct lirc_scancode` from the LIRC device. The `scancode` field is set to the received scancode and the *IR protocol* is set in `rc_proto`. If the scancode maps to a valid key code, this is set in the `keycode` field, else it is set to `KEY_RESERVED`.

The `flags` can have `LIRC_SCANCODE_FLAG_TOGGLE` set if the toggle bit is set in protocols that support it (e.g. rc-5 and rc-6), or `LIRC_SCANCODE_FLAG_REPEAT` for when a repeat is received for protocols that support it (e.g. nec).

In the Sanyo and NEC protocol, if you hold a button on remote, rather than repeating the entire scancode, the remote sends a shorter message with no scancode, which just means button is held, a "repeat". When this is received, the `LIRC_SCANCODE_FLAG_REPEAT` is set and the scancode and keycode is repeated.

With nec, there is no way to distinguish "button hold" from "repeatedly pressing the same button". The rc-5 and rc-6 protocols have a toggle bit. When a button is released and pressed again, the toggle bit is inverted. If the toggle bit is set, the `LIRC_SCANCODE_FLAG_TOGGLE` is set.

The `timestamp` field is filled with the time nanoseconds (in `CLOCK_MONOTONIC`) when the scancode was decoded.

### LIRC\_MODE\_MODE2

The driver returns a sequence of pulse and space codes to userspace, as a series of `u32` values.

This mode is used only for IR receive.

The upper 8 bits determine the packet type, and the lower 24 bits the payload. Use `LIRC_VALUE()` macro to get the payload, and the macro `LIRC_MODE2()` will give you the type, which is one of:

#### LIRC\_MODE2\_PULSE

Signifies the presence of IR in microseconds, also known as *flash*.

#### LIRC\_MODE2\_SPACE

Signifies absence of IR in microseconds, also known as *gap*.

#### LIRC\_MODE2\_FREQUENCY

If measurement of the carrier frequency was enabled with `ioctl LIRC_SET_MEASURE_CARRIER_MODE` then this packet gives you the carrier frequency in Hertz.

#### LIRC\_MODE2\_TIMEOUT

When the timeout set with [ioctl LIRC\\_GET\\_REC\\_TIMEOUT](#) and [LIRC\\_SET\\_REC\\_TIMEOUT](#) expires due to no IR being detected, this packet will be sent, with the number of microseconds with no IR.

### LIRC\_MODE2\_OVERFLOW

Signifies that the IR receiver encounter an overflow, and some IR is missing. The IR data after this should be correct again. The actual value is not important, but this is set to 0xffffffff by the kernel for compatibility with lircd.

### LIRC\_MODE\_PULSE

In pulse mode, a sequence of pulse/space integer values are written to the lirc device using [LIRC write\(\)](#).

The values are alternating pulse and space lengths, in microseconds. The first and last entry must be a pulse, so there must be an odd number of entries.

This mode is used only for IR send.

## Data types used by LIRC\_MODE\_SCANCODE

### struct lirc\_scancode

decoded scancode with protocol for use with LIRC\_MODE\_SCANCODE

#### Definition:

```
struct lirc_scancode {  
    __u64 timestamp;  
    __u16 flags;  
    __u16 rc_proto;  
    __u32 keycode;  
    __u64 scancode;  
};
```

#### Members

##### timestamp

Timestamp in nanoseconds using CLOCK\_MONOTONIC when IR was decoded.

##### flags

should be 0 for transmit. When receiving scancodes, LIRC\_SCANCODE\_FLAG\_TOGGLE or LIRC\_SCANCODE\_FLAG\_REPEAT can be set depending on the protocol

##### rc\_proto

see [enum rc\\_proto](#)

##### keycode

the translated keycode. Set to 0 for transmit.

##### scancode

the scancode received or to be sent

##### enum rc\_proto

the Remote Controller protocol

## Constants

**RC\_PROTO\_UNKNOWN**

Protocol not known

**RC\_PROTO\_OTHER**

Protocol known but proprietary

**RC\_PROTO\_RC5**

Philips RC5 protocol

**RC\_PROTO\_RC5X\_20**

Philips RC5x 20 bit protocol

**RC\_PROTO\_RC5\_SZ**

StreamZap variant of RC5

**RC\_PROTO\_JVC**

JVC protocol

**RC\_PROTO\_SONY12**

Sony 12 bit protocol

**RC\_PROTO\_SONY15**

Sony 15 bit protocol

**RC\_PROTO\_SONY20**

Sony 20 bit protocol

**RC\_PROTO\_NECK**

NEC protocol

**RC\_PROTO\_NECX**

Extended NEC protocol

**RC\_PROTO\_NECK32**

NEC 32 bit protocol

**RC\_PROTO\_SANYO**

Sanyo protocol

**RC\_PROTO\_MCIR2\_KBD**

RC6-ish MCE keyboard

**RC\_PROTO\_MCIR2\_MSE**

RC6-ish MCE mouse

**RC\_PROTO\_RC6\_0**

Philips RC6-0-16 protocol

**RC\_PROTO\_RC6\_6A\_20**

Philips RC6-6A-20 protocol

**RC\_PROTO\_RC6\_6A\_24**

Philips RC6-6A-24 protocol

**RC\_PROTO\_RC6\_6A\_32**

Philips RC6-6A-32 protocol

**RC\_PROTO\_RC6\_MCE**

MCE (Philips RC6-6A-32 subtype) protocol

**RC\_PROTO\_SHARP**  
Sharp protocol

**RC\_PROTO\_XMP**  
XMP protocol

**RC\_PROTO\_CEC**  
CEC protocol

**RC\_PROTO\_IMON**  
iMon Pad protocol

**RC\_PROTO\_RCMM12**  
RC-MM protocol 12 bits

**RC\_PROTO\_RCMM24**  
RC-MM protocol 24 bits

**RC\_PROTO\_RCMM32**  
RC-MM protocol 32 bits

**RC\_PROTO\_XBOX\_DVD**  
Xbox DVD Movie Playback Kit protocol

**RC\_PROTO\_MAX**  
Maximum value of *enum rc\_proto*

## BPF based IR decoder

The kernel has support for decoding the most common *IR protocols*, but there are many protocols which are not supported. To support these, it is possible to load an BPF program which does the decoding. This can only be done on LIRC devices which support reading raw IR.

First, using the [bpf\(2\)](#) syscall with the `BPF_LOAD_PROG` argument, program must be loaded of type `BPF_PROG_TYPE_LIRC_MODE2`. Once attached to the LIRC device, this program will be called for each pulse, space or timeout event on the LIRC device. The context for the BPF program is a pointer to a unsigned int, which is a `LIRC_MODE_MODE2` value. When the program has decoded the scancode, it can be submitted using the BPF functions `bpf_rc_keydown()` or `bpf_rc_repeat()`. Mouse or pointer movements can be reported using `bpf_rc_pointer_rel()`.

Once you have the file descriptor for the `BPF_PROG_TYPE_LIRC_MODE2` BPF program, it can be attached to the LIRC device using the [bpf\(2\)](#) syscall. The target must be the file descriptor for the LIRC device, and the attach type must be `BPF_LIRC_MODE2`. No more than 64 BPF programs can be attached to a single LIRC device at a time.

## LIRC Function Reference

### LIRC read()

#### Name

`lirc-read` - Read from a LIRC device

## Synopsis

```
#include <unistd.h>
```

```
ssize_t read(int fd, void *buf, size_t count)
```

## Arguments

### fd

File descriptor returned by `open()`.

### buf

Buffer to be filled

### count

Max number of bytes to read

## Description

`read()` attempts to read up to `count` bytes from file descriptor `fd` into the buffer starting at `buf`. If `count` is zero, `read()` returns zero and has no other results. If `count` is greater than `SSIZE_MAX`, the result is unspecified.

The exact format of the data depends on what *LIRC modes* a driver uses. Use `ioctl LIRC_GET_FEATURES` to get the supported mode, and use `ioctls LIRC_GET_REC_MODE and LIRC_SET_REC_MODE` set the current active mode.

The mode `LIRC_MODE_MODE2` is for raw IR, in which packets containing an unsigned int value describing an IR signal are read from the chardev.

Alternatively, `LIRC_MODE_SCANCODE` can be available, in this mode scancodes which are either decoded by software decoders, or by hardware decoders. The `rc_proto` member is set to the *IR protocol* used for transmission, and `scancode` to the decoded scancode, and the `keycode` set to the keycode or `KEY_RESERVED`.

## Return Value

On success, the number of bytes read is returned. It is not an error if this number is smaller than the number of bytes requested, or the amount of data required for one frame. On error, -1 is returned, and the `errno` variable is set appropriately.

## LIRC write()

### Name

lirc-write - Write to a LIRC device

### Synopsis

```
#include <unistd.h>
```

```
ssize_t write(int fd, void *buf, size_t count)
```

### Arguments

#### fd

File descriptor returned by `open()`.

#### buf

Buffer with data to be written

#### count

Number of bytes at the buffer

### Description

`write()` writes up to `count` bytes to the device referenced by the file descriptor `fd` from the buffer starting at `buf`.

The exact format of the data depends on what mode a driver is in, use `ioctl LIRC_GET_FEATURES` to get the supported modes and use `ioctls LIRC_GET_SEND_MODE and LIRC_SET_SEND_MODE` set the mode.

When in `LIRC_MODE_PULSE` mode, the data written to the chardev is a pulse/space sequence of integer values. Pulses and spaces are only marked implicitly by their position. The data must start and end with a pulse, therefore, the data must always include an uneven number of samples. The write function blocks until the data has been transmitted by the hardware. If more data is provided than the hardware can send, the driver returns `EINVAL`.

When in `LIRC_MODE_SCANCODE` mode, one `struct lirc_scancode` must be written to the chardev at a time, else `EINVAL` is returned. Set the desired scancode in the `scancode` member, and the `IR protocol` in the `rc_proto:` member. All other members must be set to 0, else `EINVAL` is returned. If there is no protocol encoder for the protocol or the scancode is not valid for the specified protocol, `EINVAL` is returned. The write function blocks until the scancode is transmitted by the hardware.

## Return Value

On success, the number of bytes written is returned. It is not an error if this number is smaller than the number of bytes requested, or the amount of data required for one frame. On error, -1 is returned, and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## ioctl LIRC\_GET\_FEATURES

### Name

`LIRC_GET_FEATURES` - Get the underlying hardware device's features

### Synopsis

#### `LIRC_GET_FEATURES`

```
int ioctl(int fd, LIRC_GET_FEATURES, __u32 *features)
```

### Arguments

#### `fd`

File descriptor returned by `open()`.

#### `features`

Bitmask with the LIRC features.

### Description

Get the underlying hardware device's features. If a driver does not announce support of certain features, calling of the corresponding ioctls is undefined.

### LIRC features

#### `LIRC_CAN_REC_RAW`

Unused. Kept just to avoid breaking uAPI.

#### `LIRC_CAN_REC_PULSE`

Unused. Kept just to avoid breaking uAPI. `LIRC_MODE_PULSE` can only be used for transmitting.

#### `LIRC_CAN_REC_MODE2`

This is raw IR driver for receiving. This means that `LIRC_MODE_MODE2` is used. This also implies that `LIRC_MODE_SCANCODE` is also supported, as long as the kernel is recent enough. Use the `ioctls LIRC_GET_REC_MODE` and `LIRC_SET_REC_MODE` to switch modes.

## LIRC\_CAN\_REC\_LIRCCODE

Unused. Kept just to avoid breaking uAPI.

## LIRC\_CAN\_REC\_SCANCODE

This is a scancode driver for receiving. This means that *LIRC\_MODE\_SCANCODE* is used.

## LIRC\_CAN\_SET\_SEND\_CARRIER

The driver supports changing the modulation frequency via *ioctl LIRC\_SET\_SEND\_CARRIER*.

## LIRC\_CAN\_SET\_SEND\_DUTY\_CYCLE

The driver supports changing the duty cycle using *ioctl LIRC\_SET\_SEND\_DUTY\_CYCLE*.

## LIRC\_CAN\_SET\_TRANSMITTER\_MASK

The driver supports changing the active transmitter(s) using *ioctl LIRC\_SET\_TRANSMITTER\_MASK*.

## LIRC\_CAN\_SET\_REC\_CARRIER

The driver supports setting the receive carrier frequency using *ioctl LIRC\_SET\_REC\_CARRIER*.

## LIRC\_CAN\_SET\_REC\_CARRIER\_RANGE

The driver supports *ioctl LIRC\_SET\_REC\_CARRIER\_RANGE*.

## LIRC\_CAN\_GET\_REC\_RESOLUTION

The driver supports *ioctl LIRC\_GET\_REC\_RESOLUTION*.

## LIRC\_CAN\_SET\_REC\_TIMEOUT

The driver supports *ioctl LIRC\_SET\_REC\_TIMEOUT*.

## LIRC\_CAN\_MEASURE\_CARRIER

The driver supports measuring of the modulation frequency using *ioctl LIRC\_SET\_MEASURE\_CARRIER\_MODE*.

## LIRC\_CAN\_USE\_WIDEBAND\_RECEIVER

The driver supports learning mode using *ioctl LIRC\_SET\_WIDEBAND\_RECEIVER*.

## LIRC\_CAN\_SEND\_RAW

Unused. Kept just to avoid breaking uAPI.

## LIRC\_CAN\_SEND\_PULSE

The driver supports sending (also called as IR blasting or IR TX) using *LIRC\_MODE\_PULSE*. This implies that *LIRC\_MODE\_SCANCODE* is also supported for transmit, as long as the kernel is recent enough. Use the *ioctls LIRC\_GET\_SEND\_MODE* and *LIRC\_SET\_SEND\_MODE* to switch modes.

## LIRC\_CAN\_SEND\_MODE2

Unused. Kept just to avoid breaking uAPI. *LIRC\_MODE\_MODE2* can only be used for receiving.

## LIRC\_CAN\_SEND\_LIRCCODE

Unused. Kept just to avoid breaking uAPI.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## ioctls LIRC\_GET\_SEND\_MODE and LIRC\_SET\_SEND\_MODE

### Name

`LIRC_GET_SEND_MODE/LIRC_SET_SEND_MODE` - Get/set current transmit mode.

### Synopsis

#### `LIRC_GET_SEND_MODE`

```
int ioctl(int fd, LIRC_GET_SEND_MODE, __u32 *mode)
```

#### `LIRC_SET_SEND_MODE`

```
int ioctl(int fd, LIRC_SET_SEND_MODE, __u32 *mode)
```

### Arguments

#### `fd`

File descriptor returned by `open()`.

#### `mode`

The mode used for transmitting.

### Description

Get/set current transmit mode.

Only `LIRC_MODE_PULSE` and `LIRC_MODE_SCANCODE` are supported by for IR send, depending on the driver. Use `ioctl LIRC_GET_FEATURES` to find out which modes the driver supports.

## Return Value

ENODEV	Device not available.
ENOTTY	Device does not support transmitting.
EINVAL	Invalid mode or invalid mode for this device.

## ioctls LIRC\_GET\_REC\_MODE and LIRC\_SET\_REC\_MODE

### Name

LIRC\_GET\_REC\_MODE/LIRC\_SET\_REC\_MODE - Get/set current receive mode.

### Synopsis

#### LIRC\_GET\_REC\_MODE

```
int ioctl(int fd, LIRC_GET_REC_MODE, __u32 *mode)
```

#### LIRC\_SET\_REC\_MODE

```
int ioctl(int fd, LIRC_SET_REC_MODE, __u32 *mode)
```

### Arguments

#### fd

File descriptor returned by open().

#### mode

Mode used for receive.

### Description

Get and set the current receive mode. Only [LIRC\\_MODE\\_MODE2](#) and [LIRC\\_MODE\\_SCANCODE](#) are supported. Use [ioctl LIRC\\_GET\\_FEATURES](#) to find out which modes the driver supports.

## Return Value

ENODEV	Device not available.
ENOTTY	Device does not support receiving.
EINVAL	Invalid mode or invalid mode for this device.

## ioctl LIRC\_GET\_REC\_RESOLUTION

### Name

LIRC\_GET\_REC\_RESOLUTION - Obtain the value of receive resolution, in microseconds.

### Synopsis

#### **LIRC\_GET\_REC\_RESOLUTION**

```
int ioctl(int fd, LIRC_GET_REC_RESOLUTION, __u32 *microseconds)
```

### Arguments

#### **fd**

File descriptor returned by open().

#### **microseconds**

Resolution, in microseconds.

### Description

Some receivers have maximum resolution which is defined by internal sample rate or data format limitations. E.g. it's common that signals can only be reported in 50 microsecond steps. This ioctl returns the integer value with such resolution, with can be used by userspace applications like lircd to automatically adjust the tolerance value.

### Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## ioctl LIRC\_SET\_SEND\_DUTY\_CYCLE

### Name

LIRC\_SET\_SEND\_DUTY\_CYCLE - Set the duty cycle of the carrier signal for IR transmit.

### Synopsis

#### LIRC\_SET\_SEND\_DUTY\_CYCLE

```
int ioctl(int fd, LIRC_SET_SEND_DUTY_CYCLE, __u32 *duty_cycle)
```

### Arguments

#### fd

File descriptor returned by open().

#### duty\_cycle

Duty cycle, describing the pulse width in percent (from 1 to 99) of the total cycle. Values 0 and 100 are reserved.

### Description

Get/set the duty cycle of the carrier signal for IR transmit.

Currently, no special meaning is defined for 0 or 100, but this could be used to switch off carrier generation in the future, so these values should be reserved.

### Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## ioctls LIRC\_GET\_MIN\_TIMEOUT and LIRC\_GET\_MAX\_TIMEOUT

### Name

LIRC\_GET\_MIN\_TIMEOUT / LIRC\_GET\_MAX\_TIMEOUT - Obtain the possible timeout range for IR receive.

### Synopsis

#### LIRC\_GET\_MIN\_TIMEOUT

```
int ioctl(int fd, LIRC_GET_MIN_TIMEOUT, __u32 *timeout)
```

#### LIRC\_GET\_MAX\_TIMEOUT

```
int ioctl(int fd, LIRC_GET_MAX_TIMEOUT, __u32 *timeout)
```

## Arguments

### **fd**

File descriptor returned by open().

### **timeout**

Timeout, in microseconds.

## Description

Some devices have internal timers that can be used to detect when there's no IR activity for a long time. This can help lircd in detecting that a IR signal is finished and can speed up the decoding process. Returns an integer value with the minimum/maximum timeout that can be set.

---

**Note:** Some devices have a fixed timeout, in that case both ioctls will return the same value even though the timeout cannot be changed via [\*ioctl LIRC\\_GET\\_REC\\_TIMEOUT\*](#) and [\*LIRC\\_SET\\_REC\\_TIMEOUT\*](#).

---

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [\*Generic Error Codes\*](#) chapter.

## **ioctl LIRC\_GET\_REC\_TIMEOUT and LIRC\_SET\_REC\_TIMEOUT**

### Name

`LIRC_GET_REC_TIMEOUT/LIRC_SET_REC_TIMEOUT` - Get/set the integer value for IR inactivity timeout.

### Synopsis

#### **LIRC\_GET\_REC\_TIMEOUT**

```
int ioctl(int fd, LIRC_GET_REC_TIMEOUT, __u32 *timeout)
```

#### **LIRC\_SET\_REC\_TIMEOUT**

```
int ioctl(int fd, LIRC_SET_REC_TIMEOUT, __u32 *timeout)
```

### Arguments

#### fd

File descriptor returned by open().

#### timeout

Timeout, in microseconds.

### Description

Get and set the integer value for IR inactivity timeout.

If supported by the hardware, setting it to 0 disables all hardware timeouts and data should be reported as soon as possible. If the exact value cannot be set, then the next possible value \_greater\_ than the given value should be set.

---

**Note:** The range of supported timeout is given by *ioctls LIRC\_GET\_MIN\_TIMEOUT and LIRC\_GET\_MAX\_TIMEOUT*.

---

### Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the *Generic Error Codes* chapter.

## ioctl LIRC\_SET\_REC\_CARRIER

### Name

LIRC\_SET\_REC\_CARRIER - Set carrier used to modulate IR receive.

### Synopsis

#### LIRC\_SET\_REC\_CARRIER

```
int ioctl(int fd, LIRC_SET_REC_CARRIER, __u32 *frequency)
```

### Arguments

#### fd

File descriptor returned by open().

#### frequency

Frequency of the carrier that modulates PWM data, in Hz.

## Description

Set receive carrier used to modulate IR PWM pulses and spaces.

---

**Note:** If called together with [ioctl LIRC\\_SET\\_REC\\_CARRIER\\_RANGE](#), this ioctl sets the upper bound frequency that will be recognized by the device.

---

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## ioctl LIRC\_SET\_REC\_CARRIER\_RANGE

### Name

`LIRC_SET_REC_CARRIER_RANGE` - Set lower bound of the carrier used to modulate IR receive.

### Synopsis

#### `LIRC_SET_REC_CARRIER_RANGE`

```
int ioctl(int fd, LIRC_SET_REC_CARRIER_RANGE, __u32 *frequency)
```

### Arguments

#### `fd`

File descriptor returned by `open()`.

#### `frequency`

Frequency of the carrier that modulates PWM data, in Hz.

## Description

This ioctl sets the upper range of carrier frequency that will be recognized by the IR receiver.

---

**Note:** To set a range use [LIRC\\_SET\\_REC\\_CARRIER\\_RANGE](#) with the lower bound first and later call [LIRC\\_SET\\_REC\\_CARRIER](#) with the upper bound.

---

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## ioctl LIRC\_SET\_SEND\_CARRIER

### Name

`LIRC_SET_SEND_CARRIER` - Set send carrier used to modulate IR TX.

### Synopsis

#### `LIRC_SET_SEND_CARRIER`

```
int ioctl(int fd, LIRC_SET_SEND_CARRIER, __u32 *frequency)
```

### Arguments

#### `fd`

File descriptor returned by `open()`.

#### `frequency`

Frequency of the carrier to be modulated, in Hz.

### Description

Set send carrier used to modulate IR PWM pulses and spaces.

### Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## ioctl LIRC\_SET\_TRANSMITTER\_MASK

### Name

`LIRC_SET_TRANSMITTER_MASK` - Enables send codes on a given set of transmitters

## Synopsis

### **LIRC\_SET\_TRANSMITTER\_MASK**

```
int ioctl(int fd, LIRC_SET_TRANSMITTER_MASK, __u32 *mask)
```

## Arguments

### **fd**

File descriptor returned by `open()`.

### **mask**

Mask with channels to enable tx. Channel 0 is the least significant bit.

## Description

Some IR TX devices have multiple output channels, in such case, `LIRC_CAN_SET_TRANSMITTER_MASK` is returned via `ioctl LIRC_GET_FEATURES` and this ioctl sets what channels will send IR codes.

This ioctl enables the given set of transmitters. The first transmitter is encoded by the least significant bit and so on.

When an invalid bit mask is given, i.e. a bit is set, even though the device does not have so many transmitters, then this ioctl returns the number of available transmitters and does nothing otherwise.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### **ioctl LIRC\_SET\_MEASURE\_CARRIER\_MODE**

## Name

`LIRC_SET_MEASURE_CARRIER_MODE` - enable or disable measure mode

## Synopsis

### **LIRC\_SET\_MEASURE\_CARRIER\_MODE**

```
int ioctl(int fd, LIRC_SET_MEASURE_CARRIER_MODE, __u32 *enable)
```

## Arguments

### fd

File descriptor returned by open().

### enable

enable = 1 means enable measure mode, enable = 0 means disable measure mode.

## Description

Enable or disable measure mode. If enabled, from the next key press on, the driver will send LIRC\_MODE2\_FREQUENCY packets. By default this should be turned off.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## ioctl LIRC\_SET\_WIDEBAND\_RECEIVER

### Name

`LIRC_SET_WIDEBAND_RECEIVER` - enable wide band receiver.

### Synopsis

#### `LIRC_SET_WIDEBAND_RECEIVER`

```
int ioctl(int fd, LIRC_SET_WIDEBAND_RECEIVER, __u32 *enable)
```

## Arguments

### fd

File descriptor returned by open().

### enable

enable = 1 means enable wideband receiver, enable = 0 means disable wideband receiver.

## Description

Some receivers are equipped with special wide band receiver which is intended to be used to learn output of existing remote. This ioctl allows enabling or disabling it.

This might be useful of receivers that have otherwise narrow band receiver that prevents them to be used with some remotes. Wide band receiver might also be more precise. On the other hand its disadvantage it usually reduced range of reception.

---

**Note:** Wide band receiver might be implicitly enabled if you enable carrier reports. In that case it will be disabled as soon as you disable carrier reports. Trying to disable wide band receiver while carrier reports are active will do nothing.

---

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## LIRC Header File

### `lirc.h`

```
/* SPDX-License-Identifier: GPL-2.0 WITH Linux-syscall-note */
/*
 * lirc.h - linux infrared remote control header file
 */

#ifndef _LINUX_LIRC_H
#define _LINUX_LIRC_H

#include <linux/types.h>
#include <linux/ioctl.h>

#define PULSE_BIT          0x01000000
#define PULSE_MASK         0x00FFFFFF

#define LIRC_MODE2_SPACE    0x00000000
#define LIRC_MODE2_PULSE    0x01000000
#define LIRC_MODE2_FREQUENCY 0x02000000
#define LIRC_MODE2_TIMEOUT   0x03000000
#define LIRC_MODE2_OVERFLOW   0x04000000

#define LIRC_VALUE_MASK     0x00FFFFFF
#define LIRC_MODE2_MASK     0xFF000000

#define LIRC_SPACE(val) (((val) & LIRC_VALUE_MASK) | LIRC_MODE2_SPACE)
#define LIRC_PULSE(val) (((val) & LIRC_VALUE_MASK) | LIRC_MODE2_PULSE)
#define LIRC_FREQUENCY(val) (((val) & LIRC_VALUE_MASK) | LIRC_MODE2_FREQUENCY)
```

```

#define LIRC_TIMEOUT(val) (((val) & LIRC_VALUE_MASK) | LIRC_MODE2_TIMEOUT)
#define LIRC_OVERFLOW(val) (((val) & LIRC_VALUE_MASK) | LIRC_MODE2_OVERFLOW)

#define LIRC_VALUE(val) ((val)&LIRC_VALUE_MASK)
#define LIRC_MODE2(val) ((val)&LIRC_MODE2_MASK)

#define LIRC_IS_SPACE(val) (LIRC_MODE2(val) == LIRC_MODE2_SPACE)
#define LIRC_IS_PULSE(val) (LIRC_MODE2(val) == LIRC_MODE2_PULSE)
#define LIRC_IS_FREQUENCY(val) (LIRC_MODE2(val) == LIRC_MODE2_FREQUENCY)
#define LIRC_IS_TIMEOUT(val) (LIRC_MODE2(val) == LIRC_MODE2_TIMEOUT)
#define LIRC_IS_OVERFLOW(val) (LIRC_MODE2(val) == LIRC_MODE2_OVERFLOW)

/* used heavily by lirc userspace */
#define lirc_t int

/*** lirc compatible hardware features ***/

#define LIRC_MODE2SEND(x) (x)
#define LIRC_SEND2MODE(x) (x)
#define LIRC_MODE2REC(x) ((x) << 16)
#define LIRC_REC2MODE(x) ((x) >> 16)

#define LIRC_MODE_RAW          0x00000001
#define LIRC_MODE_PULSE         0x00000002
#define LIRC_MODE_MODE2         0x00000004
#define LIRC_MODE_SCANCODE      0x00000008
#define LIRC_MODE_LIRCCODE     0x00000010

#define LIRC_CAN_SEND_RAW      LIRC_MODE2SEND(LIRC_MODE_RAW)
#define LIRC_CAN_SEND_PULSE     LIRC_MODE2SEND(LIRC_MODE_PULSE)
#define LIRC_CAN_SEND_MODE2     LIRC_MODE2SEND(LIRC_MODE_MODE2)
#define LIRC_CAN_SEND_LIRCCODE LIRC_MODE2SEND(LIRC_MODE_LIRCCODE)

#define LIRC_CAN_SEND_MASK      0x0000003f

#define LIRC_CAN_SET_SEND_CARRIER 0x00000100
#define LIRC_CAN_SET_SEND_DUTY_CYCLE 0x00000200
#define LIRC_CAN_SET_TRANSMITTER_MASK 0x00000400

#define LIRC_CAN_REC_RAW        LIRC_MODE2REC(LIRC_MODE_RAW)
#define LIRC_CAN_REC_PULSE       LIRC_MODE2REC(LIRC_MODE_PULSE)
#define LIRC_CAN_REC_MODE2       LIRC_MODE2REC(LIRC_MODE_MODE2)
#define LIRC_CAN_REC_SCANCODE    LIRC_MODE2REC(LIRC_MODE_SCANCODE)
#define LIRC_CAN_REC_LIRCCODE   LIRC_MODE2REC(LIRC_MODE_LIRCCODE)

#define LIRC_CAN_REC_MASK        LIRC_MODE2REC(LIRC_CAN_SEND_MASK)

#define LIRC_CAN_SET_REC_CARRIER (LIRC_CAN_SET_SEND_CARRIER << 16)

#define LIRC_CAN_SET_REC_CARRIER_RANGE 0x80000000
#define LIRC_CAN_GET_REC_RESOLUTION 0x20000000

```

```

#define LIRC_CAN_SET_REC_TIMEOUT          0x10000000
#define LIRC_CAN_MEASURE_CARRIER         0x02000000
#define LIRC_CAN_USE_WIDEBAND_RECEIVER   0x04000000

#define LIRC_CAN_SEND(x) ((x)&LIRC_CAN_SEND_MASK)
#define LIRC_CAN_REC(x) ((x)&LIRC_CAN_REC_MASK)

/*
 * Unused features. These features were never implemented, in tree or
 * out of tree. These definitions are here so not to break the lircd build.
 */
#define LIRC_CAN_SET_REC_FILTER          0
#define LIRC_CAN_NOTIFY_DECODE          0

/** IOCTL commands for lirc driver **/


#define LIRC_GET_FEATURES              _IOR('i', 0x00000000, __u32)
#define LIRC_GET_SEND_MODE              _IOR('i', 0x00000001, __u32)
#define LIRC_GET_REC_MODE               _IOR('i', 0x00000002, __u32)
#define LIRC_GET_REC_RESOLUTION        _IOR('i', 0x00000007, __u32)

#define LIRC_GET_MIN_TIMEOUT           _IOR('i', 0x00000008, __u32)
#define LIRC_GET_MAX_TIMEOUT           _IOR('i', 0x00000009, __u32)

/* code length in bits, currently only for LIRC_MODE_LIRCCODE */
#define LIRC_GET_LENGTH                _IOR('i', 0x0000000f, __u32)

#define LIRC_SET_SEND_MODE             _IOW('i', 0x00000011, __u32)
#define LIRC_SET_REC_MODE              _IOW('i', 0x00000012, __u32)
/* Note: these can reset the according pulse_width */
#define LIRC_SET_SEND_CARRIER          _IOW('i', 0x00000013, __u32)
#define LIRC_SET_REC_CARRIER           _IOW('i', 0x00000014, __u32)
#define LIRC_SET_SEND_DUTY_CYCLE       _IOW('i', 0x00000015, __u32)
#define LIRC_SET_TRANSMITTER_MASK      _IOW('i', 0x00000017, __u32)

/*
 * when a timeout != 0 is set the driver will send a
 * LIRC_MODE2_TIMEOUT data packet, otherwise LIRC_MODE2_TIMEOUT is
 * never sent, timeout is disabled by default
 */
#define LIRC_SET_REC_TIMEOUT           _IOW('i', 0x00000018, __u32)

/* 1 enables, 0 disables timeout reports in MODE2 */
#define LIRC_SET_REC_TIMEOUT_REPORTS   _IOW('i', 0x00000019, __u32)

/*
 * if enabled from the next key press on the driver will send
 * LIRC_MODE2_FREQUENCY packets
*/

```

```
#define LIRC_SET_MEASURE_CARRIER_MODE      _IOW('i', 0x0000001d, __u32)

/*
 * to set a range use LIRC_SET_REC_CARRIER_RANGE with the
 * lower bound first and later LIRC_SET_REC_CARRIER with the upper bound
 */
#define LIRC_SET_REC_CARRIER_RANGE      _IOW('i', 0x0000001f, __u32)

#define LIRC_SET_WIDEBAND_RECEIVER      _IOW('i', 0x00000023, __u32)

/*
 * Return the recording timeout, which is either set by
 * the ioctl LIRC_SET_REC_TIMEOUT or by the kernel after setting the protocols.
 */
#define LIRC_GET_REC_TIMEOUT          _IOR('i', 0x00000024, __u32)

/***
 * struct lirc_scancode - decoded scancode with protocol for use with
 *      LIRC_MODE_SCANCODE
 *
 * @timestamp: Timestamp in nanoseconds using CLOCK_MONOTONIC when IR
 *      was decoded.
 * @flags: should be 0 for transmit. When receiving scancodes,
 *      LIRC_SCANCODE_FLAG_TOGGLE or LIRC_SCANCODE_FLAG_REPEAT can be set
 *      depending on the protocol
 * @rc_proto: see enum rc_proto
 * @keycode: the translated keycode. Set to 0 for transmit.
 * @scancode: the scancode received or to be sent
 */
struct lirc_scancode {
    __u64 timestamp;
    __u16 flags;
    __u16 rc_proto;
    __u32 keycode;
    __u64 scancode;
};

/* Set if the toggle bit of rc-5 or rc-6 is enabled */
#define LIRC_SCANCODE_FLAG_TOGGLE      1
/* Set if this is a nec or sanyo repeat */
#define LIRC_SCANCODE_FLAG_REPEAT     2

/***
 * enum rc_proto - the Remote Controller protocol
 *
 * @RC_PROTO_UNKNOWN: Protocol not known
 * @RC_PROTO_OTHER: Protocol known but proprietary
 * @RC_PROTO_RC5: Philips RC5 protocol
 * @RC_PROTO_RC5X_20: Philips RC5x 20 bit protocol
 * @RC_PROTO_RC5_SZ: StreamZap variant of RC5
 * @RC_PROTO_JVC: JVC protocol
 */
```

```

* @RC_PROTO_SONY12: Sony 12 bit protocol
* @RC_PROTO_SONY15: Sony 15 bit protocol
* @RC_PROTO_SONY20: Sony 20 bit protocol
* @RC_PROTO_NEC: NEC protocol
* @RC_PROTO_NECX: Extended NEC protocol
* @RC_PROTO_NEC32: NEC 32 bit protocol
* @RC_PROTO_SANYO: Sanyo protocol
* @RC_PROTO_MCIR2_KBD: RC6-ish MCE keyboard
* @RC_PROTO_MCIR2_MSE: RC6-ish MCE mouse
* @RC_PROTO_RC6_0: Philips RC6-0-16 protocol
* @RC_PROTO_RC6_6A_20: Philips RC6-6A-20 protocol
* @RC_PROTO_RC6_6A_24: Philips RC6-6A-24 protocol
* @RC_PROTO_RC6_6A_32: Philips RC6-6A-32 protocol
* @RC_PROTO_RC6_MCE: MCE (Philips RC6-6A-32 subtype) protocol
* @RC_PROTO_SHARP: Sharp protocol
* @RC_PROTO_XMP: XMP protocol
* @RC_PROTO_CEC: CEC protocol
* @RC_PROTO_IMON: iMon Pad protocol
* @RC_PROTO_RCMM12: RC-MM protocol 12 bits
* @RC_PROTO_RCMM24: RC-MM protocol 24 bits
* @RC_PROTO_RCMM32: RC-MM protocol 32 bits
* @RC_PROTO_XBOX_DVD: Xbox DVD Movie Playback Kit protocol
* @RC_PROTO_MAX: Maximum value of enum rc_proto
*/
enum rc_proto {
    RC_PROTO_UNKNOWN      = 0,
    RC_PROTO_OTHER        = 1,
    RC_PROTO_RC5          = 2,
    RC_PROTO_RC5X_20      = 3,
    RC_PROTO_RC5_SZ       = 4,
    RC_PROTO_JVC          = 5,
    RC_PROTO_SONY12        = 6,
    RC_PROTO_SONY15        = 7,
    RC_PROTO_SONY20        = 8,
    RC_PROTO_NEC          = 9,
    RC_PROTO_NECX         = 10,
    RC_PROTO_NEC32         = 11,
    RC_PROTO_SANYO         = 12,
    RC_PROTO_MCIR2_KBD    = 13,
    RC_PROTO_MCIR2_MSE    = 14,
    RC_PROTO_RC6_0          = 15,
    RC_PROTO_RC6_6A_20     = 16,
    RC_PROTO_RC6_6A_24     = 17,
    RC_PROTO_RC6_6A_32     = 18,
    RC_PROTO_RC6_MCE       = 19,
    RC_PROTO_SHARP         = 20,
    RC_PROTO_XMP           = 21,
    RC_PROTO_CEC           = 22,
    RC_PROTO_IMON          = 23,
    RC_PROTO_RCMM12        = 24,
    RC_PROTO_RCMM24        = 25,
}

```

```
    RC_PROTO_RCMM32      = 26,  
    RC_PROTO_XBOX_DVD    = 27,  
    RC_PROTO_MAX          = RC_PROTO_XBOX_DVD,  
};  
#endif
```

### 13.4.7 Revision and Copyright

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- Initial version.

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### 13.4.8 Revision History

#### **revision**

3.15 / 2014-02-06 (*mcc*)

Added the interface description and the RC sysfs class description.

#### **revision**

1.0 / 2009-09-06 (*mcc*)

Initial revision

## 13.5 Part IV - Media Controller API

### 13.5.1 Introduction

Media devices increasingly handle multiple related functions. Many USB cameras include microphones, video capture hardware can also output video, or SoC camera interfaces also perform memory-to-memory operations similar to video codecs.

Independent functions, even when implemented in the same hardware, can be modelled as separate devices. A USB camera with a microphone will be presented to userspace applications as V4L2 and ALSA capture devices. The devices' relationships (when using a webcam, end-users shouldn't have to manually select the associated USB microphone), while not made available directly to applications by the drivers, can usually be retrieved from sysfs.

With more and more advanced SoC devices being introduced, the current approach will not scale. Device topologies are getting increasingly complex and can't always be represented by a tree structure. Hardware blocks are shared between different functions, creating dependencies between seemingly unrelated devices.

Kernel abstraction APIs such as V4L2 and ALSA provide means for applications to access hardware parameters. As newer hardware expose an increasingly high number of those parameters, drivers need to guess what applications really require based on limited information, thereby implementing policies that belong to userspace.

The media controller API aims at solving those problems.

### 13.5.2 Media device model

Discovering a device internal topology, and configuring it at runtime, is one of the goals of the media controller API. To achieve this, hardware devices and Linux Kernel interfaces are modelled as graph objects on an oriented graph. The object types that constitute the graph are:

- An **entity** is a basic media hardware or software building block. It can correspond to a large variety of logical blocks such as physical hardware devices (CMOS sensor for instance), logical hardware devices (a building block in a System-on-Chip image processing pipeline), DMA channels or physical connectors.
- An **interface** is a graph representation of a Linux Kernel userspace API interface, like a device node or a sysfs file that controls one or more entities in the graph.
- A **pad** is a data connection endpoint through which an entity can interact with other entities. Data (not restricted to video) produced by an entity flows from the entity's output to one or more entity inputs. Pads should not be confused with physical pins at chip boundaries.
- A **data link** is a point-to-point oriented connection between two pads, either on the same entity or on different entities. Data flows from a source pad to a sink pad.
- An **interface link** is a point-to-point bidirectional control connection between a Linux Kernel interface and an entity.
- An **ancillary link** is a point-to-point connection denoting that two entities form a single logical unit. For example this could represent the fact that a particular camera sensor and lens controller form a single physical module, meaning this lens controller drives the lens for this camera sensor.

### 13.5.3 Types and flags used to represent the media graph elements

Table 294: Media entity functions

<code>MEDIA_ENT_F_UNKNOWN</code>	and	Unknown entity. That generally indicates that a driver didn't initialize properly the entity, which is a Kernel bug
<code>MEDIA_ENT_F_V4L2_SUBDEV_UNKNOWN</code>		
<code>MEDIA_ENT_F_IO_V4L</code>		Data streaming input and/or output entity.
<code>MEDIA_ENT_F_IO_VBI</code>		V4L VBI streaming input or output entity
<code>MEDIA_ENT_F_IO_SWRADIO</code>		V4L Software Digital Radio (SDR) streaming input or output entity
<code>MEDIA_ENT_F_IO_DTV</code>		DVB Digital TV streaming input or output entity
<code>MEDIA_ENT_F_DTV_DEMOD</code>		Digital TV demodulator entity.
<code>MEDIA_ENT_F_TS_DEMUX</code>		MPEG Transport stream demux entity. Could be implemented on hardware or in Kernelspace by the Linux DVB subsystem.
<code>MEDIA_ENT_F_DTV_CA</code>		Digital TV Conditional Access module (CAM) entity

continues on next page

Table 294 – continued from previous page

MEDIA_ENT_F_DTV_NET_DECAP	Digital TV network ULE/MLE desencapsulation entity. Could be implemented on hardware or in Kernelspace
MEDIA_ENT_F_CONN_RF	Connector for a Radio Frequency (RF) signal.
MEDIA_ENT_F_CONN_SVIDEO	Connector for a S-Video signal.
MEDIA_ENT_F_CONN_COMPOSITE	Connector for a RGB composite signal.
MEDIA_ENT_F_CAM_SENSOR	Camera video sensor entity.
MEDIA_ENT_F_FLASH	Flash controller entity.
MEDIA_ENT_F_LENS	Lens controller entity.
MEDIA_ENT_F_ATV_DECODER	Analog video decoder, the basic function of the video decoder is to accept analogue video from a wide variety of sources such as broadcast, DVD players, cameras and video cassette recorders, in either NTSC, PAL, SECAM or HD format, separating the stream into its component parts, luminance and chrominance, and output it in some digital video standard, with appropriate timing signals.
MEDIA_ENT_F_TUNER	Digital TV, analog TV, radio and/or software radio tuner, with consists on a PLL tuning stage that converts radio frequency (RF) signal into an Intermediate Frequency (IF). Modern tuners have internally IF-PLL decoders for audio and video, but older models have those stages implemented on separate entities.
MEDIA_ENT_F_IF_VID_DECODER	IF-PLL video decoder. It receives the IF from a PLL and decodes the analog TV video signal. This is commonly found on some very old analog tuners, like Philips MK3 designs. They all contain a tda9887 (or some software compatible similar chip, like tda9885). Those devices use a different I2C address than the tuner PLL.
MEDIA_ENT_F_IF_AUD_DECODER	IF-PLL sound decoder. It receives the IF from a PLL and decodes the analog TV audio signal. This is commonly found on some very old analog hardware, like Micronas msp3400, Philips tda9840, tda985x, etc. Those devices use a different I2C address than the tuner PLL and should be controlled together with the IF-PLL video decoder.
MEDIA_ENT_F_AUDIO_CAPTURE	Audio Capture Function Entity.
MEDIA_ENT_F_AUDIO_PLAYBACK	Audio Playback Function Entity.
MEDIA_ENT_F_AUDIO_MIXER	Audio Mixer Function Entity.

continues on next page

Table 294 – continued from previous page

MEDIA_ENT_F_PROC_VIDEO_COMPOSER	Video composer (blender). An entity capable of video composing must have at least two sink pads and one source pad, and composes input video frames onto output video frames. Composition can be performed using alpha blending, color keying, raster operations (ROP), stitching or any other means.
MEDIA_ENT_F_PROC_VIDEO_PIXEL_FORMATTER	Video pixel formatter. An entity capable of pixel formatting must have at least one sink pad and one source pad. Read pixel formatters read pixels from memory and perform a subset of unpacking, cropping, color keying, alpha multiplication and pixel encoding conversion. Write pixel formatters perform a subset of dithering, pixel encoding conversion and packing and write pixels to memory.
MEDIA_ENT_F_PROC_VIDEO_PIXEL_ENC_CONV	Video pixel encoding converter. An entity capable of pixel encoding conversion must have at least one sink pad and one source pad, and convert the encoding of pixels received on its sink pad(s) to a different encoding output on its source pad(s). Pixel encoding conversion includes but isn't limited to RGB to/from HSV, RGB to/from YUV and CFA (Bayer) to RGB conversions.
MEDIA_ENT_F_PROC_VIDEO_LUT	Video look-up table. An entity capable of video lookup table processing must have one sink pad and one source pad. It uses the values of the pixels received on its sink pad to look up entries in internal tables and output them on its source pad. The lookup processing can be performed on all components separately or combine them for multi-dimensional table lookups.
MEDIA_ENT_F_PROC_VIDEO_SCALER	Video scaler. An entity capable of video scaling must have at least one sink pad and one source pad, and scale the video frame(s) received on its sink pad(s) to a different resolution output on its source pad(s). The range of supported scaling ratios is entity-specific and can differ between the horizontal and vertical directions (in particular scaling can be supported in one direction only). Binning and sub-sampling (occasionally also referred to as skipping) are considered as scaling.

continues on next page

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MEDIA_ENT_F_PROC_VIDEO_STATISTICS	Video statistics computation (histogram, 3A, etc.). An entity capable of statistics computation must have one sink pad and one source pad. It computes statistics over the frames received on its sink pad and outputs the statistics data on its source pad.
MEDIA_ENT_F_PROC_VIDEO_ENCODER	Video (MPEG, HEVC, VPx, etc.) encoder. An entity capable of compressing video frames. Must have one sink pad and at least one source pad.
MEDIA_ENT_F_PROC_VIDEO_DECODER	Video (MPEG, HEVC, VPx, etc.) decoder. An entity capable of decompressing a compressed video stream into uncompressed video frames. Must have one sink pad and at least one source pad.
MEDIA_ENT_F_PROC_VIDEO_ISP	An Image Signal Processor (ISP) device. ISPs generally are one of a kind devices that have their specific control interfaces using a combination of custom V4L2 controls and IOCTLs, and parameters supplied in a metadata buffer.
MEDIA_ENT_F_VID_MUX	Video multiplexer. An entity capable of multiplexing must have at least two sink pads and one source pad, and must pass the video frame(s) received from the active sink pad to the source pad.
MEDIA_ENT_F_VID_IF_BRIDGE	Video interface bridge. A video interface bridge entity must have at least one sink pad and at least one source pad. It receives video frames on its sink pad from an input video bus of one type (HDMI, eDP, MIPI CSI-2, etc.), and outputs them on its source pad to an output video bus of another type (eDP, MIPI CSI-2, parallel, etc.).
MEDIA_ENT_F_DV_DECODER	Digital video decoder. The basic function of the video decoder is to accept digital video from a wide variety of sources and output it in some digital video standard, with appropriate timing signals.
MEDIA_ENT_F_DV_ENCODER	Digital video encoder. The basic function of the video encoder is to accept digital video from some digital video standard with appropriate timing signals (usually a parallel video bus with sync signals) and output this to a digital video output connector such as HDMI or DisplayPort.

Table 295: Media entity flags

MEDIA_ENT_FL_DEFAULT	Default entity for its type. Used to discover the default audio, VBI and video devices, the default camera sensor, etc.
MEDIA_ENT_FL_CONNECTOR	The entity represents a connector.

Table 296: Media interface types

<code>MEDIA_INTF_T_DVB_FE</code>	Device node interface for the Digital TV frontend	typically, /dev/dvb/adapter?/frontend?
<code>MEDIA_INTF_T_DVB_DEMUX</code>	Device node interface for the Digital TV demux	typically, /dev/dvb/adapter?/demux?
<code>MEDIA_INTF_T_DVB_DVR</code>	Device node interface for the Digital TV DVR	typically, /dev/dvb/adapter?/dvr?
<code>MEDIA_INTF_T_DVB_CA</code>	Device node interface for the Digital TV Conditional Access	typically, /dev/dvb/adapter?/ca?
<code>MEDIA_INTF_T_DVB_NET</code>	Device node interface for the Digital TV network control	typically, /dev/dvb/adapter?/net?
<code>MEDIA_INTF_T_V4L_VIDEO</code>	Device node interface for video (V4L)	typically, /dev/video?
<code>MEDIA_INTF_T_V4L_VBI</code>	Device node interface for VBI (V4L)	typically, /dev/vbi?
<code>MEDIA_INTF_T_V4L_RADIO</code>	Device node interface for radio (V4L)	typically, /dev/radio?
<code>MEDIA_INTF_T_V4L_SUBDEV</code>	Device node interface for a V4L subdevice	typically, /dev/v4l-subdev?
<code>MEDIA_INTF_T_V4L_SWRADIO</code>	Device node interface for Software Defined Radio (V4L)	typically, /dev/swradio?
<code>MEDIA_INTF_T_V4L_TOUCH</code>	Device node interface for Touch device (V4L)	typically, /dev/v4l-touch?
<code>MEDIA_INTF_T_ALSA_PCM_CAPTURE</code>	Device node interface for ALSA PCM Capture	typically, /dev/snd/pcmC?D?c
<code>MEDIA_INTF_T_ALSA_PCM_PLAYBACK</code>	Device node interface for ALSA PCM Playback	typically, /dev/snd/pcmC?D?p
<code>MEDIA_INTF_T_ALSA_CONTROL</code>	Device node interface for ALSA Control	typically, /dev/snd/controlC?
<code>MEDIA_INTF_T_ALSA_COMPRESS</code>	Device node interface for ALSA Compress	typically, /dev/snd/compr?
<code>MEDIA_INTF_T_ALSA_RAWMIDI</code>	Device node interface for ALSA Raw MIDI	typically, /dev/snd/midi?
<code>MEDIA_INTF_T_ALSA_HWDEP</code>	Device node interface for ALSA Hardware Dependent	typically, /dev/snd/hwC?D?
<code>MEDIA_INTF_T_ALSA_SEQUENCER</code>	Device node interface for ALSA Sequencer	typically, /dev/snd/seq
<code>MEDIA_INTF_T_ALSA_TIMER</code>	Device node interface for ALSA Timer	typically, /dev/snd/timer

Table 297: Media pad flags

<code>MEDIA_PAD_FL_SINK</code>	Input pad, relative to the entity. Input pads sink data and are targets of links.
<code>MEDIA_PAD_FL_SOURCE</code>	Output pad, relative to the entity. Output pads source data and are origins of links.
<code>MEDIA_PAD_FL_MUST_CONNECT</code>	If this flag is set and the pad is linked to any other pad, then at least one of those links must be enabled for the entity to be able to stream. There could be temporary reasons (e.g. device configuration dependent) for the pad to need enabled links even when this flag isn't set; the absence of the flag doesn't imply there is none.

One and only one of `MEDIA_PAD_FL_SINK` and `MEDIA_PAD_FL_SOURCE` must be set for every pad.

Table 298: Media link flags

<code>MEDIA_LNK_FL_ENABLED</code>	The link is enabled and can be used to transfer media data. When two or more links target a sink pad, only one of them can be enabled at a time.
<code>MEDIA_LNK_FL_IMMUTABLE</code>	The link enabled state can't be modified at runtime. An immutable link is always enabled.
<code>MEDIA_LNK_FL_DYNAMIC</code>	The link enabled state can be modified during streaming. This flag is set by drivers and is read-only for applications.
<code>MEDIA_LNK_FL_LINK_TYPE</code>	This is a bitmask that defines the type of the link. The following link types are currently supported: <code>MEDIA_LNK_FL_DATA_LINK</code> for links that represent a data connection between two pads. <code>MEDIA_LNK_FL_INTERFACE_LINK</code> for links that associate an entity to its interface. <code>MEDIA_LNK_FL_ANCILLARY_LINK</code> for links that represent a physical relationship between two entities. The link may or may not be immutable, so applications must not assume either case.

### 13.5.4 Request API

The Request API has been designed to allow V4L2 to deal with requirements of modern devices (stateless codecs, complex camera pipelines, ...) and APIs (Android Codec v2). One such requirement is the ability for devices belonging to the same pipeline to reconfigure and collaborate closely on a per-frame basis. Another is support of stateless codecs, which require controls to be applied to specific frames (aka 'per-frame controls') in order to be used efficiently.

While the initial use-case was V4L2, it can be extended to other subsystems as well, as long as they use the media controller.

Supporting these features without the Request API is not always possible and if it is, it is terribly inefficient: user-space would have to flush all activity on the media pipeline, reconfigure it for the next frame, queue the buffers to be processed with that configuration, and wait until they are all available for dequeuing before considering the next frame. This defeats the purpose of having buffer queues since in practice only one buffer would be queued at a time.

The Request API allows a specific configuration of the pipeline (media controller topology + configuration for each media entity) to be associated with specific buffers. This allows user-space to schedule several tasks ("requests") with different configurations in advance, knowing that the configuration will be applied when needed to get the expected result. Configuration values at the time of request completion are also available for reading.

## General Usage

The Request API extends the Media Controller API and cooperates with subsystem-specific APIs to support request usage. At the Media Controller level, requests are allocated from the supporting Media Controller device node. Their life cycle is then managed through the request file descriptors in an opaque way. Configuration data, buffer handles and processing results stored in requests are accessed through subsystem-specific APIs extended for request support, such as V4L2 APIs that take an explicit `request_fd` parameter.

## Request Allocation

User-space allocates requests using `ioctl MEDIA_IOC_REQUEST_ALLOC` for the media device node. This returns a file descriptor representing the request. Typically, several such requests will be allocated.

## Request Preparation

Standard V4L2 ioctls can then receive a request file descriptor to express the fact that the ioctl is part of said request, and is not to be applied immediately. See `ioctl MEDIA_IOC_REQUEST_ALLOC` for a list of ioctls that support this. Configurations set with a `request_fd` parameter are stored instead of being immediately applied, and buffers queued to a request do not enter the regular buffer queue until the request itself is queued.

## Request Submission

Once the configuration and buffers of the request are specified, it can be queued by calling `ioctl MEDIA_REQUEST_IOC_QUEUE` on the request file descriptor. A request must contain at least one buffer, otherwise `ENOENT` is returned. A queued request cannot be modified anymore.

**Caution:** For *memory-to-memory devices* you can use requests only for output buffers, not for capture buffers. Attempting to add a capture buffer to a request will result in an `EBADR` error.

If the request contains configurations for multiple entities, individual drivers may synchronize so the requested pipeline's topology is applied before the buffers are processed. Media controller drivers do a best effort implementation since perfect atomicity may not be possible due to hardware limitations.

**Caution:** It is not allowed to mix queuing requests with directly queuing buffers: whichever method is used first locks this in place until `VIDIOC_STREAMOFF` is called or the device is *closed*. Attempts to directly queue a buffer when earlier a buffer was queued via a request or vice versa will result in an EBUSY error.

Controls can still be set without a request and are applied immediately, regardless of whether a request is in use or not.

**Caution:** Setting the same control through a request and also directly can lead to undefined behavior!

User-space can `poll()` a request file descriptor in order to wait until the request completes. A request is considered complete once all its associated buffers are available for dequeuing and all the associated controls have been updated with the values at the time of completion. Note that user-space does not need to wait for the request to complete to dequeue its buffers: buffers that are available halfway through a request can be dequeued independently of the request's state.

A completed request contains the state of the device after the request was executed. User-space can query that state by calling `ioctl VIDIOC_G_EXT_CTRLS` with the request file descriptor. Calling `ioctl VIDIOC_G_EXT_CTRLS` for a request that has been queued but not yet completed will return EBUSY since the control values might be changed at any time by the driver while the request is in flight.

## Recycling and Destruction

Finally, a completed request can either be discarded or be reused. Calling `close()` on a request file descriptor will make that file descriptor unusable and the request will be freed once it is no longer in use by the kernel. That is, if the request is queued and then the file descriptor is closed, then it won't be freed until the driver completed the request.

The `ioctl MEDIA_REQUEST_IOC_REINIT` will clear a request's state and make it available again. No state is retained by this operation: the request is as if it had just been allocated.

## Example for a Codec Device

For use-cases such as `codecs`, the request API can be used to associate specific controls to be applied by the driver for the OUTPUT buffer, allowing user-space to queue many such buffers in advance. It can also take advantage of requests' ability to capture the state of controls when the request completes to read back information that may be subject to change.

Put into code, after obtaining a request, user-space can assign controls and one OUTPUT buffer to it:

```
struct v4l2_buffer buf;
struct v4l2_ext_controls ctrls;
int req_fd;
...
if (ioctl(media_fd, MEDIA_IOC_REQUEST_ALLOC, &req_fd))
```

```

    return errno;
...
ctrls.which = V4L2_CTRL WHICH_REQUEST_VAL;
ctrls.request_fd = req_fd;
if (ioctl(codec_fd, VIDIOC_S_EXT_CTRLS, &ctrls))
    return errno;
...
buf.type = V4L2_BUF_TYPE_VIDEO_OUTPUT;
buf.flags |= V4L2_BUF_FLAG_REQUEST_FD;
buf.request_fd = req_fd;
if (ioctl(codec_fd, VIDIOC_QBUF, &buf))
    return errno;

```

Note that it is not allowed to use the Request API for CAPTURE buffers since there are no per-frame settings to report there.

Once the request is fully prepared, it can be queued to the driver:

```

if (ioctl(req_fd, MEDIA_REQUEST_IOC_QUEUE))
    return errno;

```

User-space can then either wait for the request to complete by calling `poll()` on its file descriptor, or start dequeuing CAPTURE buffers. Most likely, it will want to get CAPTURE buffers as soon as possible and this can be done using a regular `VIDIOC_DQBUF`:

```

struct v4l2_buffer buf;

memset(&buf, 0, sizeof(buf));
buf.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
if (ioctl(codec_fd, VIDIOC_DQBUF, &buf))
    return errno;

```

Note that this example assumes for simplicity that for every OUTPUT buffer there will be one CAPTURE buffer, but this does not have to be the case.

We can then, after ensuring that the request is completed via polling the request file descriptor, query control values at the time of its completion via a call to `VIDIOC_G_EXT_CTRLS`. This is particularly useful for volatile controls for which we want to query values as soon as the capture buffer is produced.

```

struct pollfd pfd = { .events = POLLPRI, .fd = req_fd };
poll(&pfd, 1, -1);
...
ctrls.which = V4L2_CTRL WHICH_REQUEST_VAL;
ctrls.request_fd = req_fd;
if (ioctl(codec_fd, VIDIOC_G_EXT_CTRLS, &ctrls))
    return errno;

```

Once we don't need the request anymore, we can either recycle it for reuse with `ioctl MEDIA_REQUEST_IOC_REINIT`...

```

if (ioctl(req_fd, MEDIA_REQUEST_IOC_REINIT))
    return errno;

```

... or close its file descriptor to completely dispose of it.

```
close(req_fd);
```

### Example for a Simple Capture Device

With a simple capture device, requests can be used to specify controls to apply for a given CAPTURE buffer.

```
struct v4l2_buffer buf;
struct v4l2_ext_controls ctrls;
int req_fd;
...
if (ioctl(media_fd, MEDIA_IOC_REQUEST_ALLOC, &req_fd))
    return errno;
...
ctrls.which = V4L2_CTRL WHICH REQUEST VAL;
ctrls.request_fd = req_fd;
if (ioctl(camera_fd, VIDIOC_S_EXT_CTRLS, &ctrls))
    return errno;
...
buf.type = V4L2_BUF_TYPE_VIDEO_CAPTURE;
buf.flags |= V4L2_BUF_FLAG_REQUEST_FD;
buf.request_fd = req_fd;
if (ioctl(camera_fd, VIDIOC_QBUF, &buf))
    return errno;
```

Once the request is fully prepared, it can be queued to the driver:

```
if (ioctl(req_fd, MEDIA_REQUEST_IOC_QUEUE))
    return errno;
```

User-space can then dequeue buffers, wait for the request completion, query controls and recycle the request as in the M2M example above.

### 13.5.5 Function Reference

#### media open()

##### Name

media-open - Open a media device

## Synopsis

```
#include <fcntl.h>
```

```
int open(const char *device_name, int flags)
```

## Arguments

### device\_name

Device to be opened.

### flags

Open flags. Access mode must be either `O_RDONLY` or `O_RDWR`. Other flags have no effect.

## Description

To open a media device applications call `open()` with the desired device name. The function has no side effects; the device configuration remain unchanged.

When the device is opened in read-only mode, attempts to modify its configuration will result in an error, and `errno` will be set to `EBADF`.

## Return Value

`open()` returns the new file descriptor on success. On error, -1 is returned, and `errno` is set appropriately. Possible error codes are:

### EACCES

The requested access to the file is not allowed.

### EMFILE

The process already has the maximum number of files open.

### ENFILE

The system limit on the total number of open files has been reached.

### ENOMEM

Insufficient kernel memory was available.

### ENXIO

No device corresponding to this device special file exists.

## media close()

### Name

media-close - Close a media device

### Synopsis

```
#include <unistd.h>
```

```
int close(int fd)
```

### Arguments

#### fd

File descriptor returned by *open()*.

### Description

Closes the media device. Resources associated with the file descriptor are freed. The device configuration remain unchanged.

### Return Value

*close()* returns 0 on success. On error, -1 is returned, and *errno* is set appropriately. Possible error codes are:

#### EBADF

fd is not a valid open file descriptor.

## media ioctl()

### Name

media-ioctl - Control a media device

### Synopsis

```
#include <sys/ioctl.h>
```

```
int ioctl(int fd, int request, void *argp)
```

## Arguments

### fd

File descriptor returned by `open()`.

### request

Media ioctl request code as defined in the media.h header file, for example `MEDIA_IOC_SETUP_LINK`.

### argp

Pointer to a request-specific structure.

## Description

The `ioctl()` function manipulates media device parameters. The argument `fd` must be an open file descriptor.

The ioctl request code specifies the media function to be called. It has encoded in it whether the argument is an input, output or read/write parameter, and the size of the argument `argp` in bytes.

Macros and structures definitions specifying media ioctl requests and their parameters are located in the media.h header file. All media ioctl requests, their respective function and parameters are specified in *Function Reference*.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the *Generic Error Codes* chapter.

Request-specific error codes are listed in the individual requests descriptions.

When an ioctl that takes an output or read/write parameter fails, the parameter remains unmodified.

## ioctl MEDIA\_IOC\_DEVICE\_INFO

### Name

`MEDIA_IOC_DEVICE_INFO` - Query device information

### Synopsis

#### `MEDIA_IOC_DEVICE_INFO`

```
int ioctl(int fd, MEDIA_IOC_DEVICE_INFO, struct media_device_info *argp)
```

## Arguments

### fd

File descriptor returned by `open()`.

### argp

Pointer to struct `media_device_info`.

## Description

All media devices must support the `MEDIA_IOC_DEVICE_INFO` ioctl. To query device information, applications call the ioctl with a pointer to a struct `media_device_info`. The driver fills the structure and returns the information to the application. The ioctl never fails.

type `media_device_info`

Table 299: struct `media_device_info`

char	<code>driver[16]</code>	Name of the driver implementing the media API as a NUL-terminated ASCII string. The driver version is stored in the <code>driver_version</code> field. Driver specific applications can use this information to verify the driver identity. It is also useful to work around known bugs, or to identify drivers in error reports.
char	<code>model[32]</code>	Device model name as a NUL-terminated UTF-8 string. The device version is stored in the <code>device_version</code> field and is not be appended to the model name.
char	<code>serial[40]</code>	Serial number as a NUL-terminated ASCII string.
char	<code>bus_info[32]</code>	Location of the device in the system as a NUL-terminated ASCII string. This includes the bus type name (PCI, USB, ...) and a bus-specific identifier.
<code>_u32</code>	<code>media_version</code>	Media API version, formatted with the <code>KERNEL_VERSION()</code> macro.
<code>_u32</code>	<code>hw_revision</code>	Hardware device revision in a driver-specific format.
<code>_u32</code>	<code>driver_version</code>	Media device driver version, formatted with the <code>KERNEL_VERSION()</code> macro. Together with the <code>driver</code> field this identifies a particular driver.
<code>_u32</code>	<code>reserved[31]</code>	Reserved for future extensions. Drivers and applications must set this array to zero.

The `serial` and `bus_info` fields can be used to distinguish between multiple instances of otherwise identical hardware. The serial number takes precedence when provided and can be assumed to be unique. If the serial number is an empty string, the `bus_info` field can be used

instead. The `bus_info` field is guaranteed to be unique, but can vary across reboots or device unplug/replug.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## ioctl MEDIA\_IOC\_G\_TOPOLOGY

### Name

`MEDIA_IOC_G_TOPOLOGY` - Enumerate the graph topology and graph element properties

### Synopsis

#### `MEDIA_IOC_G_TOPOLOGY`

```
int ioctl(int fd, MEDIA_IOC_G_TOPOLOGY, struct media_v2_topology *argp)
```

### Arguments

#### `fd`

File descriptor returned by [`open\(\)`](#).

#### `argp`

Pointer to struct [`media\_v2\_topology`](#).

### Description

The typical usage of this ioctl is to call it twice. On the first call, the structure defined at struct [`media\_v2\_topology`](#) should be zeroed. At return, if no errors happen, this ioctl will return the `topology_version` and the total number of entities, interfaces, pads and links.

Before the second call, the userspace should allocate arrays to store the graph elements that are desired, putting the pointers to them at the `ptr_entities`, `ptr_interfaces`, `ptr_links` and/or `ptr_pads`, keeping the other values untouched.

If the `topology_version` remains the same, the ioctl should fill the desired arrays with the media graph elements.

type `media_v2_topology`

Table 300: struct media\_v2\_topology

<code>__u64</code>	<code>topology_version</code>	Version of the media graph topology. When the graph is created, this field starts with zero. Every time a graph element is added or removed, this field is incremented.
<code>__u32</code>	<code>num_entities</code>	Number of entities in the graph
<code>__u32</code>	<code>reserved1</code>	Applications and drivers shall set this to 0.
<code>__u64</code>	<code>ptr_entities</code>	A pointer to a memory area where the entities array will be stored, converted to a 64-bits integer. It can be zero. if zero, the ioctl won't store the entities. It will just update <code>num_entities</code>
<code>__u32</code>	<code>num_interfaces</code>	Number of interfaces in the graph
<code>__u32</code>	<code>reserved2</code>	Applications and drivers shall set this to 0.
<code>__u64</code>	<code>ptr_interfaces</code>	A pointer to a memory area where the interfaces array will be stored, converted to a 64-bits integer. It can be zero. if zero, the ioctl won't store the interfaces. It will just update <code>num_interfaces</code>
<code>__u32</code>	<code>num_pads</code>	Total number of pads in the graph
<code>__u32</code>	<code>reserved3</code>	Applications and drivers shall set this to 0.
<code>__u64</code>	<code>ptr_pads</code>	A pointer to a memory area where the pads array will be stored, converted to a 64-bits integer. It can be zero. if zero, the ioctl won't store the pads. It will just update <code>num_pads</code>
<code>__u32</code>	<code>num_links</code>	Total number of data and interface links in the graph
<code>__u32</code>	<code>reserved4</code>	Applications and drivers shall set this to 0.
<code>__u64</code>	<code>ptr_links</code>	A pointer to a memory area where the links array will be stored, converted to a 64-bits integer. It can be zero. if zero, the ioctl won't store the links. It will just update <code>num_links</code>

type `media_v2_entity`

Table 301: struct media\_v2\_entity

<code>__u32</code>	<code>id</code>	Unique ID for the entity. Do not expect that the ID will always be the same for each instance of the device. In other words, do not hardcode entity IDs in an application.
<code>char</code>	<code>name[64]</code>	Entity name as an UTF-8 NULL-terminated string. This name must be unique within the media topology.
<code>__u32</code>	<code>function</code>	Entity main function, see <a href="#">Media entity functions</a> for details.
<code>__u32</code>	<code>flags</code>	Entity flags, see <a href="#">Media entity flags</a> for details. Only valid if <code>MEDIA_V2_ENTITY_HAS_FLAGS(media_version)</code> returns true. The <code>media_version</code> is defined in struct <a href="#">media_device_info</a> and can be retrieved using <a href="#">ioctl MEDIA_IOC_DEVICE_INFO</a> .
<code>__u32</code>	<code>reserved[5]</code>	Reserved for future extensions. Drivers and applications must set this array to zero.

type `media_v2_interface`

Table 302: struct media\_v2\_interface

<code>_u32</code>	<code>id</code>	Unique ID for the interface. Do not expect that the ID will always be the same for each instance of the device. In other words, do not hardcode interface IDs in an application.
<code>_u32</code>	<code>intf_type</code>	Interface type, see <a href="#">Media interface types</a> for details.
<code>_u32</code>	<code>flags</code>	Interface flags. Currently unused.
<code>_u32</code>	<code>reserved[9]</code>	Reserved for future extensions. Drivers and applications must set this array to zero.

type **media\_v2\_intf\_devnode**

Table 303: struct media\_v2\_intf\_devnode

<code>_u32</code>	<code>major</code>	Device node major number.
<code>_u32</code>	<code>minor</code>	Device node minor number.

type **media\_v2\_pad**

Table 304: struct media\_v2\_pad

<code>_u32</code>	<code>id</code>	Unique ID for the pad. Do not expect that the ID will always be the same for each instance of the device. In other words, do not hardcode pad IDs in an application.
<code>_u32</code>	<code>entity_id</code>	Unique ID for the entity where this pad belongs.
<code>_u32</code>	<code>flags</code>	Pad flags, see <a href="#">Media pad flags</a> for more details.
<code>_u32</code>	<code>index</code>	Pad index, starts at 0. Only valid if <code>MEDIA_V2_PAD_HAS_INDEX(media_version)</code> returns true. The <code>media_version</code> is defined in struct <a href="#">media_device_info</a> and can be retrieved using <code>ioctl MEDIA_IOC_DEVICE_INFO</code> .
<code>_u32</code>	<code>reserved[4]</code>	Reserved for future extensions. Drivers and applications must set this array to zero.

type **media\_v2\_link**

Table 305: struct media\_v2\_link

<code>_u32</code>	<code>id</code>	Unique ID for the link. Do not expect that the ID will always be the same for each instance of the device. In other words, do not hardcode link IDs in an application.
<code>_u32</code>	<code>source_id</code>	On pad to pad links: unique ID for the source pad. On interface to entity links: unique ID for the interface.
<code>_u32</code>	<code>sink_id</code>	On pad to pad links: unique ID for the sink pad. On interface to entity links: unique ID for the entity.
<code>_u32</code>	<code>flags</code>	Link flags, see <a href="#">Media link flags</a> for more details.
<code>_u32</code>	<code>reserved[6]</code>	Reserved for future extensions. Drivers and applications must set this array to zero.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## ENOSPC

This is returned when either one or more of the `num_entities`, `num_interfaces`, `num_links` or `num_pads` are non-zero and are smaller than the actual number of elements inside the graph. This may happen if the `topology_version` changed when compared to the last time this ioctl was called. Userspace should usually free the area for the pointers, zero the struct elements and call this ioctl again.

## ioctl MEDIA\_IOC\_ENUM\_ENTITIES

### Name

`MEDIA_IOC_ENUM_ENTITIES` - Enumerate entities and their properties

### Synopsis

#### `MEDIA_IOC_ENUM_ENTITIES`

```
int ioctl(int fd, MEDIA_IOC_ENUM_ENTITIES, struct media_entity_desc *argp)
```

### Arguments

#### `fd`

File descriptor returned by [`open\(\)`](#).

#### `argp`

Pointer to struct [`media\_entity\_desc`](#).

### Description

To query the attributes of an entity, applications set the `id` field of a struct [`media\_entity\_desc`](#) structure and call the `MEDIA_IOC_ENUM_ENTITIES` ioctl with a pointer to this structure. The driver fills the rest of the structure or returns an `EINVAL` error code when the `id` is invalid.

Entities can be enumerated by or'ing the `id` with the `MEDIA_ENT_ID_FLAG_NEXT` flag. The driver will return information about the entity with the smallest `id` strictly larger than the requested one ('next entity'), or the `EINVAL` error code if there is none.

Entity IDs can be non-contiguous. Applications must *not* try to enumerate entities by calling `MEDIA_IOC_ENUM_ENTITIES` with increasing `id`'s until they get an error.

type `media_entity_desc`

Table 306: struct media\_entity\_desc

<code>_u32</code>	<code>id</code>		Entity ID, set by the application. When the ID is or'ed with <code>MEDIA_ENT_ID_FLAG_NEXT</code> , the driver clears the flag and returns the first entity with a larger ID. Do not expect that the ID will always be the same for each instance of the device. In other words, do not hard-code entity IDs in an application.
<code>char</code>	<code>name[32]</code>		Entity name as an UTF-8

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

### EINVAL

The struct `media_entity_desc` id references a non-existing entity.

## ioctl MEDIA\_IOC\_ENUM\_LINKS

### Name

`MEDIA_IOC_ENUM_LINKS` - Enumerate all pads and links for a given entity

### Synopsis

#### `MEDIA_IOC_ENUM_LINKS`

```
int ioctl(int fd, MEDIA_IOC_ENUM_LINKS, struct media_links_enum *argp)
```

### Arguments

#### `fd`

File descriptor returned by [`open\(\)`](#).

#### `argp`

Pointer to struct `media_links_enum`.

### Description

To enumerate pads and/or links for a given entity, applications set the `entity` field of a struct `media_links_enum` structure and initialize the struct `media_pad_desc` and struct `media_link_desc` structure arrays pointed by the `pads` and `links` fields. They then call the `MEDIA_IOC_ENUM_LINKS` ioctl with a pointer to this structure.

If the `pads` field is not NULL, the driver fills the `pads` array with information about the entity's pads. The array must have enough room to store all the entity's pads. The number of pads can be retrieved with [ioctl MEDIA\\_IOC\\_ENUM\\_ENTITIES](#).

If the `links` field is not NULL, the driver fills the `links` array with information about the entity's outbound links. The array must have enough room to store all the entity's outbound links. The number of outbound links can be retrieved with [ioctl MEDIA\\_IOC\\_ENUM\\_ENTITIES](#).

Only forward links that originate at one of the entity's source pads are returned during the enumeration process.

type `media_links_enum`

Table 307: struct media\_links\_enum

<code>_u32</code>	<code>entity</code>	Entity id, set by the application.
<code>struct media_pad_desc</code>	<code>*pads</code>	Pointer to a pads array allocated by the application. Ignored if NULL.
<code>struct media_link_desc</code>	<code>*links</code>	Pointer to a links array allocated by the application. Ignored if NULL.
<code>_u32</code>	<code>reserved[4]</code>	Reserved for future extensions. Drivers and applications must set the array to zero.

type `media_pad_desc`

Table 308: struct media\_pad\_desc

<code>_u32</code>	<code>entity</code>	ID of the entity this pad belongs to.
<code>_u16</code>	<code>index</code>	Pad index, starts at 0.
<code>_u32</code>	<code>flags</code>	Pad flags, see <a href="#">Media pad flags</a> for more details.
<code>_u32</code>	<code>reserved[2]</code>	Reserved for future extensions. Drivers and applications must set the array to zero.

type `media_link_desc`

Table 309: struct media\_link\_desc

<code>struct media_pad_desc</code>	<code>source</code>	Pad at the origin of this link.
<code>struct media_pad_desc</code>	<code>sink</code>	Pad at the target of this link.
<code>_u32</code>	<code>flags</code>	Link flags, see <a href="#">Media link flags</a> for more details.
<code>_u32</code>	<code>reserved[2]</code>	Reserved for future extensions. Drivers and applications must set the array to zero.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## EINVAL

The struct `media_links_enum` id references a non-existing entity.

### ioctl MEDIA\_IOC\_SETUP\_LINK

#### Name

MEDIA\_IOC\_SETUP\_LINK - Modify the properties of a link

#### Synopsis

##### **MEDIA\_IOC\_SETUP\_LINK**

```
int ioctl(int fd, MEDIA_IOC_SETUP_LINK, struct media_link_desc *argp)
```

#### Arguments

##### **fd**

File descriptor returned by [open\(\)](#).

##### **argp**

Pointer to struct [\*media\\_link\\_desc\*](#).

#### Description

To change link properties applications fill a struct [\*media\\_link\\_desc\*](#) with link identification information (source and sink pad) and the new requested link flags. They then call the MEDIA\_IOC\_SETUP\_LINK ioctl with a pointer to that structure.

The only configurable property is the ENABLED link flag to enable/disable a link. Links marked with the IMMUTABLE link flag can not be enabled or disabled.

Link configuration has no side effect on other links. If an enabled link at the sink pad prevents the link from being enabled, the driver returns with an EBUSY error code.

Only links marked with the DYNAMIC link flag can be enabled/disabled while streaming media data. Attempting to enable or disable a streaming non-dynamic link will return an EBUSY error code.

If the specified link can't be found the driver returns with an EINVAL error code.

#### Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

#### **EINVAL**

The struct [\*media\\_link\\_desc\*](#) references a non-existing link, or the link is immutable and an attempt to modify its configuration was made.

## ioctl MEDIA\_IOC\_REQUEST\_ALLOC

### Name

MEDIA\_IOC\_REQUEST\_ALLOC - Allocate a request

### Synopsis

#### MEDIA\_IOC\_REQUEST\_ALLOC

```
int ioctl(int fd, MEDIA_IOC_REQUEST_ALLOC, int *argp)
```

### Arguments

#### fd

File descriptor returned by [open\(\)](#).

#### argp

Pointer to an integer.

### Description

If the media device supports *requests*, then this ioctl can be used to allocate a request. If it is not supported, then `errno` is set to ENOTTY. A request is accessed through a file descriptor that is returned in `*argp`.

If the request was successfully allocated, then the request file descriptor can be passed to the `VIDIOC_QBUF`, `VIDIOC_G_EXT_CTRLS`, `VIDIOC_S_EXT_CTRLS` and `VIDIOC_TRY_EXT_CTRLS` ioctls.

In addition, the request can be queued by calling `ioctl MEDIA_REQUEST_IOC_QUEUE` and re-initialized by calling `ioctl MEDIA_REQUEST_IOC_REINIT`.

Finally, the file descriptor can be *polled* to wait for the request to complete.

The request will remain allocated until all the file descriptors associated with it are closed by `close()` and the driver no longer uses the request internally. See also [here](#) for more information.

### Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

#### ENOTTY

The driver has no support for requests.

## request close()

### Name

request-close - Close a request file descriptor

### Synopsis

```
#include <unistd.h>
```

```
int close(int fd)
```

### Arguments

#### fd

File descriptor returned by *ioctl MEDIA\_IOC\_REQUEST\_ALLOC*.

### Description

Closes the request file descriptor. Resources associated with the request are freed once all file descriptors associated with the request are closed and the driver has completed the request. See [here](#) for more information.

### Return Value

*close()* returns 0 on success. On error, -1 is returned, and `errno` is set appropriately. Possible error codes are:

#### EBADF

`fd` is not a valid open file descriptor.

## request ioctl()

### Name

request-ioctl - Control a request file descriptor

## Synopsis

```
#include <sys/ioctl.h>
```

```
int ioctl(int fd, int cmd, void *argp)
```

## Arguments

### fd

File descriptor returned by [ioctl MEDIA\\_IOC\\_REQUEST\\_ALLOC](#).

### cmd

The request ioctl command code as defined in the media.h header file, for example [ioctl MEDIA\\_REQUEST\\_IOC\\_QUEUE](#).

### argp

Pointer to a request-specific structure.

## Description

The [ioctl\(\)](#) function manipulates request parameters. The argument **fd** must be an open file descriptor.

The ioctl **cmd** code specifies the request function to be called. It has encoded in it whether the argument is an input, output or read/write parameter, and the size of the argument **argp** in bytes.

Macros and structures definitions specifying request ioctl commands and their parameters are located in the media.h header file. All request ioctl commands, their respective function and parameters are specified in [Function Reference](#).

## Return Value

On success 0 is returned, on error -1 and the **errno** variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

Command-specific error codes are listed in the individual command descriptions.

When an ioctl that takes an output or read/write parameter fails, the parameter remains unmodified.

## request poll()

### Name

request-poll - Wait for some event on a file descriptor

### Synopsis

```
#include <sys/poll.h>
```

```
int poll(struct pollfd *ufds, unsigned int nfds, int timeout)
```

### Arguments

#### **ufds**

List of file descriptor events to be watched

#### **nfds**

Number of file descriptor events at the \*ufds array

#### **timeout**

Timeout to wait for events

### Description

With the *poll()* function applications can wait for a request to complete.

On success *poll()* returns the number of file descriptors that have been selected (that is, file descriptors for which the *revents* field of the respective struct *pollfd* is non-zero). Request file descriptor set the POLLPRI flag in *revents* when the request was completed. When the function times out it returns a value of zero, on failure it returns -1 and the *errno* variable is set appropriately.

Attempting to poll for a request that is not yet queued will set the POLLERR flag in *revents*.

### Return Value

On success, *poll()* returns the number of structures which have non-zero *revents* fields, or zero if the call timed out. On error -1 is returned, and the *errno* variable is set appropriately:

#### **EBADF**

One or more of the *ufds* members specify an invalid file descriptor.

#### **EFAULT**

*ufds* references an inaccessible memory area.

#### **EINTR**

The call was interrupted by a signal.

#### **EINVAL**

The *nfds* value exceeds the RLIMIT\_NOFILE value. Use *getrlimit()* to obtain this value.

## ioctl MEDIA\_REQUEST\_IOC\_QUEUE

### Name

MEDIA\_REQUEST\_IOC\_QUEUE - Queue a request

### Synopsis

#### MEDIA\_REQUEST\_IOC\_QUEUE

```
int ioctl(int request_fd, MEDIA_REQUEST_IOC_QUEUE)
```

### Arguments

#### request\_fd

File descriptor returned by [ioctl MEDIA\\_IOC\\_REQUEST\\_ALLOC](#).

### Description

If the media device supports *requests*, then this request ioctl can be used to queue a previously allocated request.

If the request was successfully queued, then the file descriptor can be *polled* to wait for the request to complete.

If the request was already queued before, then EBUSY is returned. Other errors can be returned if the contents of the request contained invalid or inconsistent data, see the next section for a list of common error codes. On error both the request and driver state are unchanged.

Once a request is queued, then the driver is required to gracefully handle errors that occur when the request is applied to the hardware. The exception is the EIO error which signals a fatal error that requires the application to stop streaming to reset the hardware state.

It is not allowed to mix queuing requests with queuing buffers directly (without a request). EBUSY will be returned if the first buffer was queued directly and you next try to queue a request, or vice versa.

A request must contain at least one buffer, otherwise this ioctl will return an ENOENT error.

### Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

#### EBUSY

The request was already queued or the application queued the first buffer directly, but later attempted to use a request. It is not permitted to mix the two APIs.

#### ENOENT

The request did not contain any buffers. All requests are required to have at least one buffer. This can also be returned if some required configuration is missing in the request.

## **ENOMEM**

Out of memory when allocating internal data structures for this request.

## **EINVAL**

The request has invalid data.

## **EIO**

The hardware is in a bad state. To recover, the application needs to stop streaming to reset the hardware state and then try to restart streaming.

## **ioctl MEDIA\_REQUEST\_IOC\_REINIT**

### **Name**

MEDIA\_REQUEST\_IOC\_REINIT - Re-initialize a request

### **Synopsis**

#### **MEDIA\_REQUEST\_IOC\_REINIT**

```
int ioctl(int request_fd, MEDIA_REQUEST_IOC_REINIT)
```

### **Arguments**

#### **request\_fd**

File descriptor returned by *ioctl MEDIA\_IOC\_REQUEST\_ALLOC*.

### **Description**

If the media device supports *requests*, then this request ioctl can be used to re-initialize a previously allocated request.

Re-initializing a request will clear any existing data from the request. This avoids having to *close()* a completed request and allocate a new request. Instead the completed request can just be re-initialized and it is ready to be used again.

A request can only be re-initialized if it either has not been queued yet, or if it was queued and completed. Otherwise it will set *errno* to EBUSY. No other error codes can be returned.

### **Return Value**

On success 0 is returned, on error -1 and the *errno* variable is set appropriately.

## **EBUSY**

The request is queued but not yet completed.

### 13.5.6 Media Controller Header File

#### media.h

```
/* SPDX-License-Identifier: GPL-2.0 WITH Linux-syscall-note */
/*
 * Multimedia device API
 *
 * Copyright (C) 2010 Nokia Corporation
 *
 * Contacts: Laurent Pinchart <laurent.pinchart@ideasonboard.com>
 *           Sakari Ailus <sakari.ailus@iki.fi>
 *
 * This program is free software; you can redistribute it and/or modify
 * it under the terms of the GNU General Public License version 2 as
 * published by the Free Software Foundation.
 *
 * This program is distributed in the hope that it will be useful,
 * but WITHOUT ANY WARRANTY; without even the implied warranty of
 * MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE. See the
 * GNU General Public License for more details.
 */
#ifndef __LINUX_MEDIA_H
#define __LINUX_MEDIA_H

#include <linux/ioctl.h>
#include <linux/types.h>

struct media_device_info {
    char driver[16];
    char model[32];
    char serial[40];
    char bus_info[32];
    __u32 media_version;
    __u32 hw_revision;
    __u32 driver_version;
    __u32 reserved[31];
};

/*
 * Base number ranges for entity functions
 *
 * NOTE: Userspace should not rely on these ranges to identify a group
 * of function types, as newer functions can be added with any name within
 * the full u32 range.
 *
 * Some older functions use the MEDIA_ENT_F_OLD_*_BASE range. Do not
 * change this, this is for backwards compatibility. When adding new
 * functions always use MEDIA_ENT_F_BASE.
 */

```

```

#define MEDIA_ENT_F_BASE                      0x00000000
#define MEDIA_ENT_F_OLD_BASE                  0x00010000
#define MEDIA_ENT_F_OLD_SUBDEV_BASE           0x00020000

/*
 * Initial value to be used when a new entity is created
 * Drivers should change it to something useful.
 */
#define MEDIA_ENT_F_UNKNOWN                  MEDIA_ENT_F_BASE

/*
 * Subdevs are initialized with MEDIA_ENT_F_V4L2_SUBDEV_UNKNOWN in order
 * to preserve backward compatibility. Drivers must change to the proper
 * subdev type before registering the entity.
 */
#define MEDIA_ENT_F_V4L2_SUBDEV_UNKNOWN      MEDIA_ENT_F_OLD_SUBDEV_BASE

/*
 * DVB entity functions
 */
#define MEDIA_ENT_F_DTV_DEMOD                (MEDIA_ENT_F_BASE + 0x00001)
#define MEDIA_ENT_F_TS_DEMUX                 (MEDIA_ENT_F_BASE + 0x00002)
#define MEDIA_ENT_F_DTV_CA                   (MEDIA_ENT_F_BASE + 0x00003)
#define MEDIA_ENT_F_DTV_NET_DECAP            (MEDIA_ENT_F_BASE + 0x00004)

/*
 * I/O entity functions
 */
#define MEDIA_ENT_F_IO_V4L                  (MEDIA_ENT_F_OLD_BASE + 1)
#define MEDIA_ENT_F_IO_DTV                  (MEDIA_ENT_F_BASE + 0x01001)
#define MEDIA_ENT_F_IO_VBI                  (MEDIA_ENT_F_BASE + 0x01002)
#define MEDIA_ENT_F_IO_SWRADIO              (MEDIA_ENT_F_BASE + 0x01003)

/*
 * Sensor functions
 */
#define MEDIA_ENT_F_CAM_SENSOR              (MEDIA_ENT_F_OLD_SUBDEV_BASE + 1)
#define MEDIA_ENT_F_FLASH                  (MEDIA_ENT_F_OLD_SUBDEV_BASE + 2)
#define MEDIA_ENT_F_LENS                   (MEDIA_ENT_F_OLD_SUBDEV_BASE + 3)

/*
 * Digital TV, analog TV, radio and/or software defined radio tuner functions.
 *
 * It is a responsibility of the master/bridge drivers to add connectors
 * and links for MEDIA_ENT_F_TUNER. Please notice that some old tuners
 * may require the usage of separate I2C chips to decode analog TV signals,
 * when the master/bridge chipset doesn't have its own TV standard decoder.
 * On such cases, the IF-PLL staging is mapped via one or two entities:

```

```

* MEDIA_ENT_F_IF_VID_DECODER and/or MEDIA_ENT_F_IF_AUD_DECODER.
*/
#define MEDIA_ENT_F_TUNER (MEDIA_ENT_F_OLD_SUBDEV_BASE +  
-5)

/*
 * Analog TV IF-PLL decoder functions
 *
 * It is a responsibility of the master/bridge drivers to create links
 * for MEDIA_ENT_F_IF_VID_DECODER and MEDIA_ENT_F_IF_AUD_DECODER.
*/
#define MEDIA_ENT_F_IF_VID_DECODER (MEDIA_ENT_F_BASE + 0x02001)
#define MEDIA_ENT_F_IF_AUD_DECODER (MEDIA_ENT_F_BASE + 0x02002)

/*
 * Audio entity functions
*/
#define MEDIA_ENT_F_AUDIO_CAPTURE (MEDIA_ENT_F_BASE + 0x03001)
#define MEDIA_ENT_F_AUDIO_PLAYBACK (MEDIA_ENT_F_BASE + 0x03002)
#define MEDIA_ENT_F_AUDIO_MIXER (MEDIA_ENT_F_BASE + 0x03003)

/*
 * Processing entity functions
*/
#define MEDIA_ENT_F_PROC_VIDEO_COMPOSER (MEDIA_ENT_F_BASE + 0x4001)
#define MEDIA_ENT_F_PROC_VIDEO_PIXEL_FORMATTER (MEDIA_ENT_F_BASE + 0x4002)
#define MEDIA_ENT_F_PROC_VIDEO_PIXEL_ENC_CONV (MEDIA_ENT_F_BASE + 0x4003)
#define MEDIA_ENT_F_PROC_VIDEO_LUT (MEDIA_ENT_F_BASE + 0x4004)
#define MEDIA_ENT_F_PROC_VIDEO_SCALER (MEDIA_ENT_F_BASE + 0x4005)
#define MEDIA_ENT_F_PROC_VIDEO_STATISTICS (MEDIA_ENT_F_BASE + 0x4006)
#define MEDIA_ENT_F_PROC_VIDEO_ENCODER (MEDIA_ENT_F_BASE + 0x4007)
#define MEDIA_ENT_F_PROC_VIDEO_DECODER (MEDIA_ENT_F_BASE + 0x4008)
#define MEDIA_ENT_F_PROC_VIDEO_ISP (MEDIA_ENT_F_BASE + 0x4009)

/*
 * Switch and bridge entity functions
*/
#define MEDIA_ENT_F_VID_MUX (MEDIA_ENT_F_BASE + 0x5001)
#define MEDIA_ENT_F_VID_IF_BRIDGE (MEDIA_ENT_F_BASE + 0x5002)

/*
 * Video decoder/encoder functions
*/
#define MEDIA_ENT_F_ATV_DECODER (MEDIA_ENT_F_OLD_SUBDEV_BASE +  
-4)
#define MEDIA_ENT_F_DV_DECODER (MEDIA_ENT_F_BASE + 0x6001)
#define MEDIA_ENT_F_DV_ENCODER (MEDIA_ENT_F_BASE + 0x6002)

/* Entity flags */
#define MEDIA_ENT_FL_DEFAULT (1U << 0)
#define MEDIA_ENT_FL_CONNECTOR (1U << 1)

```

```
/* OR with the entity id value to find the next entity */
#define MEDIA_ENT_ID_FLAG_NEXT          (1U << 31)

struct media_entity_desc {
    __u32 id;
    char name[32];
    __u32 type;
    __u32 revision;
    __u32 flags;
    __u32 group_id;
    __u16 pads;
    __u16 links;

    __u32 reserved[4];

    union {
        /* Node specifications */
        struct {
            __u32 major;
            __u32 minor;
        } dev;

#if !defined(__KERNEL__)
        /*
         * TODO: this shouldn't have been added without
         * actual drivers that use this. When the first real driver
         * appears that sets this information, special attention
         * should be given whether this information is 1) enough, and
         * 2) can deal with udev rules that rename devices. The struct
         * dev would not be sufficient for this since that does not
         * contain the subdevice information. In addition, struct dev
         * can only refer to a single device, and not to multiple (e.g.
         * pcm and mixer devices).
         */
        struct {
            __u32 card;
            __u32 device;
            __u32 subdevice;
        } alsa;

        /*
         * DEPRECATED: previous node specifications. Kept just to
         * avoid breaking compilation. Use media_entity_desc.dev
         * instead.
         */
        struct {
            __u32 major;
            __u32 minor;
        } v4l;
        struct {

```

```

        __u32 major;
        __u32 minor;
    } fb;
    int dvb;
#endif

/* Sub-device specifications */
/* Nothing needed yet */
__u8 raw[184];
};

#define MEDIA_PAD_FL_SINK           (1U << 0)
#define MEDIA_PAD_FL_SOURCE         (1U << 1)
#define MEDIA_PAD_FL_MUST_CONNECT   (1U << 2)

struct media_pad_desc {
    __u32 entity;                /* entity ID */
    __u16 index;                 /* pad index */
    __u32 flags;                 /* pad flags */
    __u32 reserved[2];
};

#define MEDIA_LNK_FL_ENABLED        (1U << 0)
#define MEDIA_LNK_FL_IMMUTABLE      (1U << 1)
#define MEDIA_LNK_FL_DYNAMIC        (1U << 2)

#define MEDIA_LNK_FL_LINK_TYPE      (0xf << 28)
#define MEDIA_LNK_FL_DATA_LINK      (0U << 28)
#define MEDIA_LNK_FL_INTERFACE_LINK (1U << 28)
#define MEDIA_LNK_FL_ANCILLARY_LINK (2U << 28)

struct media_link_desc {
    struct media_pad_desc source;
    struct media_pad_desc sink;
    __u32 flags;
    __u32 reserved[2];
};

struct media_links_enum {
    __u32 entity;
    /* Should have enough room for pads elements */
    struct media_pad_desc __user *pads;
    /* Should have enough room for links elements */
    struct media_link_desc __user *links;
    __u32 reserved[4];
};

/* Interface type ranges */

#define MEDIA_INTF_T_DVB_BASE       0x000000100

```

```

#define MEDIA_INTF_T_V4L_BASE           0x00000200
/* Interface types */

#define MEDIA_INTF_T_DVB_FE            (MEDIA_INTF_T_DVB_BASE)
#define MEDIA_INTF_T_DVB_DEMUX         (MEDIA_INTF_T_DVB_BASE + 1)
#define MEDIA_INTF_T_DVB_DVR           (MEDIA_INTF_T_DVB_BASE + 2)
#define MEDIA_INTF_T_DVB_CA            (MEDIA_INTF_T_DVB_BASE + 3)
#define MEDIA_INTF_T_DVB_NET           (MEDIA_INTF_T_DVB_BASE + 4)

#define MEDIA_INTF_T_V4L_VIDEO          (MEDIA_INTF_T_V4L_BASE)
#define MEDIA_INTF_T_V4L_VBI             (MEDIA_INTF_T_V4L_BASE + 1)
#define MEDIA_INTF_T_V4L_RADIO           (MEDIA_INTF_T_V4L_BASE + 2)
#define MEDIA_INTF_T_V4L_SUBDEV          (MEDIA_INTF_T_V4L_BASE + 3)
#define MEDIA_INTF_T_V4L_SWRADIO         (MEDIA_INTF_T_V4L_BASE + 4)
#define MEDIA_INTF_T_V4L_TOUCH           (MEDIA_INTF_T_V4L_BASE + 5)

#define MEDIA_INTF_T_ALSA_BASE          0x00000300
#define MEDIA_INTF_T_ALSA_PCM_CAPTURE    (MEDIA_INTF_T_ALSA_BASE)
#define MEDIA_INTF_T_ALSA_PCM_PLAYBACK   (MEDIA_INTF_T_ALSA_BASE + 1)
#define MEDIA_INTF_T_ALSA_CONTROL        (MEDIA_INTF_T_ALSA_BASE + 2)

#if defined(__KERNEL__)

/*
 * Connector functions
 *
 * For now these should not be used in userspace, as some definitions may
 * change.
 *
 * It is the responsibility of the entity drivers to add connectors and links.
 */
#define MEDIA_ENT_F_CONN_RF             (MEDIA_ENT_F_BASE + 0x30001)
#define MEDIA_ENT_F_CONN_SVIDEO          (MEDIA_ENT_F_BASE + 0x30002)
#define MEDIA_ENT_F_CONN_COMPOSITE        (MEDIA_ENT_F_BASE + 0x30003)

#endif

/*
 * MC next gen API definitions
 */

/*
 * Appeared in 4.19.0.
 *
 * The media_version argument comes from the media_version field in
 * struct media_device_info.
 */
#define MEDIA_V2_ENTITY_HAS_FLAGS(media_version) \
    ((media_version) >= ((4U << 16) | (19U << 8) | 0U))

```

```

struct media_v2_entity {
    __u32 id;
    char name[64];
    __u32 function;           /* Main function of the entity */
    __u32 flags;
    __u32 reserved[5];
} __attribute__ ((packed));

/* Should match the specific fields at media_intf_devnode */
struct media_v2_intf_devnode {
    __u32 major;
    __u32 minor;
} __attribute__ ((packed));

struct media_v2_interface {
    __u32 id;
    __u32 intf_type;
    __u32 flags;
    __u32 reserved[9];

    union {
        struct media_v2_intf_devnode devnode;
        __u32 raw[16];
    };
} __attribute__ ((packed));

/*
 * Appeared in 4.19.0.
 *
 * The media_version argument comes from the media_version field in
 * struct media_device_info.
 */
#define MEDIA_V2_PAD_HAS_INDEX(media_version) \
    ((media_version) >= ((4U << 16) | (19U << 8) | 0U))

struct media_v2_pad {
    __u32 id;
    __u32 entity_id;
    __u32 flags;
    __u32 index;
    __u32 reserved[4];
} __attribute__ ((packed));

struct media_v2_link {
    __u32 id;
    __u32 source_id;
    __u32 sink_id;
    __u32 flags;
    __u32 reserved[6];
} __attribute__ ((packed));

```

```

struct media_v2_topology {
    __u64 topology_version;

    __u32 num_entities;
    __u32 reserved1;
    __u64 ptr_entities;

    __u32 num_interfaces;
    __u32 reserved2;
    __u64 ptr_interfaces;

    __u32 num_pads;
    __u32 reserved3;
    __u64 ptr_pads;

    __u32 num_links;
    __u32 reserved4;
    __u64 ptr_links;
} __attribute__ ((packed));

/* ioctls */

#define MEDIA_IOC_DEVICE_INFO      _IOWR(' '|', 0x00, struct media_device_info)
#define MEDIA_IOC_ENUM_ENTITIES    _IOWR(''|', 0x01, struct media_entity_desc)
#define MEDIA_IOC_ENUM_LINKS       _IOWR(''|', 0x02, struct media_links_enum)
#define MEDIA_IOC_SETUP_LINK       _IOWR(''|', 0x03, struct media_link_desc)
#define MEDIA_IOC_G_TOPOLOGY       _IOWR(''|', 0x04, struct media_v2_topology)
#define MEDIA_IOC_REQUEST_ALLOC    _IOR ('|', 0x05, int)

/*
 * These ioctls are called on the request file descriptor as returned
 * by MEDIA_IOC_REQUEST_ALLOC.
 */
#define MEDIA_REQUEST_IOC_QUEUE     _IO(''|', 0x80)
#define MEDIA_REQUEST_IOC_REINIT    _IO(''|', 0x81)

#ifndef __KERNEL__

/*
 * Legacy symbols used to avoid userspace compilation breakages.
 * Do not use any of this in new applications!
 *
 * Those symbols map the entity function into types and should be
 * used only on legacy programs for legacy hardware. Don't rely
 * on those for MEDIA_IOC_G_TOPOLOGY.
 */
#define MEDIA_ENT_TYPE_SHIFT          16
#define MEDIA_ENT_TYPE_MASK           0x00ff0000
#define MEDIA_ENT_SUBTYPE_MASK        0x0000ffff

#define MEDIA_ENT_T_DEVNODE_UNKNOWN   (MEDIA_ENT_F_OLD_BASE | \

```

```

MEDIA_ENT_SUBTYPE_MASK)

#define MEDIA_ENT_T_DEVNODE
#define MEDIA_ENT_T_DEVNODE_V4L
#define MEDIA_ENT_T_DEVNODE_FB
#define MEDIA_ENT_T_DEVNODE_ALSA
#define MEDIA_ENT_T_DEVNODE_DVB

#define MEDIA_ENT_T_UNKNOWN
#define MEDIA_ENT_T_V4L2_VIDEO
#define MEDIA_ENT_T_V4L2_SUBDEV
#define MEDIA_ENT_T_V4L2_SUBDEV_SENSOR
#define MEDIA_ENT_T_V4L2_SUBDEV_FLASH
#define MEDIA_ENT_T_V4L2_SUBDEV_LENS
#define MEDIA_ENT_T_V4L2_SUBDEV_DECODER
#define MEDIA_ENT_T_V4L2_SUBDEV_TUNER

#define MEDIA_ENT_F_DTV_DECODER
                           MEDIA_ENT_F_DV_DECODER

/*
 * There is still no full ALSA support in the media controller. These
 * defines should not have been added and we leave them here only
 * in case some application tries to use these defines.
 *
 * The ALSA defines that are in use have been moved into __KERNEL__
 * scope. As support gets added to these interface types, they should
 * be moved into __KERNEL__ scope with the code that uses them.
 */
#define MEDIA_INTF_T_ALSA_COMPRESS          (MEDIA_INTF_T_ALSA_BASE + 3)
#define MEDIA_INTF_T_ALSA_RAWMIDI           (MEDIA_INTF_T_ALSA_BASE + 4)
#define MEDIA_INTF_T_ALSA_HWDEP             (MEDIA_INTF_T_ALSA_BASE + 5)
#define MEDIA_INTF_T_ALSA_SEQUENCER         (MEDIA_INTF_T_ALSA_BASE + 6)
#define MEDIA_INTF_T_ALSA_TIMER             (MEDIA_INTF_T_ALSA_BASE + 7)

/* Obsolete symbol for media_version, no longer used in the kernel */
#define MEDIA_API_VERSION      ((0U << 16) | (1U << 8) | 0U)

#endif
#endif /* __LINUX_MEDIA_H */

```

### 13.5.7 Revision and Copyright

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- Initial version.
- Carvalho Chehab, Mauro <[mchehab@kernel.org](mailto:mchehab@kernel.org)>
- MEDIA\_IOC\_G\_TOPOLOGY documentation and documentation improvements.

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### 13.5.8 Revision History

**revision**

1.1.0 / 2015-12-12 (mcc)

**revision**

1.0.0 / 2010-11-10 (lp)

Initial revision

## 13.6 Part V - Consumer Electronics Control API

This part describes the CEC: Consumer Electronics Control

### 13.6.1 Introduction

HDMI connectors provide a single pin for use by the Consumer Electronics Control protocol. This protocol allows different devices connected by an HDMI cable to communicate. The protocol for CEC version 1.4 is defined in supplements 1 (CEC) and 2 (HEAC or HDMI Ethernet and Audio Return Channel) of the HDMI 1.4a ([HDMI](#)) specification and the extensions added to CEC version 2.0 are defined in chapter 11 of the HDMI 2.0 ([HDMI2](#)) specification.

The bitrate is very slow (effectively no more than 36 bytes per second) and is based on the ancient AV.link protocol used in old SCART connectors. The protocol closely resembles a crazy Rube Goldberg contraption and is an unholy mix of low and high level messages. Some messages, especially those part of the HEAC protocol layered on top of CEC, need to be handled by the kernel, others can be handled either by the kernel or by userspace.

In addition, CEC can be implemented in HDMI receivers, transmitters and in USB devices that have an HDMI input and an HDMI output and that control just the CEC pin.

Drivers that support CEC will create a CEC device node (/dev/cecX) to give userspace access to the CEC adapter. The [\*ioctl CEC\\_ADAP\\_G\\_CAPS\*](#) ioctl will tell userspace what it is allowed to do.

In order to check the support and test it, it is suggested to download the [\*v4l-utils\*](#) package. It provides three tools to handle CEC:

- `cec-ctl`: the Swiss army knife of CEC. Allows you to configure, transmit and monitor CEC messages.
- `cec-compliance`: does a CEC compliance test of a remote CEC device to determine how compliant the CEC implementation is.
- `cec-follower`: emulates a CEC follower.

## 13.6.2 Function Reference

### cec open()

#### Name

cec-open - Open a cec device

#### Synopsis

```
#include <fcntl.h>
```

```
int open(const char *device_name, int flags)
```

#### Arguments

##### device\_name

Device to be opened.

##### flags

Open flags. Access mode must be O\_RDWR.

When the O\_NONBLOCK flag is given, the *CEC\_RECEIVE* and *CEC\_DQEVENT* ioctls will return the EAGAIN error code when no message or event is available, and ioctls *CEC\_TRANSMIT*, *CEC\_ADAP\_S\_PHYS\_ADDR* and *CEC\_ADAP\_S\_LOG\_ADDRS* all return 0.

Other flags have no effect.

#### Description

To open a cec device applications call *open()* with the desired device name. The function has no side effects; the device configuration remain unchanged.

When the device is opened in read-only mode, attempts to modify its configuration will result in an error, and *errno* will be set to EBADF.

#### Return Value

*open()* returns the new file descriptor on success. On error, -1 is returned, and *errno* is set appropriately. Possible error codes include:

##### EACCES

The requested access to the file is not allowed.

##### EMFILE

The process already has the maximum number of files open.

##### ENFILE

The system limit on the total number of open files has been reached.

### **ENOMEM**

Insufficient kernel memory was available.

### **ENXIO**

No device corresponding to this device special file exists.

## **cec close()**

### **Name**

cec-close - Close a cec device

### **Synopsis**

```
#include <unistd.h>
```

```
int close(int fd)
```

### **Arguments**

#### **fd**

File descriptor returned by *open()*.

### **Description**

Closes the cec device. Resources associated with the file descriptor are freed. The device configuration remain unchanged.

### **Return Value**

*close()* returns 0 on success. On error, -1 is returned, and *errno* is set appropriately. Possible error codes are:

### **EBADF**

fd is not a valid open file descriptor.

## **cec ioctl()**

### **Name**

cec-ioctl - Control a cec device

## Synopsis

```
#include <sys/ioctl.h>
```

```
int ioctl(int fd, int request, void *argp)
```

## Arguments

### fd

File descriptor returned by [open\(\)](#).

### request

CEC ioctl request code as defined in the cec.h header file, for example [CEC\\_ADAP\\_G\\_CAPS](#).

### argp

Pointer to a request-specific structure.

## Description

The `ioctl()` function manipulates cec device parameters. The argument `fd` must be an open file descriptor.

The `request` code specifies the cec function to be called. It has encoded in it whether the argument is an input, output or read/write parameter, and the size of the argument `argp` in bytes.

Macros and structures definitions specifying cec ioctl requests and their parameters are located in the `cec.h` header file. All cec ioctl requests, their respective function and parameters are specified in [Function Reference](#).

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

Request-specific error codes are listed in the individual requests descriptions.

When an `ioctl` that takes an output or read/write parameter fails, the parameter remains unmodified.

## cec poll()

## Name

cec-poll - Wait for some event on a file descriptor

### Synopsis

```
#include <sys/poll.h>
```

```
int poll(struct pollfd *ufds, unsigned int nfds, int timeout)
```

### Arguments

#### **ufds**

List of FD events to be watched

#### **nfds**

Number of FD events at the \*ufds array

#### **timeout**

Timeout to wait for events

### Description

With the `poll()` function applications can wait for CEC events.

On success `poll()` returns the number of file descriptors that have been selected (that is, file descriptors for which the `revents` field of the respective `struct pollfd` is non-zero). CEC devices set the `POLLIN` and `POLLRDNORM` flags in the `revents` field if there are messages in the receive queue. If the transmit queue has room for new messages, the `POLLOUT` and `POLLWRNORM` flags are set. If there are events in the event queue, then the `POLLPRI` flag is set. When the function times out it returns a value of zero, on failure it returns -1 and the `errno` variable is set appropriately.

For more details see the `poll()` manual page.

### Return Value

On success, `poll()` returns the number structures which have non-zero `revents` fields, or zero if the call timed out. On error -1 is returned, and the `errno` variable is set appropriately:

#### **EBADF**

One or more of the `ufds` members specify an invalid file descriptor.

#### **EFAULT**

`ufds` references an inaccessible memory area.

#### **EINTR**

The call was interrupted by a signal.

#### **EINVAL**

The `nfds` value exceeds the `RLIMIT_NOFILE` value. Use `getrlimit()` to obtain this value.

## ioctl CEC\_ADAP\_G\_CAPS

### Name

CEC\_ADAP\_G\_CAPS - Query device capabilities

### Synopsis

#### **CEC\_ADAP\_G\_CAPS**

```
int ioctl(int fd, CEC_ADAP_G_CAPS, struct cec_caps *argp)
```

### Arguments

#### **fd**

File descriptor returned by [open\(\)](#).

#### **argp**

### Description

All cec devices must support [ioctl CEC\\_ADAP\\_G\\_CAPS](#). To query device information, applications call the ioctl with a pointer to a struct [cec\\_caps](#). The driver fills the structure and returns the information to the application. The ioctl never fails.

type **cec\_caps**

Table 310: struct cec\_caps

char	driver[32]	The name of the cec adapter driver.
char	name[32]	The name of this CEC adapter. The combination <b>driver</b> and <b>name</b> must be unique.
__u32	available_logaddmax	The maximum number of logical addresses that can be configured.
__u32	capabilities	The capabilities of the CEC adapter, see <a href="#">CEC Capabilities Flags</a> .
__u32	version	CEC Framework API version, formatted with the KERNEL_VERSION() macro.

Table 311: CEC Capabilities Flags

CEC_CAP_PHYS_ADDR	0x00000001	Userspace has to configure the physical address by calling <a href="#"><i>ioctl CEC_ADAP_S_PHYS_ADDR</i></a> . If this capability isn't set, then setting the physical address is handled by the kernel whenever the EDID is set (for an HDMI receiver) or read (for an HDMI transmitter).
CEC_CAP_LOG_ADDRS	0x00000002	Userspace has to configure the logical addresses by calling <a href="#"><i>ioctl CEC_ADAP_S_LOG_ADDRS</i></a> . If this capability isn't set, then the kernel will have configured this.
CEC_CAP_TRANSMIT	0x00000004	Userspace can transmit CEC messages by calling <a href="#"><i>ioctl CEC_TRANSMIT</i></a> . This implies that userspace can be a follower as well, since being able to transmit messages is a prerequisite of becoming a follower. If this capability isn't set, then the kernel will handle all CEC transmits and process all CEC messages it receives.
CEC_CAP_PASSTHROUGH	0x00000008	Userspace can use the passthrough mode by calling <a href="#"><i>ioctl CEC_S_MODE</i></a> .
CEC_CAP_RC	0x00000010	This adapter supports the remote control protocol.
CEC_CAP_MONITOR_ALL	0x00000020	The CEC hardware can monitor all messages, not just directed and broadcast messages.
CEC_CAP_NEEDS_HPD	0x00000040	The CEC hardware is only active if the HDMI Hotplug Detect pin is high. This makes it impossible to use CEC to wake up displays that set the HPD pin low when in standby mode, but keep the CEC bus alive.
CEC_CAP_MONITOR_PIN	0x00000080	The CEC hardware can monitor CEC pin changes from low to high voltage and vice versa. When in pin monitoring mode the application will receive <code>CEC_EVENT_PIN_CEC_LOW</code> and <code>CEC_EVENT_PIN_CEC_HIGH</code> events.
CEC_CAP_CONNECTOR_INFO	0x00000100	If this capability is set, then <a href="#"><i>ioctl CEC_ADAP_G_CONNECTOR_INFO</i></a> can be used.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

## `ioctl CEC_ADAP_G_LOG_ADDRS` and `CEC_ADAP_S_LOG_ADDRS`

### Name

`CEC_ADAP_G_LOG_ADDRS`, `CEC_ADAP_S_LOG_ADDRS` - Get or set the logical addresses

### Synopsis

#### `CEC_ADAP_G_LOG_ADDRS`

```
int ioctl(int fd, CEC_ADAP_G_LOG_ADDRS, struct cec_log_addrs *argp)
```

#### `CEC_ADAP_S_LOG_ADDRS`

```
int ioctl(int fd, CEC_ADAP_S_LOG_ADDRS, struct cec_log_addrs *argp)
```

### Arguments

#### `fd`

File descriptor returned by [`open\(\)`](#).

#### `argp`

Pointer to struct `cec_log_addrs`.

### Description

To query the current CEC logical addresses, applications call `ioctl CEC_ADAP_G_LOG_ADDRS` with a pointer to a struct `cec_log_addrs` where the driver stores the logical addresses.

To set new logical addresses, applications fill in struct `cec_log_addrs` and call `ioctl CEC_ADAP_S_LOG_ADDRS` with a pointer to this struct. The `ioctl CEC_ADAP_S_LOG_ADDRS` is only available if `CEC_CAP_LOG_ADDRS` is set (the ENOTTY error code is returned otherwise). The `ioctl CEC_ADAP_S_LOG_ADDRS` can only be called by a file descriptor in initiator mode (see `ioctls CEC_G_MODE` and `CEC_S_MODE`), if not the EBUSY error code will be returned.

To clear existing logical addresses set `num_log_addrs` to 0. All other fields will be ignored in that case. The adapter will go to the unconfigured state and the `cec_version`, `vendor_id` and `osd_name` fields are all reset to their default values (CEC version 2.0, no vendor ID and an empty OSD name).

If the physical address is valid (see `ioctl CEC_ADAP_S_PHYS_ADDR`), then this ioctl will block until all requested logical addresses have been claimed. If the file descriptor is in non-blocking mode then it will not wait for the logical addresses to be claimed, instead it just returns 0.

A `CEC_EVENT_STATE_CHANGE` event is sent when the logical addresses are claimed or cleared.

Attempting to call `ioctl CEC_ADAP_S_LOG_ADDRS` when logical address types are already defined will return with error EBUSY.

type **cec\_log\_addrs**

Table 312: struct cec\_log\_addrs

<code>_u8</code>	<code>log_addr[CEC_MAX_LOG_ADDRS]</code>	The actual logical addresses that were claimed. This is set by the driver. If no logical address could be claimed, then it is set to <code>CEC_LOG_ADDR_INVALID</code> . If this adapter is Unregistered, then <code>log_addr[0]</code> is set to 0xf and all others to <code>CEC_LOG_ADDR_INVALID</code> .
<code>_u16</code>	<code>log_addr_mask</code>	The bitmask of all logical addresses this adapter has claimed. If this adapter is Unregistered then <code>log_addr_mask</code> sets bit 15 and clears all other bits. If this adapter is not configured at all, then <code>log_addr_mask</code> is set to 0. Set by the driver.
<code>_u8</code>	<code>cec_version</code>	The CEC version that this adapter shall use. See <a href="#">CEC Versions</a> . Used to implement the <code>CEC_MSG_CEC_VERSION</code> and <code>CEC_MSG_REPORT_FEATURES</code> messages. Note that <a href="#">CEC_OP_CEC_VERSION_1_3A</a> is not allowed by the CEC framework.
<code>_u8</code>	<code>num_log_addrs</code>	Number of logical addresses to set up. Must be $\leq$ <code>available_log_addrs</code> as returned by <code>ioctl CEC_ADAP_G_CAPS</code> . All arrays in this structure are only filled up to index <code>available_log_addrs-1</code> . The remaining array elements will be ignored. Note that the CEC 2.0 standard allows for a maximum of 2 logical addresses, although some hardware has support for more. <code>CEC_MAX_LOG_ADDRS</code> is 4. The driver will return the actual number of logical addresses it could claim, which may be less than what was requested. If this field is set to 0, then the CEC adapter shall clear all claimed logical addresses and all other fields will be ignored.
<code>_u32</code>	<code>vendor_id</code>	The vendor ID is a 24-bit number that identifies the specific vendor or entity. Based on this ID vendor specific commands may be defined. If you do not want a vendor ID then set it to <code>CEC_VENDOR_ID_NONE</code> .

continues on next page

Table 312 – continued from previous page

__u32	flags	Flags. See <a href="#">Flags for struct cec_log_addrs</a> for a list of available flags.
char	osd_name[15]	The On-Screen Display name as is returned by the CEC_MSG_SET OSD_NAME message.
__u8	primary_device_type[CEC_MAX_LOG_ADDRS]	Primary device type for each logical address. See <a href="#">CEC Primary Device Types</a> for possible types.
__u8	log_addr_type[CEC_MAX_LOG_ADDRS]	Logical address types. See <a href="#">CEC Logical Address Types</a> for possible types. The driver will update this with the actual logical address type that it claimed (e.g. it may have to fallback to <a href="#">CEC_LOG_ADDR_TYPE_UNREGISTERED</a> ).
__u8	all_device_types[CEC_MAX_LOG_ADDRS]	CEC 2.0 specific: the bit mask of all device types. See <a href="#">CEC All Device Types Flags</a> . It is used in the CEC 2.0 CEC_MSG_REPORT_FEATURES message. For CEC 1.4 you can either leave this field to 0, or fill it in according to the CEC 2.0 guidelines to give the CEC framework more information about the device type, even though the framework won't use it directly in the CEC message.
__u8	features[CEC_MAX_LOG_ADDRS][12]	Features for each logical address. It is used in the CEC 2.0 CEC_MSG_REPORT_FEATURES message. The 12 bytes include both the RC Profile and the Device Features. For CEC 1.4 you can either leave this field to all 0, or fill it in according to the CEC 2.0 guidelines to give the CEC framework more information about the device type, even though the framework won't use it directly in the CEC message.

Table 313: Flags for struct cec\_log\_addrs

<code>CEC_LOG_ADDRS_FL_ALLOW_UNREG_FALLBACK</code>		By default if no logical address of the requested type can be claimed, then it will go back to the unconfigured state. If this flag is set, then it will fallback to the Unregistered logical address. Note that if the Unregistered logical address was explicitly requested, then this flag has no effect.
<code>CEC_LOG_ADDRS_FL_ALLOW_RC_PASSTHRU</code>	2	By default the <code>CEC_MSG_USER_CONTROL_PRESSED</code> and <code>CEC_MSG_USER_CONTROL_RELEASED</code> messages are only passed on to the follower(s), if any. If this flag is set, then these messages are also passed on to the remote control input subsystem and will appear as keystrokes. This features needs to be enabled explicitly. If CEC is used to enter e.g. passwords, then you may not want to enable this to avoid trivial snooping of the keystrokes.
<code>CEC_LOG_ADDRS_FL_CDC_ONLY</code>	4	If this flag is set, then the device is CDC-Only. CDC-Only CEC devices are CEC devices that can only handle CDC messages. All other messages are ignored.

Table 314: CEC Versions

<code>CEC_OP_CEC_VERSION_1_3A</code>	4	CEC version according to the HDMI 1.3a standard.
<code>CEC_OP_CEC_VERSION_1_4B</code>	5	CEC version according to the HDMI 1.4b standard.
<code>CEC_OP_CEC_VERSION_2_0</code>	6	CEC version according to the HDMI 2.0 standard.

Table 315: CEC Primary Device Types

<code>CEC_OP_PRIM_DEVTYPE_TV</code>	0	Use for a TV.
<code>CEC_OP_PRIM_DEVTYPE_RECORD</code>	1	Use for a recording device.
<code>CEC_OP_PRIM_DEVTYPE_TUNER</code>	3	Use for a device with a tuner.
<code>CEC_OP_PRIM_DEVTYPE_PLAYBACK</code>	4	Use for a playback device.
<code>CEC_OP_PRIM_DEVTYPE_AUDIOSYSTEM</code>	5	Use for an audio system (e.g. an audio/video receiver).
<code>CEC_OP_PRIM_DEVTYPE_SWITCH</code>	6	Use for a CEC switch.
<code>CEC_OP_PRIM_DEVTYPE_VIDEOPROC</code>	7	Use for a video processor device.

Table 316: CEC Logical Address Types

<code>CEC_LOG_ADDR_TYPE_TV</code>	0	Use for a TV.
<code>CEC_LOG_ADDR_TYPE_RECORD</code>	1	Use for a recording device.
<code>CEC_LOG_ADDR_TYPE_TUNER</code>	2	Use for a tuner device.
<code>CEC_LOG_ADDR_TYPE_PLAYBACK</code>	3	Use for a playback device.
<code>CEC_LOG_ADDR_TYPE_AUDIOSYSTEM</code>	4	Use for an audio system device.
<code>CEC_LOG_ADDR_TYPE_SPECIFIC</code>	5	Use for a second TV or for a video processor device.
<code>CEC_LOG_ADDR_TYPE_UNREGISTERED</code>	6	Use this if you just want to remain unregistered. Used for pure CEC switches or CDC-only devices (CDC: Capability Discovery and Control).

Table 317: CEC All Device Types Flags

<code>CEC_OP_ALL_DEVTYPE_TV</code>	0x80	This supports the TV type.
<code>CEC_OP_ALL_DEVTYPE_RECORD</code>	0x40	This supports the Recording type.
<code>CEC_OP_ALL_DEVTYPE_TUNER</code>	0x20	This supports the Tuner type.
<code>CEC_OP_ALL_DEVTYPE_PLAYBACK</code>	0x10	This supports the Playback type.
<code>CEC_OP_ALL_DEVTYPE_AUDIOSYSTEM</code>	0x08	This supports the Audio System type.
<code>CEC_OP_ALL_DEVTYPE_SWITCH</code>	0x04	This supports the CEC Switch or Video Processing type.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

The `ioctl CEC_ADAP_S_LOG_ADDRS` can return the following error codes:

### ENOTTY

The `CEC_CAP_LOG_ADDRS` capability wasn't set, so this ioctl is not supported.

### EBUSY

The CEC adapter is currently configuring itself, or it is already configured and `num_log_addrs` is non-zero, or another filehandle is in exclusive follower or initiator mode, or the filehandle is in mode `CEC_MODE_NO_INITIATOR`.

### EINVAL

The contents of struct `cecc_log_addrs` is invalid.

## ioctls CEC\_ADAP\_G\_PHYS\_ADDR and CEC\_ADAP\_S\_PHYS\_ADDR

### Name

`CEC_ADAP_G_PHYS_ADDR`, `CEC_ADAP_S_PHYS_ADDR` - Get or set the physical address

### Synopsis

#### `CEC_ADAP_G_PHYS_ADDR`

```
int ioctl(int fd, CEC_ADAP_G_PHYS_ADDR, __u16 *argp)
```

#### `CEC_ADAP_S_PHYS_ADDR`

```
int ioctl(int fd, CEC_ADAP_S_PHYS_ADDR, __u16 *argp)
```

### Arguments

#### `fd`

File descriptor returned by [`open\(\)`](#).

#### `argp`

Pointer to the CEC address.

### Description

To query the current physical address applications call `ioctl CEC_ADAP_G_PHYS_ADDR` with a pointer to a `__u16` where the driver stores the physical address.

To set a new physical address applications store the physical address in a `__u16` and call `ioctl CEC_ADAP_S_PHYS_ADDR` with a pointer to this integer. The `ioctl CEC_ADAP_S_PHYS_ADDR` is only available if `CEC_CAP_PHYS_ADDR` is set (the `ENOTTY` error code will be returned otherwise).

The `ioctl CEC_ADAP_S_PHYS_ADDR` can only be called by a file descriptor in initiator mode (see `ioctls CEC_G_MODE` and `CEC_S_MODE`), if not the EBUSY error code will be returned.

To clear an existing physical address use `CEC_PHYS_ADDR_INVALID`. The adapter will go to the unconfigured state.

If logical address types have been defined (see `ioctl CEC_ADAP_S_LOG_ADDRS`), then this ioctl will block until all requested logical addresses have been claimed. If the file descriptor is in non-blocking mode then it will not wait for the logical addresses to be claimed, instead it just returns 0.

A `CEC_EVENT_STATE_CHANGE` event is sent when the physical address changes.

The physical address is a 16-bit number where each group of 4 bits represent a digit of the physical address a.b.c.d where the most significant 4 bits represent 'a'. The CEC root device (usually the TV) has address 0.0.0.0. Every device that is hooked up to an input of the TV has address a.0.0.0 (where 'a' is  $\geq 1$ ), devices hooked up to those in turn have addresses a.b.0.0, etc. So a topology of up to 5 devices deep is supported. The physical address a device shall use is stored in the EDID of the sink.

For example, the EDID for each HDMI input of the TV will have a different physical address of the form a.0.0.0 that the sources will read out and use as their physical address.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

The `ioctl CEC_ADAP_S_PHYS_ADDR` can return the following error codes:

### ENOTTY

The `CEC_CAP_PHYS_ADDR` capability wasn't set, so this ioctl is not supported.

### EBUSY

Another filehandle is in exclusive follower or initiator mode, or the filehandle is in mode `CEC_MODE_NO_INITIATOR`.

### EINVAL

The physical address is malformed.

## ioctl CEC\_ADAP\_G\_CONNECTOR\_INFO

### Name

`CEC_ADAP_G_CONNECTOR_INFO` - Query HDMI connector information

## Synopsis

### **CEC\_ADAP\_G\_CONNECTOR\_INFO**

```
int ioctl(int fd, CEC_ADAP_G_CONNECTOR_INFO, struct cec_connector_info *argp)
```

## Arguments

### **fd**

File descriptor returned by *open()*.

### **argp**

## Description

Using this ioctl an application can learn which HDMI connector this CEC device corresponds to. While calling this ioctl the application should provide a pointer to a `cec_connector_info` struct which will be populated by the kernel with the info provided by the adapter's driver. This ioctl is only available if the `CEC_CAP_CONNECTOR_INFO` capability is set.

### type `cec_connector_info`

Table 318: `struct cec_connector_info`

<code>_u32</code>	<code>type</code>	The type of connector this adapter is associated with.
<code>union {</code>	<code>(anonymous)</code>	
<code>struct drm_cec_drm_connector_info</code>	<code>struct</code>	<code>cec_drm_connector_info</code>
<code>}</code>		

Table 319: Connector types

<code>CEC_CONNECTOR_TYPE_NO_CONNECTOR</code>	No connector is associated with the adapter/the information is not provided by the driver.
<code>CEC_CONNECTOR_TYPE_DRM</code>	Indicates that a DRM connector is associated with this adapter. Information about the connector can be found in <code>struct cec_drm_connector_info</code> .

### type `cec_drm_connector_info`

Table 320: struct cec\_drm\_connector\_info

<code>_u32</code>	<code>card_no</code>	DRM card number: the number from a card's path, e.g. 0 in case of /dev/card0.
<code>_u32</code>	<code>connector_id</code>	DRM connector ID.

## ioctl CEC\_DQEVENT

### Name

`CEC_DQEVENT` - Dequeue a CEC event

### Synopsis

#### `CEC_DQEVENT`

```
int ioctl(int fd, CEC_DQEVENT, struct cec_event *argp)
```

### Arguments

#### `fd`

File descriptor returned by `open()`.

#### `argp`

### Description

CEC devices can send asynchronous events. These can be retrieved by calling `CEC_DQEVENT()`. If the file descriptor is in non-blocking mode and no event is pending, then it will return -1 and set `errno` to the `EAGAIN` error code.

The internal event queues are per-filehandle and per-event type. If there is no more room in a queue then the last event is overwritten with the new one. This means that intermediate results can be thrown away but that the latest event is always available. This also means that it is possible to read two successive events that have the same value (e.g. two `CEC_EVENT_STATE_CHANGE` events with the same state). In that case the intermediate state changes were lost but it is guaranteed that the state did change in between the two events.

type `cec_event_state_change`

Table 321: struct cec\_event\_state\_change

__u16	phys_addr	The current physical address. This is CEC_PHYS_ADDR_INVALID if no valid physical address is set.
__u16	log_addr_mask	The current set of claimed logical addresses. This is 0 if no logical addresses are claimed or if phys_addr is CEC_PHYS_ADDR_INVALID. If bit 15 is set ( $1 \ll \text{CEC\_LOG\_ADDR\_UNREGISTERED}$ ) then this device has the unregistered logical address. In that case all other bits are 0.
__u16	have_conn_info	If non-zero, then HDMI connector information is available. This field is only valid if CEC_CAP_CONNECTOR_INFO is set. If that capability is set and have_conn_info is zero, then that indicates that the HDMI connector device is not instantiated, either because the HDMI driver is still configuring the device or because the HDMI device was unbound.

type **cec\_event\_lost\_msgs**

Table 322: struct cec\_event\_lost\_msgs

__u32	lost_msgs	Set to the number of lost messages since the filehandle was opened or since the last time this event was dequeued for this filehandle. The messages lost are the oldest messages. So when a new message arrives and there is no more room, then the oldest message is discarded to make room for the new one. The internal size of the message queue guarantees that all messages received in the last two seconds will be stored. Since messages should be replied to within a second according to the CEC specification, this is more than enough.
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type **cec\_event**

Table 323: struct cec\_event

<code>_u64</code>	<code>ts</code>	Timestamp of the event in ns. The timestamp has been taken from the <code>CLOCK_MONOTONIC</code> clock. To access the same clock from userspace use <code>clock_gettime()</code> .
<code>_u32</code>	<code>event</code>	The CEC event type, see <a href="#">CEC Events Types</a> .
<code>_u32</code>	<code>flags</code>	Event flags, see <a href="#">CEC Event Flags</a> .
union {	(anonymous)	
<code>struct cec_event_state_change</code>	<code>state_change</code>	The new adapter state as sent by the <a href="#">CEC_EVENT_STATE_CHANGE</a> event.
<code>struct cec_event_lost_msgs</code>	<code>lost_msgs</code>	The number of lost messages as sent by the <a href="#">CEC_EVENT_LOST_MSGS</a> event.
}		

Table 324: CEC Events Types

CEC_EVENT_STATE_CHANGE	1	Generated when the CEC Adapter's state changes. When open() is called an initial event will be generated for that filehandle with the CEC Adapter's state at that time.
CEC_EVENT_LOST_MSGS	2	Generated if one or more CEC messages were lost because the application didn't dequeue CEC messages fast enough.
CEC_EVENT_PIN_CEC_LOW	3	Generated if the CEC pin goes from a high voltage to a low voltage. Only applies to adapters that have the CEC_CAP_MONITOR_PIN capability set.
CEC_EVENT_PIN_CEC_HIGH	4	Generated if the CEC pin goes from a low voltage to a high voltage. Only applies to adapters that have the CEC_CAP_MONITOR_PIN capability set.
CEC_EVENT_PIN_HPD_LOW	5	Generated if the HPD pin goes from a high voltage to a low voltage. Only applies to adapters that have the CEC_CAP_MONITOR_PIN capability set. When open() is called, the HPD pin can be read and if the HPD is low, then an initial event will be generated for that filehandle.
CEC_EVENT_PIN_HPD_HIGH	6	Generated if the HPD pin goes from a low voltage to a high voltage. Only applies to adapters that have the CEC_CAP_MONITOR_PIN capability set. When open() is called, the HPD pin can be read and if the HPD is high, then an initial event will be generated for that filehandle.
CEC_EVENT_PIN_5V_LOW	6	Generated if the 5V pin goes from a high voltage to a low voltage. Only applies to adapters that have the CEC_CAP_MONITOR_PIN capability set. When open() is called, the 5V pin can be read and if the 5V is low, then an initial event will be generated for that filehandle.
CEC_EVENT_PIN_5V_HIGH	7	Generated if the 5V pin goes from a low voltage to a high voltage. Only applies to adapters that have the CEC_CAP_MONITOR_PIN capability set. When open() is called, the 5V pin can be read and if the 5V is high, then an initial event will be generated for that filehandle.

Table 325: CEC Event Flags

CEC_EVENT_FL_INITIAL_STATE	1	Set for the initial events that are generated when the device is opened. See the table above for which events do this. This allows applications to learn the initial state of the CEC adapter at open() time.
CEC_EVENT_FL_DROPPED_EVENTS	2	Set if one or more events of the given event type have been dropped. This is an indication that the application cannot keep up.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

The `ioctl CEC_DQEVENT` can return the following error codes:

### EAGAIN

This is returned when the filehandle is in non-blocking mode and there are no pending events.

### ERESTARTSYS

An interrupt (e.g. Ctrl-C) arrived while in blocking mode waiting for events to arrive.

## ioctls CEC\_G\_MODE and CEC\_S\_MODE

`CEC_G_MODE`, `CEC_S_MODE` - Get or set exclusive use of the CEC adapter

## Synopsis

### `CEC_G_MODE`

```
int ioctl(int fd, CEC_G_MODE, __u32 *argp)
```

### `CEC_S_MODE`

```
int ioctl(int fd, CEC_S_MODE, __u32 *argp)
```

## Arguments

### `fd`

File descriptor returned by `open()`.

### `argp`

Pointer to CEC mode.

## Description

By default any filehandle can use [ioctls CEC\\_RECEIVE and CEC\\_TRANSMIT](#), but in order to prevent applications from stepping on each others toes it must be possible to obtain exclusive access to the CEC adapter. This ioctl sets the filehandle to initiator and/or follower mode which can be exclusive depending on the chosen mode. The initiator is the filehandle that is used to initiate messages, i.e. it commands other CEC devices. The follower is the filehandle that receives messages sent to the CEC adapter and processes them. The same filehandle can be both initiator and follower, or this role can be taken by two different filehandles.

When a CEC message is received, then the CEC framework will decide how it will be processed. If the message is a reply to an earlier transmitted message, then the reply is sent back to the filehandle that is waiting for it. In addition the CEC framework will process it.

If the message is not a reply, then the CEC framework will process it first. If there is no follower, then the message is just discarded and a feature abort is sent back to the initiator if the framework couldn't process it. If there is a follower, then the message is passed on to the follower who will use [ioctl CEC\\_RECEIVE](#) to dequeue the new message. The framework expects the follower to make the right decisions.

The CEC framework will process core messages unless requested otherwise by the follower. The follower can enable the passthrough mode. In that case, the CEC framework will pass on most core messages without processing them and the follower will have to implement those messages. There are some messages that the core will always process, regardless of the passthrough mode. See [Core Message Processing](#) for details.

If there is no initiator, then any CEC filehandle can use [ioctl CEC\\_TRANSMIT](#). If there is an exclusive initiator then only that initiator can call [ioctls CEC\\_RECEIVE and CEC\\_TRANSMIT](#). The follower can of course always call [ioctl CEC\\_TRANSMIT](#).

Available initiator modes are:

Table 326: Initiator Modes

CEC_MODE_NO_INITIATOR	0x0	This is not an initiator, i.e. it cannot transmit CEC messages or make any other changes to the CEC adapter.
CEC_MODE_INITIATOR	0x1	This is an initiator (the default when the device is opened) and it can transmit CEC messages and make changes to the CEC adapter, unless there is an exclusive initiator.
CEC_MODE_EXCL_INITIATOR	0x2	This is an exclusive initiator and this file descriptor is the only one that can transmit CEC messages and make changes to the CEC adapter. If someone else is already the exclusive initiator then an attempt to become one will return the EBUSY error code error.

Available follower modes are:

Table 327: Follower Modes

CEC_MODE_NO_FOLLOWER	0x00	This is not a follower (the default when the device is opened).
CEC_MODE_FOLLOWER	0x10	This is a follower and it will receive CEC messages unless there is an exclusive follower. You cannot become a follower if <a href="#">CEC_CAP_TRANSMIT</a> is not set or if <a href="#">CEC_MODE_NO_INITIATOR</a> was specified, the EINVAL error code is returned in that case.
CEC_MODE_EXCL_FOLLOWER	0x20	This is an exclusive follower and only this file descriptor will receive CEC messages for processing. If someone else is already the exclusive follower then an attempt to become one will return the EBUSY error code. You cannot become a follower if <a href="#">CEC_CAP_TRANSMIT</a> is not set or if <a href="#">CEC_MODE_NO_INITIATOR</a> was specified, the EINVAL error code is returned in that case.
CEC_MODE_EXCL_FOLLOWER_PASSTHRU	0x30	This is an exclusive follower and only this file descriptor will receive CEC messages for processing. In addition it will put the CEC device into passthrough mode, allowing the exclusive follower to handle most core messages instead of relying on the CEC framework for that. If someone else is already the exclusive follower then an attempt to become one will return the EBUSY error code. You cannot become a follower if <a href="#">CEC_CAP_TRANSMIT</a> is not set or if <a href="#">CEC_MODE_NO_INITIATOR</a> was specified, the EINVAL error code is returned in that case.
CEC_MODE_MONITOR_PIN	0xd0	Put the file descriptor into pin monitoring mode. Can only be used in combination with <a href="#">CEC_MODE_NO_INITIATOR</a> , otherwise the EINVAL error code will be returned. This mode requires that the <a href="#">CEC_CAP_MONITOR_PIN</a> capability is set, otherwise the EINVAL error code is returned. While in pin monitoring mode this file descriptor can receive the <a href="#">CEC_EVENT_PIN_CEC_LOW</a> and <a href="#">CEC_EVENT_PIN_CEC_HIGH</a> events to see the low-level CEC pin transitions. This is very useful for debugging. This mode is only allowed if the process has the CAP_NET_ADMIN capability. If that is not set, then the EPERM error code is returned.

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CEC_MODE_MONITOR	0xe0	Put the file descriptor into monitor mode. Can only be used in combination with <a href="#"><i>CEC_MODE_NO_INITIATOR</i></a> , otherwise the EINVAL error code will be returned. In monitor mode all messages this CEC device transmits and all messages it receives (both broadcast messages and directed messages for one its logical addresses) will be reported. This is very useful for debugging. This is only allowed if the process has the CAP_NET_ADMIN capability. If that is not set, then the EPERM error code is returned.
CEC_MODE_MONITOR_ALL	0xf0	Put the file descriptor into 'monitor all' mode. Can only be used in combination with <a href="#"><i>CEC_MODE_NO_INITIATOR</i></a> , otherwise the EINVAL error code will be returned. In 'monitor all' mode all messages this CEC device transmits and all messages it receives, including directed messages for other CEC devices, will be reported. This is very useful for debugging, but not all devices support this. This mode requires that the <a href="#"><i>CEC_CAP_MONITOR_ALL</i></a> capability is set, otherwise the EINVAL error code is returned. This is only allowed if the process has the CAP_NET_ADMIN capability. If that is not set, then the EPERM error code is returned.

Core message processing details:

Table 328: Core Message Processing

CEC_MSG_GET_CEC_VERSION	The core will return the CEC version that was set with <i>ioctl CEC_ADAP_S_LOG_ADDRS</i> , except when in passthrough mode. In passthrough mode the core does nothing and this message has to be handled by a follower instead.
CEC_MSG_GIVE_DEVICE_VENDOR_ID	The core will return the vendor ID that was set with <i>ioctl CEC_ADAP_S_LOG_ADDRS</i> , except when in passthrough mode. In passthrough mode the core does nothing and this message has to be handled by a follower instead.
CEC_MSG_ABORT	The core will return a Feature Abort message with reason 'Feature Refused' as per the specification, except when in passthrough mode. In passthrough mode the core does nothing and this message has to be handled by a follower instead.
CEC_MSG_GIVE_PHYSICAL_ADDR	The core will report the current physical address, except when in passthrough mode. In passthrough mode the core does nothing and this message has to be handled by a follower instead.
CEC_MSG_GIVE OSD_NAME	The core will report the current OSD name that was set with <i>ioctl CEC_ADAP_S_LOG_ADDRS</i> , except when in passthrough mode. In passthrough mode the core does nothing and this message has to be handled by a follower instead.
CEC_MSG_GIVE_FEATURES	The core will do nothing if the CEC version is older than 2.0, otherwise it will report the current features that were set with <i>ioctl CEC_ADAP_S_LOG_ADDRS</i> , except when in passthrough mode. In passthrough mode the core does nothing (for any CEC version) and this message has to be handled by a follower instead.
CEC_MSG_USER_CONTROL_PRESSED	If <i>CEC_CAP_RC</i> is set and if <i>CEC_LOG_ADDRS_FL_ALLOW_RC_PASSTHRU</i> is set, then generate a remote control key press. This message is always passed on to the follower(s).
CEC_MSG_USER_CONTROL_RELEASED	If <i>CEC_CAP_RC</i> is set and if <i>CEC_LOG_ADDRS_FL_ALLOW_RC_PASSTHRU</i> is set, then generate a remote control key release. This message is always passed on to the follower(s).
CEC_MSG_REPORT_PHYSICAL_ADDR	The CEC framework will make note of the reported physical address and then just pass the message on to the follower(s).

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

The `ioctl CEC_S_MODE` can return the following error codes:

### EINVAL

The requested mode is invalid.

### EPERM

Monitor mode is requested, but the process does have the `CAP_NET_ADMIN` capability.

### EBUSY

Someone else is already an exclusive follower or initiator.

## ioctls CEC\_RECEIVE and CEC\_TRANSMIT

### Name

`CEC_RECEIVE`, `CEC_TRANSMIT` - Receive or transmit a CEC message

### Synopsis

#### `CEC_RECEIVE`

```
int ioctl(int fd, CEC_RECEIVE, struct cec_msg *argp)
```

#### `CEC_TRANSMIT`

```
int ioctl(int fd, CEC_TRANSMIT, struct cec_msg *argp)
```

### Arguments

#### `fd`

File descriptor returned by `open()`.

#### `argp`

Pointer to struct `cec_msg`.

### Description

To receive a CEC message the application has to fill in the `timeout` field of struct `cec_msg` and pass it to `ioctl CEC RECEIVE`. If the file descriptor is in non-blocking mode and there are no received messages pending, then it will return -1 and set `errno` to the `EAGAIN` error code. If the file descriptor is in blocking mode and `timeout` is non-zero and no message arrived within `timeout` milliseconds, then it will return -1 and set `errno` to the `ETIMEDOUT` error code.

A received message can be:

1. a message received from another CEC device (the `sequence` field will be 0, `tx_status` will be 0 and `rx_status` will be non-zero).

2. the transmit result of an earlier non-blocking transmit (the sequence field will be non-zero, tx\_status will be non-zero and rx\_status will be 0).
3. the reply to an earlier non-blocking transmit (the sequence field will be non-zero, tx\_status will be 0 and rx\_status will be non-zero).

To send a CEC message the application has to fill in the struct `cec_msg` and pass it to `ioctl CEC_TRANSMIT`. The `ioctl CEC_TRANSMIT` is only available if `CEC_CAP_TRANSMIT` is set. If there is no more room in the transmit queue, then it will return -1 and set `errno` to the EBUSY error code. The transmit queue has enough room for 18 messages (about 1 second worth of 2-byte messages). Note that the CEC kernel framework will also reply to core messages (see [Core Message Processing](#)), so it is not a good idea to fully fill up the transmit queue.

If the file descriptor is in non-blocking mode then the transmit will return 0 and the result of the transmit will be available via `ioctl CEC_RECEIVE` once the transmit has finished. If a non-blocking transmit also specified waiting for a reply, then the reply will arrive in a later message. The sequence field can be used to associate both transmit results and replies with the original transmit.

Normally calling `ioctl CEC_TRANSMIT` when the physical address is invalid (due to e.g. a disconnect) will return ENONET.

However, the CEC specification allows sending messages from 'Unregistered' to 'TV' when the physical address is invalid since some TVs pull the hotplug detect pin of the HDMI connector low when they go into standby, or when switching to another input.

When the hotplug detect pin goes low the EDID disappears, and thus the physical address, but the cable is still connected and CEC still works. In order to detect/wake up the device it is allowed to send poll and 'Image/Text View On' messages from initiator 0xf ('Unregistered') to destination 0 ('TV').

type `cec_msg`

Table 329: struct `cec_msg`

<code>_u64</code>	<code>tx_ts</code>	Timestamp in ns of when the last byte of the message was transmitted. The timestamp has been taken from the <code>CLOCK_MONOTONIC</code> clock. To access the same clock from userspace use <code>clock_gettime()</code> .
<code>_u64</code>	<code>rx_ts</code>	Timestamp in ns of when the last byte of the message was received. The timestamp has been taken from the <code>CLOCK_MONOTONIC</code> clock. To access the same clock from userspace use <code>clock_gettime()</code> .
<code>_u32</code>	<code>len</code>	The length of the message. For <code>ioctl CEC_TRANSMIT</code> this is filled in by the application. The driver will fill this in for <code>ioctl CEC_RECEIVE</code> . For <code>ioctl CEC_TRANSMIT</code> it will be filled in by the driver with the length of the reply message if reply was set.
<code>_u32</code>	<code>timeout</code>	The timeout in milliseconds. This is the time the device will wait for a message to be received before timing out. If it is set to 0, then it will wait indefinitely when it is called by <code>ioctl CEC_RECEIVE</code> . If it is 0 and it is called by <code>ioctl CEC_TRANSMIT</code> , then it will be replaced by 1000 if the reply is non-zero or ignored if reply is 0.

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<code>_u32</code>	<code>sequence</code>	A non-zero sequence number is automatically assigned by the CEC framework for all transmitted messages. It is used by the CEC framework when it queues the transmit result for a non-blocking transmit. This allows the application to associate the received message with the original transmit. In addition, if a non-blocking transmit will wait for a reply (i.e. <code>timeout</code> was not 0), then the <code>sequence</code> field of the reply will be set to the sequence value of the original transmit. This allows the application to associate the received message with the original transmit.
<code>_u32</code>	<code>flags</code>	Flags. See <a href="#">Flags for struct cec_msg</a> for a list of available flags.
<code>_u8</code>	<code>msg[16]</code>	The message payload. For <code>ioctl CEC TRANSMIT</code> this is filled in by the application. The driver will fill this in for <code>ioctl CEC RECEIVE</code> . For <code>ioctl CEC TRANSMIT</code> it will be filled in by the driver with the payload of the reply message if <code>timeout</code> was set.
<code>_u8</code>	<code>reply</code>	Wait until this message is replied. If <code>reply</code> is 0 and the <code>timeout</code> is 0, then don't wait for a reply but return after transmitting the message. Ignored by <code>ioctl CEC RECEIVE</code> . The case where <code>reply</code> is 0 (this is the opcode for the Feature Abort message) and <code>timeout</code> is non-zero is specifically allowed to make it possible to send a message and wait up to <code>timeout</code> milliseconds for a Feature Abort reply. In this case <code>rx_status</code> will either be set to <code>CEC_RX_STATUS_TIMEOUT</code> or <code>CEC_RX_STATUS_FEATURE_ABORT</code> . If the transmitter message is <code>CEC_MSG_INITIATE_ARC</code> then the <code>reply</code> values <code>CEC_MSG_REPORT_ARC_INITIATED</code> and <code>CEC_MSG_REPORT_ARC_TERMINATED</code> are processed differently: either value will match both possible replies. The reason is that the <code>CEC_MSG_INITIATE_ARC</code> message is the only CEC message that has two possible replies other than Feature Abort. The <code>reply</code> field will be updated with the actual reply so that it is synchronized with the contents of the received message.
<code>_u8</code>	<code>rx_status</code>	The status bits of the received message. See <a href="#">CEC Receive Status</a> for the possible status values.
<code>_u8</code>	<code>tx_status</code>	The status bits of the transmitted message. See <a href="#">CEC Transmit Status</a> for the possible status values. When calling <code>ioctl CEC TRANSMIT</code> in non-blocking mode, this field will be 0 if the transmit started, or non-0 if the transmit result is known immediately. The latter would be the case when attempting to transmit a Poll message to yourself. That results in a <code>CEC_TX_STATUS_NACK</code> without ever actually transmitting the Poll message.
<code>_u8</code>	<code>tx_arb_lost_cnt</code>	A counter of the number of transmit attempts that resulted in the Arbitration Lost error. This is only set if the hardware supports this, otherwise it is always 0. This counter is only valid if the <code>CEC_TX_STATUS_ARB_LOST</code> status bit is set.

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__u8	tx_nack_cnt	A counter of the number of transmit attempts that resulted in the Not Acknowledged error. This is only set if the hardware supports this, otherwise it is always 0. This counter is only valid if the <a href="#">CEC_TX_STATUS_NACK</a> status bit is set.
__u8	tx_low_drive_cnt	A counter of the number of transmit attempts that resulted in the Arbitration Lost error. This is only set if the hardware supports this, otherwise it is always 0. This counter is only valid if the <a href="#">CEC_TX_STATUS_LOW_DRIVE</a> status bit is set.
__u8	tx_error_cnt	A counter of the number of transmit errors other than Arbitration Lost or Not Acknowledged. This is only set if the hardware supports this, otherwise it is always 0. This counter is only valid if the <a href="#">CEC_TX_STATUS_ERROR</a> status bit is set.

Table 330: Flags for struct cec\_msg

CEC_MSG_FL_REPLY_TO_FOLLOWERS1		If a CEC transmit expects a reply, then by default that reply is only sent to the filehandle that called <a href="#">ioctl CEC_TRANSMIT</a> . If this flag is set, then the reply is also sent to all followers, if any. If the filehandle that called <a href="#">ioctl CEC_TRANSMIT</a> is also a follower, then that filehandle will receive the reply twice: once as the result of the <a href="#">ioctl CEC_TRANSMIT</a> , and once via <a href="#">ioctl CEC_RECEIVE</a> .
CEC_MSG_FL_RAW	2	Normally CEC messages are validated before transmitting them. If this flag is set when <a href="#">ioctl CEC_TRANSMIT</a> is called, then no validation takes place and the message is transmitted as-is. This is useful when debugging CEC issues. This flag is only allowed if the process has the CAP_SYS_RAWIO capability. If that is not set, then the EPERM error code is returned.

Table 331: CEC Transmit Status

CEC_TX_STATUS_OK	0x01	The message was transmitted successfully. This is mutually exclusive with <a href="#">CEC_TX_STATUS_MAX_RETRIES</a> . Other bits can still be set if earlier attempts met with failure before the transmit was eventually successful.
CEC_TX_STATUS_ARB_LOST	0x02	CEC line arbitration was lost, i.e. another transmit started at the same time with a higher priority. Optional status, not all hardware can detect this error condition.
CEC_TX_STATUS_NACK	0x04	Message was not acknowledged. Note that some hardware cannot tell apart a 'Not Acknowledged' status from other error conditions, i.e. the result of a transmit is just OK or FAIL. In that case this status will be returned when the transmit failed.
CEC_TX_STATUS_LOW_DRIVE	0x08	Low drive was detected on the CEC bus. This indicates that a follower detected an error on the bus and requests a retransmission. Optional status, not all hardware can detect this error condition.
CEC_TX_STATUS_ERROR	0x10	Some error occurred. This is used for any errors that do not fit CEC_TX_STATUS_ARB_LOST or CEC_TX_STATUS_LOW_DRIVE, either because the hardware could not tell which error occurred, or because the hardware tested for other conditions besides those two. Optional status.
CEC_TX_STATUS_MAX_RETRIES	0x20	The transmit failed after one or more retries. This status bit is mutually exclusive with <a href="#">CEC_TX_STATUS_OK</a> . Other bits can still be set to explain which failures were seen.
CEC_TX_STATUS_ABORTED	0x40	The transmit was aborted due to an HDMI disconnect, or the adapter was unconfigured, or a transmit was interrupted, or the driver returned an error when attempting to start a transmit.
CEC_TX_STATUS_TIMEOUT	0x80	The transmit timed out. This should not normally happen and this indicates a driver problem.

Table 332: CEC Receive Status

CEC_RX_STATUS_OK	0x01	The message was received successfully.
CEC_RX_STATUS_TIMEOUT	0x02	The reply to an earlier transmitted message timed out.
CEC_RX_STATUS_FEATURE_ABORT	0x04	The message was received successfully but the reply was <code>CEC_MSG_FEATURE_ABORT</code> . This status is only set if this message was the reply to an earlier transmitted message.
CEC_RX_STATUS_ABORTED	0x08	The wait for a reply to an earlier transmitted message was aborted because the HDMI cable was disconnected, the adapter was unconfigured or the <code>CEC_TRANSMIT</code> that waited for a reply was interrupted.

## Return Value

On success 0 is returned, on error -1 and the `errno` variable is set appropriately. The generic error codes are described at the [Generic Error Codes](#) chapter.

The `ioctl CEC_RECEIVE` can return the following error codes:

### EAGAIN

No messages are in the receive queue, and the filehandle is in non-blocking mode.

### ETIMEDOUT

The timeout was reached while waiting for a message.

### ERESTARTSYS

The wait for a message was interrupted (e.g. by Ctrl-C).

The `ioctl CEC_TRANSMIT` can return the following error codes:

### ENOTTY

The `CEC_CAP_TRANSMIT` capability wasn't set, so this ioctl is not supported.

### EPERM

The CEC adapter is not configured, i.e. `ioctl CEC_ADAP_S_LOG_ADDRS` has never been called, or `CEC_MSG_FL_RAW` was used from a process that did not have the `CAP_SYS_RAWIO` capability.

### ENONET

The CEC adapter is not configured, i.e. `ioctl CEC_ADAP_S_LOG_ADDRS` was called, but the physical address is invalid so no logical address was claimed. An exception is made in this case for transmits from initiator 0xf ('Unregistered') to destination 0 ('TV'). In that case the transmit will proceed as usual.

### EBUSY

Another filehandle is in exclusive follower or initiator mode, or the filehandle is in mode `CEC_MODE_NO_INITIATOR`. This is also returned if the transmit queue is full.

### EINVAL

The contents of struct `cec_msg` is invalid.

## ERESTARTSYS

The wait for a successful transmit was interrupted (e.g. by Ctrl-C).

### 13.6.3 CEC Pin Framework Error Injection

The CEC Pin Framework is a core CEC framework for CEC hardware that only has low-level support for the CEC bus. Most hardware today will have high-level CEC support where the hardware deals with driving the CEC bus, but some older devices aren't that fancy. However, this framework also allows you to connect the CEC pin to a GPIO on e.g. a Raspberry Pi and you have now made a CEC adapter.

What makes doing this so interesting is that since we have full control over the bus it is easy to support error injection. This is ideal to test how well CEC adapters can handle error conditions.

Currently only the cec-gpio driver (when the CEC line is directly connected to a pull-up GPIO line) and the AllWinner A10/A20 drm driver support this framework.

If CONFIG\_CEC\_PIN\_ERROR\_INJ is enabled, then error injection is available through debugfs. Specifically, in /sys/kernel/debug/cec/cecX/ there is now an `error-inj` file.

---

**Note:** The error injection commands are not a stable ABI and may change in the future.

---

With `cat error-inj` you can see both the possible commands and the current error injection status:

```
$ cat /sys/kernel/debug/cec/cec0/error-inj
# Clear error injections:
#   clear          clear all rx and tx error injections
#   rx-clear       clear all rx error injections
#   tx-clear       clear all tx error injections
#   <op> clear     clear all rx and tx error injections for <op>
#   <op> rx-clear  clear all rx error injections for <op>
#   <op> tx-clear  clear all tx error injections for <op>
#
# RX error injection:
#   <op>[,<mode>] rx-nack           NACK the message instead of sending an ACK
#   <op>[,<mode>] rx-low-drive <bit>  force a low-drive condition at this bit position
#   <op>[,<mode>] rx-add-byte        add a spurious byte to the received CEC message
#   <op>[,<mode>] rx-remove-byte    remove the last byte from the received CEC message
#   any[,<mode>] rx-arb-lost [<poll>] generate a POLL message to trigger an arbitration lost
#
# TX error injection settings:
#   tx-ignore-nack-until-eom      ignore early NACKs until EOM
#   tx-custom-low-usecs <usecs>   define the 'low' time for the custom pulse
#   tx-custom-high-usecs <usecs>  define the 'high' time for the custom pulse
```

```

# tx-custom-pulse                                transmit the custom pulse once the bus
#      is idle
#
# TX error injection:
#   <op>[,<mode>] tx-no-eom                  don't set the EOM bit
#   <op>[,<mode>] tx-early-eom                set the EOM bit one byte too soon
#   <op>[,<mode>] tx-add-bytes <num>        append <num> (1-255) spurious bytes to
#      the message
#   <op>[,<mode>] tx-remove-byte               drop the last byte from the message
#   <op>[,<mode>] tx-short-bit <bit>         make this bit shorter than allowed
#   <op>[,<mode>] tx-long-bit <bit>          make this bit longer than allowed
#   <op>[,<mode>] tx-custom-bit <bit>        send the custom pulse instead of this
#      bit
#   <op>[,<mode>] tx-short-start              send a start pulse that's too short
#   <op>[,<mode>] tx-long-start                send a start pulse that's too long
#   <op>[,<mode>] tx-custom-start             send the custom pulse instead of the
#      start pulse
#   <op>[,<mode>] tx-last-bit <bit>         stop sending after this bit
#   <op>[,<mode>] tx-low-drive <bit>        force a low-drive condition at this bit
#      position
#
# <op>          CEC message opcode (0-255) or 'any'
# <mode>        'once' (default), 'always', 'toggle' or 'off'
# <bit>         CEC message bit (0-159)
#           10 bits per 'byte': bits 0-7: data, bit 8: EOM, bit 9: ACK
# <poll>        CEC poll message used to test arbitration lost (0x00-0xff,
#      default 0x0f)
# <usecs>       microseconds (0-10000000, default 1000)

clear

```

You can write error injection commands to `error-inj` using `echo 'cmd' >error-inj` or `cat cmd.txt >error-inj`. The `cat error-inj` output contains the current error commands. You can save the output to a file and use it as an input to `error-inj` later.

## Basic Syntax

Leading spaces/tabs are ignored. If the next character is a # or the end of the line was reached, then the whole line is ignored. Otherwise a command is expected.

The error injection commands fall in two main groups: those relating to receiving CEC messages and those relating to transmitting CEC messages. In addition, there are commands to clear existing error injection commands and to create custom pulses on the CEC bus.

Most error injection commands can be executed for specific CEC opcodes or for all opcodes (any). Each command also has a 'mode' which can be off (can be used to turn off an existing error injection command), once (the default) which will trigger the error injection only once for the next received or transmitted message, always to always trigger the error injection and toggle to toggle the error injection on or off for every transmit or receive.

So 'any rx-nack' will NACK the next received CEC message, 'any,always rx-nack' will NACK all received CEC messages and '0x82,toggle rx-nack' will only NACK if an Active Source

message was received and do that only for every other received message.

After an error was injected with mode once the error injection command is cleared automatically, so once is a one-time deal.

All combinations of <op> and error injection commands can co-exist. So this is fine:

```
0x9e tx-add-bytes 1
0x9e tx-early-eom
0x9f tx-add-bytes 2
any rx-nack
```

All four error injection commands will be active simultaneously.

However, if the same <op> and command combination is specified, but with different arguments:

```
0x9e tx-add-bytes 1
0x9e tx-add-bytes 2
```

Then the second will overwrite the first.

## Clear Error Injections

### **clear**

Clear all error injections.

### **rx-clear**

Clear all receive error injections

### **tx-clear**

Clear all transmit error injections

### **<op> clear**

Clear all error injections for the given opcode.

### **<op> rx-clear**

Clear all receive error injections for the given opcode.

### **<op> tx-clear**

Clear all transmit error injections for the given opcode.

## Receive Messages

### **<op>[,<mode>] rx-nack**

NACK broadcast messages and messages directed to this CEC adapter. Every byte of the message will be NACKed in case the transmitter keeps transmitting after the first byte was NACKed.

### **<op>[,<mode>] rx-low-drive <bit>**

Force a Low Drive condition at this bit position. If <op> specifies a specific CEC opcode then the bit position must be at least 18, otherwise the opcode hasn't been received yet. This tests if the transmitter can handle the Low Drive condition correctly and reports the error correctly. Note that a Low Drive in the first 4 bits can also be interpreted as an Arbitration Lost condition by the transmitter. This is implementation dependent.

**<op>[ ,<mode>] rx-add-byte**

Add a spurious 0x55 byte to the received CEC message, provided the message was 15 bytes long or less. This is useful to test the high-level protocol since spurious bytes should be ignored.

**<op>[ ,<mode>] rx-remove-byte**

Remove the last byte from the received CEC message, provided it was at least 2 bytes long. This is useful to test the high-level protocol since messages that are too short should be ignored.

**<op>[ ,<mode>] rx-arb-lost <poll>**

Generate a POLL message to trigger an Arbitration Lost condition. This command is only allowed for <op> values of next or all. As soon as a start bit has been received the CEC adapter will switch to transmit mode and it will transmit a POLL message. By default this is 0x0f, but it can also be specified explicitly via the <poll> argument.

This command can be used to test the Arbitration Lost condition in the remote CEC transmitter. Arbitration happens when two CEC adapters start sending a message at the same time. In that case the initiator with the most leading zeroes wins and the other transmitter has to stop transmitting ('Arbitration Lost'). This is very hard to test, except by using this error injection command.

This does not work if the remote CEC transmitter has logical address 0 ('TV') since that will always win.

## Transmit Messages

**tx-ignore-nack-until-eom**

This setting changes the behavior of transmitting CEC messages. Normally as soon as the receiver NACKs a byte the transmit will stop, but the specification also allows that the full message is transmitted and only at the end will the transmitter look at the ACK bit. This is not recommended behavior since there is no point in keeping the CEC bus busy for longer than is strictly needed. Especially given how slow the bus is.

This setting can be used to test how well a receiver deals with transmitters that ignore NACKs until the very end of the message.

**<op>[ ,<mode>] tx-no-eom**

Don't set the EOM bit. Normally the last byte of the message has the EOM (End-Of Message) bit set. With this command the transmit will just stop without ever sending an EOM. This can be used to test how a receiver handles this case. Normally receivers have a time-out after which they will go back to the Idle state.

**<op>[ ,<mode>] tx-early-eom**

Set the EOM bit one byte too soon. This obviously only works for messages of two bytes or more. The EOM bit will be set for the second-to-last byte and not for the final byte. The receiver should ignore the last byte in this case. Since the resulting message is likely to be too short for this same reason the whole message is typically ignored. The receiver should be in Idle state after the last byte was transmitted.

**<op>[ ,<mode>] tx-add-bytes <num>**

Append <num> (1-255) spurious bytes to the message. The extra bytes have the value of the byte position in the message. So if you transmit a two byte message (e.g. a Get CEC Version message) and add 2 bytes, then the full message received by the remote CEC adapter is 0x40 0x9f 0x02 0x03.

This command can be used to test buffer overflows in the receiver. E.g. what does it do when it receives more than the maximum message size of 16 bytes.

### **<op>[ ,<mode>] tx-remove-byte**

Drop the last byte from the message, provided the message is at least two bytes long. The receiver should ignore messages that are too short.

### **<op>[ ,<mode>] tx-short-bit <bit>**

Make this bit period shorter than allowed. The bit position cannot be an Ack bit. If `<op>` specifies a specific CEC opcode then the bit position must be at least 18, otherwise the opcode hasn't been received yet. Normally the period of a data bit is between 2.05 and 2.75 milliseconds. With this command the period of this bit is 1.8 milliseconds, this is done by reducing the time the CEC bus is high. This bit period is less than is allowed and the receiver should respond with a Low Drive condition.

This command is ignored for 0 bits in bit positions 0 to 3. This is because the receiver also looks for an Arbitration Lost condition in those first four bits and it is undefined what will happen if it sees a too-short 0 bit.

### **<op>[ ,<mode>] tx-long-bit <bit>**

Make this bit period longer than is valid. The bit position cannot be an Ack bit. If `<op>` specifies a specific CEC opcode then the bit position must be at least 18, otherwise the opcode hasn't been received yet. Normally the period of a data bit is between 2.05 and 2.75 milliseconds. With this command the period of this bit is 2.9 milliseconds, this is done by increasing the time the CEC bus is high.

Even though this bit period is longer than is valid it is undefined what a receiver will do. It might just accept it, or it might time out and return to Idle state. Unfortunately the CEC specification is silent about this.

This command is ignored for 0 bits in bit positions 0 to 3. This is because the receiver also looks for an Arbitration Lost condition in those first four bits and it is undefined what will happen if it sees a too-long 0 bit.

### **<op>[ ,<mode>] tx-short-start**

Make this start bit period shorter than allowed. Normally the period of a start bit is between 4.3 and 4.7 milliseconds. With this command the period of the start bit is 4.1 milliseconds, this is done by reducing the time the CEC bus is high. This start bit period is less than is allowed and the receiver should return to Idle state when this is detected.

### **<op>[ ,<mode>] tx-long-start**

Make this start bit period longer than is valid. Normally the period of a start bit is between 4.3 and 4.7 milliseconds. With this command the period of the start bit is 5 milliseconds, this is done by increasing the time the CEC bus is high. This start bit period is more than is valid and the receiver should return to Idle state when this is detected.

Even though this start bit period is longer than is valid it is undefined what a receiver will do. It might just accept it, or it might time out and return to Idle state. Unfortunately the CEC specification is silent about this.

### **<op>[ ,<mode>] tx-last-bit <bit>**

Just stop transmitting after this bit. If `<op>` specifies a specific CEC opcode then the bit position must be at least 18, otherwise the opcode hasn't been received yet. This command can be used to test how the receiver reacts when a message just suddenly stops. It should time out and go back to Idle state.

**<op>[,<mode>] tx-low-drive <bit>**

Force a Low Drive condition at this bit position. If <op> specifies a specific CEC opcode then the bit position must be at least 18, otherwise the opcode hasn't been received yet. This can be used to test how the receiver handles Low Drive conditions. Note that if this happens at bit positions 0-3 the receiver can interpret this as an Arbitration Lost condition. This is implementation dependent.

## Custom Pulses

**tx-custom-low-usecs <usecs>**

This defines the duration in microseconds that the custom pulse pulls the CEC line low. The default is 1000 microseconds.

**tx-custom-high-usecs <usecs>**

This defines the duration in microseconds that the custom pulse keeps the CEC line high (unless another CEC adapter pulls it low in that time). The default is 1000 microseconds. The total period of the custom pulse is tx-custom-low-usecs + tx-custom-high-usecs.

**<op>[,<mode>] tx-custom-bit <bit>**

Send the custom bit instead of a regular data bit. The bit position cannot be an Ack bit. If <op> specifies a specific CEC opcode then the bit position must be at least 18, otherwise the opcode hasn't been received yet.

**<op>[,<mode>] tx-custom-start**

Send the custom bit instead of a regular start bit.

**tx-custom-pulse**

Transmit a single custom pulse as soon as the CEC bus is idle.

## 13.6.4 CEC Header File

**cec.h**

```
/* SPDX-License-Identifier: ((GPL-2.0 WITH Linux-syscall-note) OR
 * BSD-3-Clause) */
/*
 * cec - HDMI Consumer Electronics Control public header
 *
 * Copyright 2016 Cisco Systems, Inc. and/or its affiliates. All rights
 * reserved.
 */

#ifndef _CEC_UAPI_H
#define _CEC_UAPI_H

#include <linux/types.h>
#include <linux/string.h>

#define CEC_MAX_MSG_SIZE          16

/***
 * struct cec_msg - CEC message structure.
 *
```

```
* @tx_ts:           Timestamp in nanoseconds using CLOCK_MONOTONIC. Set by the
*                   driver when the message transmission has finished.
* @rx_ts:           Timestamp in nanoseconds using CLOCK_MONOTONIC. Set by the
*                   driver when the message was received.
* @len:             Length in bytes of the message.
* @timeout:         The timeout (in ms) that is used to timeout CEC_RECEIVE.
*                   Set to 0 if you want to wait forever. This timeout can also be
*                   used with CEC\_TRANSMIT as the timeout for waiting for a reply.
*                   If 0, then it will use a 1 second timeout instead of waiting
*                   forever as is done with CEC_RECEIVE.
* @sequence:        The framework assigns a sequence number to messages that are
*                   sent. This can be used to track replies to previously sent
*                   messages.
* @flags:           Set to 0.
* @msg:             The message payload.
* @reply:            This field is ignored with CEC\_RECEIVE and is only used by
*                   CEC_TRANSMIT. If non-zero, then wait for a reply with this
*                   opcode. Set to CEC_MSG_FEATURE_ABORT if you want to wait for
*                   a possible ABORT reply. If there was an error when sending the
*                   msg or FeatureAbort was returned, then reply is set to 0.
*                   If reply is non-zero upon return, then len/msg are set to
*                   the received message.
*                   If reply is zero upon return and status has the
*                   CEC_TX_STATUS_FEATURE_ABORT bit set, then len/msg are set to
*                   the received feature abort message.
*                   If reply is zero upon return and status has the
*                   CEC\_TX\_STATUS\_MAX\_RETRIES bit set, then no reply was seen at
*                   all. If reply is non-zero for CEC\_TRANSMIT and the message is a
*                   broadcast, then -EINVAL is returned.
*                   if reply is non-zero, then timeout is set to 1000 (the required
*                   maximum response time).
* @rx_status:        The message receive status bits. Set by the driver.
* @tx_status:        The message transmit status bits. Set by the driver.
* @tx_arb_lost_cnt: The number of 'Arbitration Lost' events. Set by the u
*                   driver.
* @tx_nack_cnt:     The number of 'Not Acknowledged' events. Set by the driver.
* @tx_low_drive_cnt: The number of 'Low Drive Detected' events. Set by the
*                   driver.
* @tx_error_cnt:    The number of 'Error' events. Set by the driver.
*/
struct cec_msg {
    __u64 tx_ts;
    __u64 rx_ts;
    __u32 len;
    __u32 timeout;
    __u32 sequence;
    __u32 flags;
    __u8 msg[CEC_MAX_MSG_SIZE];
    __u8 reply;
    __u8 rx_status;
    __u8 tx_status;
```

```

        __u8 tx_arb_lost_cnt;
        __u8 tx_nack_cnt;
        __u8 tx_low_drive_cnt;
        __u8 tx_error_cnt;
};

/***
 * cec_msg_initiator - return the initiator's logical address.
 * @msg:          the message structure
 */
static inline __u8 cec_msg_initiator(const struct cec_msg *msg)
{
    return msg->msg[0] >> 4;
}

/***
 * cec_msg_destination - return the destination's logical address.
 * @msg:          the message structure
 */
static inline __u8 cec_msg_destination(const struct cec_msg *msg)
{
    return msg->msg[0] & 0xf;
}

/***
 * cec_msg_opcode - return the opcode of the message, -1 for poll
 * @msg:          the message structure
 */
static inline int cec_msg_opcode(const struct cec_msg *msg)
{
    return msg->len > 1 ? msg->msg[1] : -1;
}

/***
 * cec_msg_is_broadcast - return true if this is a broadcast message.
 * @msg:          the message structure
 */
static inline int cec_msg_is_broadcast(const struct cec_msg *msg)
{
    return (msg->msg[0] & 0xf) == 0xf;
}

/***
 * cec_msg_init - initialize the message structure.
 * @msg:          the message structure
 * @initiator:   the logical address of the initiator
 * @destination: the logical address of the destination (0xf for broadcast)
 *
 * The whole structure is zeroed, the len field is set to 1 (i.e. a poll
 * message) and the initiator and destination are filled in.
 */

```

```
static inline void cec_msg_init(struct cec_msg *msg,
                                __u8 initiator, __u8 destination)
{
    memset(msg, 0, sizeof(*msg));
    msg->msg[0] = (initiator << 4) | destination;
    msg->len = 1;
}

/**
 * cec_msg_set_reply_to - fill in destination/initiator in a reply message.
 * @msg:          the message structure for the reply
 * @orig:         the original message structure
 *
 * Set the msg destination to the orig initiator and the msg initiator to the
 * orig destination. Note that msg and orig may be the same pointer, in which
 * case the change is done in place.
 */
static inline void cec_msg_set_reply_to(struct cec_msg *msg,
                                        struct cec_msg *orig)
{
    /* The destination becomes the initiator and vice versa */
    msg->msg[0] = (cec_msg_destination(orig) << 4) |
                  cec_msg_initiator(orig);
    msg->reply = msg->timeout = 0;
}

/**
 * cec_msg_recv_is_tx_result - return true if this message contains the
 *                             result of an earlier non-blocking transmit
 * @msg:          the message structure from CEC_RECEIVE
 */
static inline int cec_msg_recv_is_tx_result(const struct cec_msg *msg)
{
    return msg->sequence && msg->tx_status && !msg->rx_status;
}

/**
 * cec_msg_recv_is_rx_result - return true if this message contains the
 *                             reply of an earlier non-blocking transmit
 * @msg:          the message structure from CEC_RECEIVE
 */
static inline int cec_msg_recv_is_rx_result(const struct cec_msg *msg)
{
    return msg->sequence && !msg->tx_status && msg->rx_status;
}

/* cec_msg flags field */
#define CEC_MSG_FL_REPLY_TO_FOLLOWERS     (1 << 0)
#define CEC_MSG_FL_RAW                   (1 << 1)

/* cec_msg tx/rx_status field */
```

```

#define CEC_TX_STATUS_OK          (1 << 0)
#define CEC_TX_STATUS_ARB_LOST   (1 << 1)
#define CEC_TX_STATUS_NACK        (1 << 2)
#define CEC_TX_STATUS_LOW_DRIVE   (1 << 3)
#define CEC_TX_STATUS_ERROR       (1 << 4)
#define CEC_TX_STATUS_MAX_RETRIES (1 << 5)
#define CEC_TX_STATUS_ABORTED    (1 << 6)
#define CEC_TX_STATUS_TIMEOUT     (1 << 7)

#define CEC_RX_STATUS_OK          (1 << 0)
#define CEC_RX_STATUS_TIMEOUT     (1 << 1)
#define CEC_RX_STATUS_FEATURE_ABORT (1 << 2)
#define CEC_RX_STATUS_ABORTED    (1 << 3)

static inline int cec_msg_status_is_ok(const struct cec_msg *msg)
{
    if (msg->tx_status && !(msg->tx_status & CEC_TX_STATUS_OK))
        return 0;
    if (msg->rx_status && !(msg->rx_status & CEC_RX_STATUS_OK))
        return 0;
    if (!msg->tx_status && !msg->rx_status)
        return 0;
    return !(msg->rx_status & CEC_RX_STATUS_FEATURE_ABORT);
}

#define CEC_LOG_ADDR_INVALID      0xff
#define CEC_PHYS_ADDR_INVALID     0xffff

/*
 * The maximum number of logical addresses one device can be assigned to.
 * The CEC 2.0 spec allows for only 2 logical addresses at the moment. The
 * Analog Devices CEC hardware supports 3. So let's go wild and go for 4.
 */
#define CEC_MAX_LOG_ADDRS 4

/* The logical addresses defined by CEC 2.0 */
#define CEC_LOG_ADDR_TV           0
#define CEC_LOG_ADDR_RECORD_1      1
#define CEC_LOG_ADDR_RECORD_2      2
#define CEC_LOG_ADDR_TUNER_1       3
#define CEC_LOG_ADDR_PLAYBACK_1    4
#define CEC_LOG_ADDR_AUDIOSYSTEM  5
#define CEC_LOG_ADDR_TUNER_2       6
#define CEC_LOG_ADDR_TUNER_3       7
#define CEC_LOG_ADDR_PLAYBACK_2    8
#define CEC_LOG_ADDR_RECORD_3      9
#define CEC_LOG_ADDR_TUNER_4       10
#define CEC_LOG_ADDR_PLAYBACK_3    11
#define CEC_LOG_ADDR_BACKUP_1      12
#define CEC_LOG_ADDR_BACKUP_2      13
#define CEC_LOG_ADDR_SPECIFIC     14

```

```

#define CEC_LOG_ADDR_UNREGISTERED          15 /* as initiator address */
#define CEC_LOG_ADDR_BROADCAST            15 /* as destination address */

/* The logical address types that the CEC device wants to claim */
#define CEC_LOG_ADDR_TYPE_TV              0
#define CEC_LOG_ADDR_TYPE_RECORD          1
#define CEC_LOG_ADDR_TYPE_TUNER          2
#define CEC_LOG_ADDR_TYPE_PLAYBACK        3
#define CEC_LOG_ADDR_TYPE_AUDIOSYSTEM    4
#define CEC_LOG_ADDR_TYPE_SPECIFIC        5
#define CEC_LOG_ADDR_TYPE_UNREGISTERED    6
/*
 * Switches should use UNREGISTERED.
 * Processors should use SPECIFIC.
 */

#define CEC_LOG_ADDR_MASK_TV             (1 << CEC_LOG_ADDR_TV)
#define CEC_LOG_ADDR_MASK_RECORD          (((1 << CEC_LOG_ADDR_RECORD_1) | \
                                         (1 << CEC_LOG_ADDR_RECORD_2) | \
                                         (1 << CEC_LOG_ADDR_RECORD_3)))
#define CEC_LOG_ADDR_MASK_TUNER          (((1 << CEC_LOG_ADDR_TUNER_1) | \
                                         (1 << CEC_LOG_ADDR_TUNER_2) | \
                                         (1 << CEC_LOG_ADDR_TUNER_3) | \
                                         (1 << CEC_LOG_ADDR_TUNER_4)))
#define CEC_LOG_ADDR_MASK_PLAYBACK        (((1 << CEC_LOG_ADDR_PLAYBACK_1) | \
                                         (1 << CEC_LOG_ADDR_PLAYBACK_2) | \
                                         (1 << CEC_LOG_ADDR_PLAYBACK_3)))
#define CEC_LOG_ADDR_MASK_AUDIOSYSTEM    (1 << CEC_LOG_ADDR_AUDIOSYSTEM)
#define CEC_LOG_ADDR_MASK_BACKUP          (((1 << CEC_LOG_ADDR_BACKUP_1) | \
                                         (1 << CEC_LOG_ADDR_BACKUP_2)))
#define CEC_LOG_ADDR_MASK_SPECIFIC        (1 << CEC_LOG_ADDR_SPECIFIC)
#define CEC_LOG_ADDR_MASK_UNREGISTERED    (1 << CEC_LOG_ADDR_UNREGISTERED)

static inline int cec_has_tv(__u16 log_addr_mask)
{
    return log_addr_mask & CEC_LOG_ADDR_MASK_TV;
}

static inline int cec_has_record(__u16 log_addr_mask)
{
    return log_addr_mask & CEC_LOG_ADDR_MASK_RECORD;
}

static inline int cec_has_tuner(__u16 log_addr_mask)
{
    return log_addr_mask & CEC_LOG_ADDR_MASK_TUNER;
}

static inline int cec_has_playback(__u16 log_addr_mask)
{
    return log_addr_mask & CEC_LOG_ADDR_MASK_PLAYBACK;
}

```

```

}

static inline int cec_has_audiosystem(__u16 log_addr_mask)
{
    return log_addr_mask & CEC_LOG_ADDR_MASK_AUDIOSYSTEM;
}

static inline int cec_has_backup(__u16 log_addr_mask)
{
    return log_addr_mask & CEC_LOG_ADDR_MASK_BACKUP;
}

static inline int cec_has_specific(__u16 log_addr_mask)
{
    return log_addr_mask & CEC_LOG_ADDR_MASK_SPECIFIC;
}

static inline int cec_is_unregistered(__u16 log_addr_mask)
{
    return log_addr_mask & CEC_LOG_ADDR_MASK_UNREGISTERED;
}

static inline int cec_is_unconfigured(__u16 log_addr_mask)
{
    return log_addr_mask == 0;
}

/*
 * Use this if there is no vendor ID (CEC_G_VENDOR_ID) or if the vendor ID
 * should be disabled (CEC_S_VENDOR_ID)
 */
#define CEC_VENDOR_ID_NONE          0xffffffff

/* The message handling modes */
/* Modes for initiator */
#define CEC_MODE_NO_INITIATOR        (0x0 << 0)
#define CEC_MODE_INITIATOR           (0x1 << 0)
#define CEC_MODE_EXCL_INITIATOR     (0x2 << 0)
#define CEC_MODE_INITIATOR_MSK      0x0f

/* Modes for follower */
#define CEC_MODE_NO_FOLLOWER        (0x0 << 4)
#define CEC_MODE_FOLLOWER           (0x1 << 4)
#define CEC_MODE_EXCL_FOLLOWER     (0x2 << 4)
#define CEC_MODE_EXCL_FOLLOWER_PASSTHRU (0x3 << 4)
#define CEC_MODE_MONITOR_PIN        (0xd << 4)
#define CEC_MODE_MONITOR            (0xe << 4)
#define CEC_MODE_MONITOR_ALL        (0xf << 4)
#define CEC_MODE_FOLLOWER_MSK       0xf0

/* Userspace has to configure the physical address */

```

```
#define CEC_CAP_PHYS_ADDR          (1 << 0)
/* Userspace has to configure the logical addresses */
#define CEC_CAP_LOG_ADDRS          (1 << 1)
/* Userspace can transmit messages (and thus become follower as well) */
#define CEC_CAP_TRANSMIT           (1 << 2)
/*
 * Passthrough all messages instead of processing them.
 */
#define CEC_CAP_PASSTHROUGH        (1 << 3)
/* Supports remote control */
#define CEC_CAP_RC                  (1 << 4)
/* Hardware can monitor all messages, not just directed and broadcast. */
#define CEC_CAP_MONITOR_ALL         (1 << 5)
/* Hardware can use CEC only if the HDMI HPD pin is high. */
#define CEC_CAP_NEEDS_HPD           (1 << 6)
/* Hardware can monitor CEC pin transitions */
#define CEC_CAP_MONITOR_PIN          (1 << 7)
/* CEC_ADAPTER_CONNECTOR_INFO is available */
#define CEC_CAP_CONNECTOR_INFO       (1 << 8)

/**
 * struct cec_caps - CEC capabilities structure.
 * @driver: name of the CEC device driver.
 * @name: name of the CEC device. @driver + @name must be unique.
 * @available_log_addrs: number of available logical addresses.
 * @capabilities: capabilities of the CEC adapter.
 * @version: version of the CEC adapter framework.
 */
struct cec_caps {
    char driver[32];
    char name[32];
    __u32 available_log_addrs;
    __u32 capabilities;
    __u32 version;
};

/**
 * struct cec_log_addrs - CEC logical addresses structure.
 * @log_addr: the claimed logical addresses. Set by the driver.
 * @log_addr_mask: current logical address mask. Set by the driver.
 * @cec_version: the CEC version that the adapter should implement. Set by the
 *   caller.
 * @num_log_addrs: how many logical addresses should be claimed. Set by the
 *   caller.
 * @vendor_id: the vendor ID of the device. Set by the caller.
 * @flags: flags.
 * @osd_name: the OSD name of the device. Set by the caller.
 * @primary_device_type: the primary device type for each logical address.
 *   Set by the caller.
 * @log_addr_type: the logical address types. Set by the caller.
 * @all_device_types: CEC 2.0: all device types represented by the logical
```

```

*      address. Set by the caller.
* @features: CEC 2.0: The logical address features. Set by the caller.
*/
struct cec_log_addrs {
    __u8 log_addr[CEC_MAX_LOG_ADDRS];
    __u16 log_addr_mask;
    __u8 cec_version;
    __u8 num_log_addrs;
    __u32 vendor_id;
    __u32 flags;
    char osd_name[15];
    __u8 primary_device_type[CEC_MAX_LOG_ADDRS];
    __u8 log_addr_type[CEC_MAX_LOG_ADDRS];

    /* CEC 2.0 */
    __u8 all_device_types[CEC_MAX_LOG_ADDRS];
    __u8 features[CEC_MAX_LOG_ADDRS][12];
};

/* Allow a fallback to unregistered */
#define CEC_LOG_ADDRS_FL_ALLOW_UNREG_FALLBACK (1 << 0)
/* Passthrough RC messages to the input subsystem */
#define CEC_LOG_ADDRS_FL_ALLOW_RC_PASSTHRU (1 << 1)
/* CDC-Only device: supports only CDC messages */
#define CEC_LOG_ADDRS_FL_CDC_ONLY (1 << 2)

/**
 * struct cec_drm_connector_info - tells which drm connector is
 * associated with the CEC adapter.
 * @card_no: drm card number
 * @connector_id: drm connector ID
 */
struct cec_drm_connector_info {
    __u32 card_no;
    __u32 connector_id;
};

#define CEC_CONNECTOR_TYPE_NO_CONNECTOR 0
#define CEC_CONNECTOR_TYPE_DRM 1

/**
 * struct cec_connector_info - tells if and which connector is
 * associated with the CEC adapter.
 * @type: connector type (if any)
 * @drm: drm connector info
 * @raw: array to pad the union
 */
struct cec_connector_info {
    __u32 type;
    union {
        struct cec_drm_connector_info drm;

```

```

        __u32 raw[16];
    };
};

/* Events */

/* Event that occurs when the adapter state changes */
#define CEC_EVENT_STATE_CHANGE 1
/*
 * This event is sent when messages are lost because the application
 * didn't empty the message queue in time
 */
#define CEC_EVENT_LOST_MSGS 2
#define CEC_EVENT_PIN_CEC_LOW 3
#define CEC_EVENT_PIN_CEC_HIGH 4
#define CEC_EVENT_PIN_HPD_LOW 5
#define CEC_EVENT_PIN_HPD_HIGH 6
#define CEC_EVENT_PIN_5V_LOW 7
#define CEC_EVENT_PIN_5V_HIGH 8

#define CEC_EVENT_FL_INITIAL_STATE (1 << 0)
#define CEC_EVENT_FL_DROPPED_EVENTS (1 << 1)

/***
 * struct cec_event_state_change - used when the CEC adapter changes state.
 * @phys_addr: the current physical address
 * @log_addr_mask: the current logical address mask
 * @have_conn_info: if non-zero, then HDMI connector information is available.
 *                   This field is only valid if CEC\_CAP\_CONNECTOR\_INFO is set. If that
 *                   capability is set and @have_conn_info is zero, then that indicates
 *                   that the HDMI connector device is not instantiated, either because
 *                   the HDMI driver is still configuring the device or because the HDMI
 *                   device was unbound.
 */
struct cec_event_state_change {
    __u16 phys_addr;
    __u16 log_addr_mask;
    __u16 have_conn_info;
};

/***
 * struct cec_event_lost_msgs - tells you how many messages were lost.
 * @lost_msgs: how many messages were lost.
 */
struct cec_event_lost_msgs {
    __u32 lost_msgs;
};

/***
 * struct cec_event - CEC event structure
 * @ts: the timestamp of when the event was sent.
 */

```

```

* @event: the event.
* @flags: event flags.
* @state_change: the event payload for CEC_EVENT_STATE_CHANGE.
* @lost_msgs: the event payload for CEC_EVENT_LOST_MSGS.
* @raw: array to pad the union.
*/
struct cec_event {
    __u64 ts;
    __u32 event;
    __u32 flags;
    union {
        struct cec_event_state_change state_change;
        struct cec_event_lost_msgs lost_msgs;
        __u32 raw[16];
    };
};

/* ioctls */

/* Adapter capabilities */
#define CEC_ADAP_G_CAPS      _IOWR('a', 0, struct cec_caps)

/*
 * phys_addr is either 0 (if this is the CEC root device)
 * or a valid physical address obtained from the sink's EDID
 * as read by this CEC device (if this is a source device)
 * or a physical address obtained and modified from a sink
 * EDID and used for a sink CEC device.
 * If nothing is connected, then phys_addr is 0xffff.
 * See HDMI 1.4b, section 8.7 (Physical Address).
 *
 * The CEC_ADAP_S_PHYS_ADDR ioctl may not be available if that is handled
 * internally.
*/
#define CEC_ADAP_G_PHYS_ADDR _IOR('a', 1, __u16)
#define CEC_ADAP_S_PHYS_ADDR _IOW('a', 2, __u16)

/*
 * Configure the CEC adapter. It sets the device type and which
 * logical types it will try to claim. It will return which
 * logical addresses it could actually claim.
 * An error is returned if the adapter is disabled or if there
 * is no physical address assigned.
*/
#define CEC_ADAP_G_LOG_ADDRS _IOR('a', 3, struct cec_log_addrs)
#define CEC_ADAP_S_LOG_ADDRS _IOWR('a', 4, struct cec_log_addrs)

/* Transmit/receive a CEC command */
#define CEC_TRANSMIT         _IOWR('a', 5, struct cec_msg)
#define CEC_RECEIVE          _IOWR('a', 6, struct cec_msg)

```

```
/* Dequeue CEC events */
#define CEC_DQEVENT           _IOWR('a', 7, struct cec_event)

/*
 * Get and set the message handling mode for this filehandle.
 */
#define CEC_G_MODE            _IOR('a', 8, __u32)
#define CEC_S_MODE            _IOW('a', 9, __u32)

/* Get the connector info */
#define CEC_ADAP_G_CONNECTOR_INFO _IOR('a', 10, struct cec_connector_info)

/*
 * The remainder of this header defines all CEC messages and operands.
 * The format matters since it the cec-ctl utility parses it to generate
 * code for implementing all these messages.
 *
 * Comments ending with 'Feature' group messages for each feature.
 * If messages are part of multiple features, then the "Has also"
 * comment is used to list the previously defined messages that are
 * supported by the feature.
 *
 * Before operands are defined a comment is added that gives the
 * name of the operand and in brackets the variable name of the
 * corresponding argument in the cec-funcs.h function.
 */
/* Messages */

/* One Touch Play Feature */
#define CEC_MSG_ACTIVE_SOURCE          0x82
#define CEC_MSG_IMAGE_VIEW_ON          0x04
#define CEC_MSG_TEXT_VIEW_ON           0x0d

/* Routing Control Feature */

/*
 * Has also:
 *      CEC_MSG_ACTIVE_SOURCE
 */
#define CEC_MSG_INACTIVE_SOURCE        0x9d
#define CEC_MSG_REQUEST_ACTIVE_SOURCE  0x85
#define CEC_MSG_ROUTING_CHANGE         0x80
#define CEC_MSG_ROUTING_INFORMATION   0x81
#define CEC_MSG_SET_STREAM_PATH        0x86

/* Standby Feature */
#define CEC_MSG_STANDBY               0x36
```

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/* One Touch Record Feature */
#define CEC_MSG_RECORD_OFF                      0x0b
#define CEC_MSG_RECORD_ON                       0x09
/* Record Source Type Operand (rec_src_type) */
#define CEC_OP_RECORD_SRC_OWN                   1
#define CEC_OP_RECORD_SRC_DIGITAL              2
#define CEC_OP_RECORD_SRC_ANALOG               3
#define CEC_OP_RECORD_SRC_EXT_PLUG             4
#define CEC_OP_RECORD_SRC_EXT_PHYS_ADDR        5
/* Service Identification Method Operand (service_id_method) */
#define CEC_OP_SERVICE_ID_METHOD_BY_DIG_ID     0
#define CEC_OP_SERVICE_ID_METHOD_BY_CHANNEL    1
/* Digital Service Broadcast System Operand (dig_bcast_system) */
#define CEC_OP_DIG_SERVICE_BCAST_SYSTEM_ARIB_GEN 0x00
#define CEC_OP_DIG_SERVICE_BCAST_SYSTEM_ATSC_GEN 0x01
#define CEC_OP_DIG_SERVICE_BCAST_SYSTEM_DVB_GEN 0x02
#define CEC_OP_DIG_SERVICE_BCAST_SYSTEM_ARIB_BS 0x08
#define CEC_OP_DIG_SERVICE_BCAST_SYSTEM_ARIB_CS 0x09
#define CEC_OP_DIG_SERVICE_BCAST_SYSTEM_ARIB_T  0x0a
#define CEC_OP_DIG_SERVICE_BCAST_SYSTEM_ATSC_CABLE 0x10
#define CEC_OP_DIG_SERVICE_BCAST_SYSTEM_ATSC_SAT 0x11
#define CEC_OP_DIG_SERVICE_BCAST_SYSTEM_ATSC_T  0x12
#define CEC_OP_DIG_SERVICE_BCAST_SYSTEM_DVB_C   0x18
#define CEC_OP_DIG_SERVICE_BCAST_SYSTEM_DVB_S   0x19
#define CEC_OP_DIG_SERVICE_BCAST_SYSTEM_DVB_S2  0x1a
#define CEC_OP_DIG_SERVICE_BCAST_SYSTEM_DVB_T   0x1b
/* Analogue Broadcast Type Operand (ana_bcast_type) */
#define CEC_OP_ANA_BCAST_TYPE_CABLE            0
#define CEC_OP_ANA_BCAST_TYPE_SATELLITE       1
#define CEC_OP_ANA_BCAST_TYPE_TERRESTRIAL     2
/* Broadcast System Operand (bcast_system) */
#define CEC_OP_BCAST_SYSTEM_PAL_BG           0x00
#define CEC_OP_BCAST_SYSTEM_SECAM_LQ         0x01 /* SECAM L' */
#define CEC_OP_BCAST_SYSTEM_PAL_M           0x02
#define CEC_OP_BCAST_SYSTEM_NTSC_M          0x03
#define CEC_OP_BCAST_SYSTEM_PAL_I           0x04
#define CEC_OP_BCAST_SYSTEM_SECAM_DK        0x05
#define CEC_OP_BCAST_SYSTEM_SECAM_BG        0x06
#define CEC_OP_BCAST_SYSTEM_SECAM_L          0x07
#define CEC_OP_BCAST_SYSTEM_PAL_DK          0x08
#define CEC_OP_BCAST_SYSTEM_OTHER           0x1f
/* Channel Number Format Operand (channel_number_fmt) */
#define CEC_OP_CHANNEL_NUMBER_FMT_1_PART    0x01
#define CEC_OP_CHANNEL_NUMBER_FMT_2_PART    0x02
#define CEC_MSG_RECORD_STATUS                0x0a
/* Record Status Operand (rec_status) */
#define CEC_OP_RECORD_STATUS_CUR_SRC        0x01
#define CEC_OP_RECORD_STATUS_DIG_SERVICE   0x02
#define CEC_OP_RECORD_STATUS_ANA_SERVICE   0x03
#define CEC_OP_RECORD_STATUS_EXT_INPUT      0x04

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#define CEC_OP_RECORD_STATUS_NO_DIG_SERVICE          0x05
#define CEC_OP_RECORD_STATUS_NO_ANA_SERVICE          0x06
#define CEC_OP_RECORD_STATUS_NO_SERVICE              0x07
#define CEC_OP_RECORD_STATUS_INVALID_EXT_PLUG        0x09
#define CEC_OP_RECORD_STATUS_INVALID_EXT_PHYS_ADDR   0x0a
#define CEC_OP_RECORD_STATUS_UNSUP_CA                0x0b
#define CEC_OP_RECORD_STATUS_NO_CA_ENTITLEMENTS      0x0c
#define CEC_OP_RECORD_STATUS_CANT_COPY_SRC           0x0d
#define CEC_OP_RECORD_STATUS_NO_MORE_COPIES          0x0e
#define CEC_OP_RECORD_STATUS_NO_MEDIA                0x10
#define CEC_OP_RECORD_STATUS_PLAYING                 0x11
#define CEC_OP_RECORD_STATUS_ALREADY_RECORDING       0x12
#define CEC_OP_RECORD_STATUS_MEDIA_PROT              0x13
#define CEC_OP_RECORD_STATUS_NO_SIGNAL               0x14
#define CEC_OP_RECORD_STATUS_MEDIA_PROBLEM           0x15
#define CEC_OP_RECORD_STATUS_NO_SPACE                0x16
#define CEC_OP_RECORD_STATUS_PARENTAL_LOCK           0x17
#define CEC_OP_RECORD_STATUS_TERMINATED_OK           0x1a
#define CEC_OP_RECORD_STATUS_ALREADY_TERM            0x1b
#define CEC_OP_RECORD_STATUS_OTHER                   0x1f

#define CEC_MSG_RECORD_TV_SCREEN                     0x0f

/* Timer Programming Feature */
#define CEC_MSG_CLEAR_ANALOGUE_TIMER                0x33
/* Recording Sequence Operand (recording_seq) */
#define CEC_OP_REC_SEQ_SUNDAY                        0x01
#define CEC_OP_REC_SEQ_MONDAY                        0x02
#define CEC_OP_REC_SEQ_TUESDAY                       0x04
#define CEC_OP_REC_SEQ_WEDNESDAY                     0x08
#define CEC_OP_REC_SEQ_THURSDAY                      0x10
#define CEC_OP_REC_SEQ_FRIDAY                        0x20
#define CEC_OP_REC_SEQ_SATURDAY                      0x40
#define CEC_OP_REC_SEQ_ONCE_ONLY                     0x00

#define CEC_MSG_CLEAR_DIGITAL_TIMER                 0x99

#define CEC_MSG_CLEAR_EXT_TIMER                     0xa1
/* External Source Specifier Operand (ext_src_spec) */
#define CEC_OP_EXT_SRC_PLUG                         0x04
#define CEC_OP_EXT_SRC_PHYS_ADDR                    0x05

#define CEC_MSG_SET_ANALOGUE_TIMER                 0x34
#define CEC_MSG_SET_DIGITAL_TIMER                  0x97
#define CEC_MSG_SET_EXT_TIMER                      0xa2

#define CEC_MSG_SET_TIMER_PROGRAM_TITLE             0x67
#define CEC_MSG_TIMER_CLEARED_STATUS               0x43
/* Timer Cleared Status Data Operand (timer_cleared_status) */
#define CEC_OP_TIMER_CLR_STAT_RECORDING            0x00
#define CEC_OP_TIMER_CLR_STAT_NO_MATCHING          0x01

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#define CEC_OP_TIMER_CLR_STAT_NO_INFO          0x02
#define CEC_OP_TIMER_CLR_STAT_CLEARED         0x80

#define CEC_MSG_TIMER_STATUS                  0x35
/* Timer Overlap Warning Operand (timer_overlap_warning) */
#define CEC_OP_TIMER_OVERLAP_WARNING_NO_OVERLAP 0
#define CEC_OP_TIMER_OVERLAP_WARNING_OVERLAP    1
/* Media Info Operand (media_info) */
#define CEC_OP_MEDIA_INFO_UNPROT_MEDIA        0
#define CEC_OP_MEDIA_INFO_PROT_MEDIA          1
#define CEC_OP_MEDIA_INFO_NO_MEDIA           2
/* Programmed Indicator Operand (prog_indicator) */
#define CEC_OP_PROG_IND_NOT_PROGRAMMED       0
#define CEC_OP_PROG_IND_PROGRAMMED          1
/* Programmed Info Operand (prog_info) */
#define CEC_OP_PROG_INFO_ENOUGH_SPACE        0x08
#define CEC_OP_PROG_INFO_NOT_ENOUGH_SPACE    0x09
#define CEC_OP_PROG_INFO_MIGHT_NOT_BE_ENOUGH_SPACE 0x0b
#define CEC_OP_PROG_INFO_NONE_AVAILABLE      0x0a
/* Not Programmed Error Info Operand (prog_error) */
#define CEC_OP_PROG_ERROR_NO_FREE_TIMER      0x01
#define CEC_OP_PROG_ERROR_DATE_OUT_OF_RANGE 0x02
#define CEC_OP_PROG_ERROR_REC_SEQ_ERROR     0x03
#define CEC_OP_PROG_ERROR_INV_EXT_PLUG      0x04
#define CEC_OP_PROG_ERROR_INV_EXT_PHYS_ADDR 0x05
#define CEC_OP_PROG_ERROR_CA_UNSUPP         0x06
#define CEC_OP_PROG_ERROR_INSUF_CA_ENTITLEMENTS 0x07
#define CEC_OP_PROG_ERROR_RESOLUTION_UNSUPP 0x08
#define CEC_OP_PROG_ERROR_PARENTAL_LOCK     0x09
#define CEC_OP_PROG_ERROR_CLOCK_FAILURE     0x0a
#define CEC_OP_PROG_ERROR_DUPLICATE         0x0e

/* System Information Feature */
#define CEC_MSG_CEC_VERSION                 0x9e
/* CEC Version Operand (cec_version) */
#define CEC_OP_CEC_VERSION_1_3A              4
#define CEC_OP_CEC_VERSION_1_4              5
#define CEC_OP_CEC_VERSION_2_0              6

#define CEC_MSG_GET_CEC_VERSION            0x9f
#define CEC_MSG_GIVE_PHYSICAL_ADDR        0x83
#define CEC_MSG_GET_MENU_LANGUAGE         0x91
#define CEC_MSG_REPORT_PHYSICAL_ADDR      0x84
/* Primary Device Type Operand (prim_devtype) */
#define CEC_OP_PRIM_DEVTYPE_TV            0
#define CEC_OP_PRIM_DEVTYPE_RECORD        1
#define CEC_OP_PRIM_DEVTYPE_TUNER         3
#define CEC_OP_PRIM_DEVTYPE_PLAYBACK      4
#define CEC_OP_PRIM_DEVTYPE_AUDIOSYSTEM   5
#define CEC_OP_PRIM_DEVTYPE_SWITCH        6
#define CEC_OP_PRIM_DEVTYPE_PROCESSOR     7

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#define CEC_MSG_SET_MENU_LANGUAGE          0x32
#define CEC_MSG_REPORT_FEATURES          0xa6      /* HDMI 2.0 */
/* All Device Types Operand (all_device_types) */
#define CEC_OP_ALL_DEVTYPE_TV            0x80
#define CEC_OP_ALL_DEVTYPE_RECORD        0x40
#define CEC_OP_ALL_DEVTYPE_TUNER         0x20
#define CEC_OP_ALL_DEVTYPE_PLAYBACK      0x10
#define CEC_OP_ALL_DEVTYPE_AUDIOSYSTEM   0x08
#define CEC_OP_ALL_DEVTYPE_SWITCH        0x04
/*
 * And if you wondering what happened to PROCESSOR devices: those should
 * be mapped to a SWITCH.
 */

/* Valid for RC Profile and Device Feature operands */
#define CEC_OP_FEAT_EXT                 0x80      /* Extension */
#define CEC_OP_FEAT_RC_TV_PROFILE_NONE    0x00
#define CEC_OP_FEAT_RC_TV_PROFILE_1       0x02
#define CEC_OP_FEAT_RC_TV_PROFILE_2       0x06
#define CEC_OP_FEAT_RC_TV_PROFILE_3       0x0a
#define CEC_OP_FEAT_RC_TV_PROFILE_4       0x0e
#define CEC_OP_FEAT_RC_SRC_HAS_DEV_ROOT_MENU 0x50
#define CEC_OP_FEAT_RC_SRC_HAS_DEV_SETUP_MENU 0x48
#define CEC_OP_FEAT_RC_SRC_HAS_CONTENTS_MENU 0x44
#define CEC_OP_FEAT_RC_SRC_HAS_MEDIA_TOP_MENU 0x42
#define CEC_OP_FEAT_RC_SRC_HAS_MEDIA_CONTEXT_MENU 0x41
/* Device Feature Operand (dev_features) */
#define CEC_OP_FEAT_DEV_HAS_RECORD_TV_SCREEN 0x40
#define CEC_OP_FEAT_DEV_HAS_SET OSD STRING 0x20
#define CEC_OP_FEAT_DEV_HAS_DECK_CONTROL   0x10
#define CEC_OP_FEAT_DEV_HAS_SET_AUDIO_RATE 0x08
#define CEC_OP_FEAT_DEV_SINK_HAS_ARC_TX    0x04
#define CEC_OP_FEAT_DEV_SOURCE_HAS_ARC_RX   0x02
#define CEC_OP_FEAT_DEV_HAS_SET_AUDIO_VOLUME_LEVEL 0x01

#define CEC_MSG_GIVE_FEATURES           0xa5      /* HDMI 2.0 */

/* Deck Control Feature */
#define CEC_MSG_DECK_CONTROL           0x42
/* Deck Control Mode Operand (deck_control_mode) */
#define CEC_OP_DECK_CTL_MODE_SKIP_FWD    1
#define CEC_OP_DECK_CTL_MODE_SKIP_REV    2
#define CEC_OP_DECK_CTL_MODE_STOP        3
#define CEC_OP_DECK_CTL_MODE_EJECT       4

#define CEC_MSG_DECK_STATUS             0x1b
/* Deck Info Operand (deck_info) */
#define CEC_OP_DECK_INFO_PLAY           0x11

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#define CEC_OP_DECK_INFO_RECORD          0x12
#define CEC_OP_DECK_INFO_PLAY_REV        0x13
#define CEC_OP_DECK_INFO_STILL           0x14
#define CEC_OP_DECK_INFO_SLOW            0x15
#define CEC_OP_DECK_INFO_SLOW_REV        0x16
#define CEC_OP_DECK_INFO_FAST_FWD        0x17
#define CEC_OP_DECK_INFO_FAST_REV        0x18
#define CEC_OP_DECK_INFO_NO_MEDIA         0x19
#define CEC_OP_DECK_INFO_STOP             0x1a
#define CEC_OP_DECK_INFO_SKIP_FWD        0x1b
#define CEC_OP_DECK_INFO_SKIP_REV        0x1c
#define CEC_OP_DECK_INFO_INDEX_SEARCH_FWD 0x1d
#define CEC_OP_DECK_INFO_INDEX_SEARCH_REV 0x1e
#define CEC_OP_DECK_INFO_OTHER            0x1f

#define CEC_MSG_GIVE_DECK_STATUS          0x1a
/* Status Request Operand (status_req) */
#define CEC_OP_STATUS_REQ_ON              1
#define CEC_OP_STATUS_REQ_OFF             2
#define CEC_OP_STATUS_REQ_ONCE            3

#define CEC_MSG_PLAY                      0x41
/* Play Mode Operand (play_mode) */
#define CEC_OP_PLAY_MODE_PLAY_FWD          0x24
#define CEC_OP_PLAY_MODE_PLAY_REV          0x20
#define CEC_OP_PLAY_MODE_PLAY_STILL         0x25
#define CEC_OP_PLAY_MODE_PLAY_FAST_FWD_MIN 0x05
#define CEC_OP_PLAY_MODE_PLAY_FAST_FWD_MED 0x06
#define CEC_OP_PLAY_MODE_PLAY_FAST_FWD_MAX 0x07
#define CEC_OP_PLAY_MODE_PLAY_FAST_REV_MIN 0x09
#define CEC_OP_PLAY_MODE_PLAY_FAST_REV_MED 0x0a
#define CEC_OP_PLAY_MODE_PLAY_FAST_REV_MAX 0x0b
#define CEC_OP_PLAY_MODE_PLAY_SLOW_FWD_MIN 0x15
#define CEC_OP_PLAY_MODE_PLAY_SLOW_FWD_MED 0x16
#define CEC_OP_PLAY_MODE_PLAY_SLOW_FWD_MAX 0x17
#define CEC_OP_PLAY_MODE_PLAY_SLOW_REV_MIN 0x19
#define CEC_OP_PLAY_MODE_PLAY_SLOW_REV_MED 0x1a
#define CEC_OP_PLAY_MODE_PLAY_SLOW_REV_MAX 0x1b

/* Tuner Control Feature */
#define CEC_MSG_GIVE_TUNER_DEVICE_STATUS    0x08
#define CEC_MSG_SELECT_ANALOGUE_SERVICE     0x92
#define CEC_MSG_SELECT_DIGITAL_SERVICE      0x93
#define CEC_MSG_TUNER_DEVICE_STATUS         0x07
/* Recording Flag Operand (rec_flag) */
#define CEC_OP_REC_FLAG_NOT_USED            0
#define CEC_OP_REC_FLAG_USED                1
/* Tuner Display Info Operand (tuner_display_info) */
#define CEC_OP_TUNER_DISPLAY_INFO_DIGITAL   0
#define CEC_OP_TUNER_DISPLAY_INFO_NONE       1
#define CEC_OP_TUNER_DISPLAY_INFO_ANALOGUE 2

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#define CEC_MSG_TUNER_STEP_DECREMENT          0x06
#define CEC_MSG_TUNER_STEP_INCREMENT          0x05

/* Vendor Specific Commands Feature */

/*
 * Has also:
 *   CEC_MSG_CEC_VERSION
 *   CEC_MSG_GET_CEC_VERSION
 */
#define CEC_MSG_DEVICE_VENDOR_ID              0x87
#define CEC_MSG_GIVE_DEVICE_VENDOR_ID         0x8c
#define CEC_MSG_VENDOR_COMMAND               0x89
#define CEC_MSG_VENDOR_COMMAND_WITH_ID       0xa0
#define CEC_MSG_VENDOR_REMOTE_BUTTON_DOWN    0x8a
#define CEC_MSG_VENDOR_REMOTE_BUTTON_UP      0x8b

/* OSD Display Feature */
#define CEC_MSG_SET OSD STRING             0x64
/* Display Control Operand (disp_ctl) */
#define CEC_OP_DISP_CTL_DEFAULT            0x00
#define CEC_OP_DISP_CTL_UNTIL_CLEARED     0x40
#define CEC_OP_DISP_CTL_CLEAR              0x80

/* Device OSD Transfer Feature */
#define CEC_MSG_GIVE OSD NAME              0x46
#define CEC_MSG_SET OSD NAME              0x47

/* Device Menu Control Feature */
#define CEC_MSG_MENU_REQUEST                0x8d
/* Menu Request Type Operand (menu_req) */
#define CEC_OP_MENU_REQUEST_ACTIVATE        0x00
#define CEC_OP_MENU_REQUEST_DEACTIVATE      0x01
#define CEC_OP_MENU_REQUEST_QUERY          0x02

#define CEC_MSG_MENU_STATUS                 0x8e
/* Menu State Operand (menu_state) */
#define CEC_OP_MENU_STATE_ACTIVATED        0x00
#define CEC_OP_MENU_STATE_DEACTIVATED      0x01

#define CEC_MSG_USER_CONTROL_PRESSED       0x44
/* UI Command Operand (ui_cmd) */
#define CEC_OP_UI_CMD_SELECT               0x00
#define CEC_OP_UI_CMD_UP                  0x01
#define CEC_OP_UI_CMD_DOWN                0x02
#define CEC_OP_UI_CMD_LEFT                0x03
#define CEC_OP_UI_CMD_RIGHT               0x04
#define CEC_OP_UI_CMD_RIGHT_UP            0x05
#define CEC_OP_UI_CMD_RIGHT_DOWN          0x06
#define CEC_OP_UI_CMD_LEFT_UP             0x07

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#define CEC_OP_UI_CMD_LEFT_DOWN	0x08
#define CEC_OP_UI_CMD_DEVICE_ROOT_MENU	0x09
#define CEC_OP_UI_CMD_DEVICE_SETUP_MENU	0x0a
#define CEC_OP_UI_CMD_CONTENTS_MENU	0x0b
#define CEC_OP_UI_CMD_FAVORITE_MENU	0x0c
#define CEC_OP_UI_CMD_BACK	0x0d
#define CEC_OP_UI_CMD_MEDIA_TOP_MENU	0x10
#define CEC_OP_UI_CMD_MEDIA_CONTEXT_SENSITIVE_MENU	0x11
#define CEC_OP_UI_CMD_NUMBER_ENTRY_MODE	0x1d
#define CEC_OP_UI_CMD_NUMBER_11	0x1e
#define CEC_OP_UI_CMD_NUMBER_12	0x1f
#define CEC_OP_UI_CMD_NUMBER_0_OR_NUMBER_10	0x20
#define CEC_OP_UI_CMD_NUMBER_1	0x21
#define CEC_OP_UI_CMD_NUMBER_2	0x22
#define CEC_OP_UI_CMD_NUMBER_3	0x23
#define CEC_OP_UI_CMD_NUMBER_4	0x24
#define CEC_OP_UI_CMD_NUMBER_5	0x25
#define CEC_OP_UI_CMD_NUMBER_6	0x26
#define CEC_OP_UI_CMD_NUMBER_7	0x27
#define CEC_OP_UI_CMD_NUMBER_8	0x28
#define CEC_OP_UI_CMD_NUMBER_9	0x29
#define CEC_OP_UI_CMD_DOT	0x2a
#define CEC_OP_UI_CMD_ENTER	0x2b
#define CEC_OP_UI_CMD_CLEAR	0x2c
#define CEC_OP_UI_CMD_NEXT_FAVORITE	0x2f
#define CEC_OP_UI_CMD_CHANNEL_UP	0x30
#define CEC_OP_UI_CMD_CHANNEL_DOWN	0x31
#define CEC_OP_UI_CMD_PREVIOUS_CHANNEL	0x32
#define CEC_OP_UI_CMD_SOUND_SELECT	0x33
#define CEC_OP_UI_CMD_INPUT_SELECT	0x34
#define CEC_OP_UI_CMD_DISPLAY_INFORMATION	0x35
#define CEC_OP_UI_CMD_HELP	0x36
#define CEC_OP_UI_CMD_PAGE_UP	0x37
#define CEC_OP_UI_CMD_PAGE_DOWN	0x38
#define CEC_OP_UI_CMD_POWER	0x40
#define CEC_OP_UI_CMD_VOLUME_UP	0x41
#define CEC_OP_UI_CMD_VOLUME_DOWN	0x42
#define CEC_OP_UI_CMD_MUTE	0x43
#define CEC_OP_UI_CMD_PLAY	0x44
#define CEC_OP_UI_CMD_STOP	0x45
#define CEC_OP_UI_CMD_PAUSE	0x46
#define CEC_OP_UI_CMD_RECORD	0x47
#define CEC_OP_UI_CMD_REWIND	0x48
#define CEC_OP_UI_CMD_FAST_FORWARD	0x49
#define CEC_OP_UI_CMD_EJECT	0x4a
#define CEC_OP_UI_CMD_SKIP_FORWARD	0x4b
#define CEC_OP_UI_CMD_SKIP_BACKWARD	0x4c
#define CEC_OP_UI_CMD_STOP_RECORD	0x4d
#define CEC_OP_UI_CMD_PAUSE_RECORD	0x4e
#define CEC_OP_UI_CMD_ANGLE	0x50
#define CEC_OP_UI_CMD_SUB_PICTURE	0x51

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#define CEC_OP_UI_CMD_VIDEO_ON_DEMAND          0x52
#define CEC_OP_UI_CMD_ELECTRONIC_PROGRAM_GUIDE 0x53
#define CEC_OP_UI_CMD_TIMER_PROGRAMMING        0x54
#define CEC_OP_UI_CMD_INITIAL_CONFIGURATION    0x55
#define CEC_OP_UI_CMD_SELECT_BROADCAST_TYPE    0x56
#define CEC_OP_UI_CMD_SELECT_SOUND_PRESENTATION 0x57
#define CEC_OP_UI_CMD_AUDIO_DESCRIPTION         0x58
#define CEC_OP_UI_CMD_INTERNET                 0x59
#define CEC_OP_UI_CMD_3D_MODE                  0x5a
#define CEC_OP_UI_CMD_PLAY_FUNCTION            0x60
#define CEC_OP_UI_CMD_PAUSE_PLAY_FUNCTION      0x61
#define CEC_OP_UI_CMD_RECORD_FUNCTION          0x62
#define CEC_OP_UI_CMD_PAUSE_RECORD_FUNCTION    0x63
#define CEC_OP_UI_CMD_STOP_FUNCTION            0x64
#define CEC_OP_UI_CMD_MUTE_FUNCTION            0x65
#define CEC_OP_UI_CMD_RESTORE_VOLUME_FUNCTION   0x66
#define CEC_OP_UI_CMD_TUNE_FUNCTION            0x67
#define CEC_OP_UI_CMD_SELECT_MEDIA_FUNCTION    0x68
#define CEC_OP_UI_CMD_SELECT_AV_INPUT_FUNCTION 0x69
#define CEC_OP_UI_CMD_SELECT_AUDIO_INPUT_FUNCTION 0x6a
#define CEC_OP_UI_CMD_POWER_TOGGLE_FUNCTION    0x6b
#define CEC_OP_UI_CMD_POWER_OFF_FUNCTION       0x6c
#define CEC_OP_UI_CMD_POWER_ON_FUNCTION        0x6d
#define CEC_OP_UI_CMD_F1_BLUE                 0x71
#define CEC_OP_UI_CMD_F2_RED                  0x72
#define CEC_OP_UI_CMD_F3_GREEN                0x73
#define CEC_OP_UI_CMD_F4_YELLOW               0x74
#define CEC_OP_UI_CMD_F5                     0x75
#define CEC_OP_UI_CMD_DATA                   0x76
/* UI Broadcast Type Operand (ui_bcast_type) */
#define CEC_OP_UI_BCAST_TYPE_TOGGLE_ALL       0x00
#define CEC_OP_UI_BCAST_TYPE_TOGGLE_DIG_ANA   0x01
#define CEC_OP_UI_BCAST_TYPE_ANALOGUE        0x10
#define CEC_OP_UI_BCAST_TYPE_ANALOGUE_T      0x20
#define CEC_OP_UI_BCAST_TYPE_ANALOGUE_CABLE  0x30
#define CEC_OP_UI_BCAST_TYPE_ANALOGUE_SAT   0x40
#define CEC_OP_UI_BCAST_TYPE_DIGITAL         0x50
#define CEC_OP_UI_BCAST_TYPE_DIGITAL_T       0x60
#define CEC_OP_UI_BCAST_TYPE_DIGITAL_CABLE   0x70
#define CEC_OP_UI_BCAST_TYPE_DIGITAL_SAT     0x80
#define CEC_OP_UI_BCAST_TYPE_DIGITAL_COM_SAT 0x90
#define CEC_OP_UI_BCAST_TYPE_DIGITAL_COM_SAT2 0x91
#define CEC_OP_UI_BCAST_TYPE_IP              0xa0
/* UI Sound Presentation Control Operand (ui_snd_pres_ctl) */
#define CEC_OP_UI SND PRES CTL DUAL_MONO      0x10
#define CEC_OP_UI SND PRES CTL KARAOKE        0x20
#define CEC_OP_UI SND PRES CTL DOWNMIX         0x80
#define CEC_OP_UI SND PRES CTL REVERB          0x90
#define CEC_OP_UI SND PRES CTL EQUALIZER       0xa0
#define CEC_OP_UI SND PRES CTL BASS_UP         0xb1
#define CEC_OP_UI SND PRES CTL BASS_NEUTRAL   0xb2

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#define CEC_OP_UI SND_PRES_CTL_BASS_DOWN          0xb3
#define CEC_OP_UI SND_PRES_CTL_TREBLE_UP          0xc1
#define CEC_OP_UI SND_PRES_CTL_TREBLE_NEUTRAL    0xc2
#define CEC_OP_UI SND_PRES_CTL_TREBLE_DOWN        0xc3

#define CEC_MSG_USER_CONTROL_RELEASED            0x45

/* Remote Control Passthrough Feature */

/*
 * Has also:
 *      CEC_MSG_USER_CONTROL_PRESSED
 *      CEC_MSG_USER_CONTROL_RELEASED
 */

/* Power Status Feature */
#define CEC_MSG_GIVE_DEVICE_POWER_STATUS          0x8f
#define CEC_MSG_REPORT_POWER_STATUS               0x90
/* Power Status Operand (pwr_state) */
#define CEC_OP_POWER_STATUS_ON                   0
#define CEC_OP_POWER_STATUS_STANDBY             1
#define CEC_OP_POWER_STATUS_TO_ON                2
#define CEC_OP_POWER_STATUS_TO_STANDBY          3

/* General Protocol Messages */
#define CEC_MSG_FEATURE_ABORT                  0x00
/* Abort Reason Operand (reason) */
#define CEC_OP_ABORT_UNRECOGNIZED_OP           0
#define CEC_OP_ABORT_INCORRECT_MODE            1
#define CEC_OP_ABORT_NO_SOURCE                 2
#define CEC_OP_ABORT_INVALID_OP                3
#define CEC_OP_ABORT_REFUSED                  4
#define CEC_OP_ABORT_UNDETERMINED             5

#define CEC_MSG_ABORT                         0xff

/* System Audio Control Feature */

/*
 * Has also:
 *      CEC_MSG_USER_CONTROL_PRESSED
 *      CEC_MSG_USER_CONTROL_RELEASED
 */

#define CEC_MSG_GIVE_AUDIO_STATUS              0x71
#define CEC_MSG_GIVE_SYSTEM_AUDIO_MODE_STATUS 0x7d
#define CEC_MSG_REPORT_AUDIO_STATUS            0x7a
/* Audio Mute Status Operand (aud_mute_status) */
#define CEC_OP_AUD_MUTE_STATUS_OFF            0
#define CEC_OP_AUD_MUTE_STATUS_ON             1

#define CEC_MSG_REPORT_SHORT_AUDIO_DESCRIPTOR 0xa3

```

```

#define CEC_MSG_REQUEST_SHORT_AUDIO_DESCRIPTOR          0xa4
#define CEC_MSG_SET_SYSTEM_AUDIO_MODE                  0x72
/* System Audio Status Operand (sys_aud_status) */
#define CEC_OP_SYS_AUD_STATUS_OFF                     0
#define CEC_OP_SYS_AUD_STATUS_ON                      1

#define CEC_MSG_SYSTEM_AUDIO_MODE_REQUEST             0x70
#define CEC_MSG_SYSTEM_AUDIO_MODE_STATUS              0x7e
/* Audio Format ID Operand (audio_format_id) */
#define CEC_OP_AUD_FMT_ID_CEA861                     0
#define CEC_OP_AUD_FMT_ID_CEA861_CXT                 1

#define CEC_MSG_SET_AUDIO_VOLUME_LEVEL                0x73

/* Audio Rate Control Feature */
#define CEC_MSG_SET_AUDIO_RATE                        0x9a
/* Audio Rate Operand (audio_rate) */
#define CEC_OP_AUD_RATE_OFF                          0
#define CEC_OP_AUD_RATE_WIDE_STD                     1
#define CEC_OP_AUD_RATE_WIDE_FAST                   2
#define CEC_OP_AUD_RATE_WIDE_SLOW                   3
#define CEC_OP_AUD_RATE_NARROW_STD                  4
#define CEC_OP_AUD_RATE_NARROW_FAST                 5
#define CEC_OP_AUD_RATE_NARROW_SLOW                 6

/* Audio Return Channel Control Feature */
#define CEC_MSG_INITIATE_ARC                         0xc0
#define CEC_MSG_REPORT_ARC_INITIATED                 0xc1
#define CEC_MSG_REPORT_ARC_TERMINATED                0xc2
#define CEC_MSG_REQUEST_ARC_INITIATION               0xc3
#define CEC_MSG_REQUEST_ARC_TERMINATION              0xc4
#define CEC_MSG_TERMINATE_ARC                        0xc5

/* Dynamic Audio Lipsync Feature */
/* Only for CEC 2.0 and up */
#define CEC_MSG_REQUEST_CURRENT_LATENCY              0xa7
#define CEC_MSG_REPORT_CURRENT_LATENCY               0xa8
/* Low Latency Mode Operand (low_latency_mode) */
#define CEC_OP_LOW_LATENCY_MODE_OFF                  0
#define CEC_OP_LOW_LATENCY_MODE_ON                   1
/* Audio Output Compensated Operand (audio_out_compensated) */
#define CEC_OP_AUD_OUT_COMPENSATED_NA                0
#define CEC_OP_AUD_OUT_COMPENSATED_DELAY             1
#define CEC_OP_AUD_OUT_COMPENSATED_NO_DELAY          2
#define CEC_OP_AUD_OUT_COMPENSATED_PARTIAL_DELAY    3

/* Capability Discovery and Control Feature */
#define CEC_MSG_CDC_MESSAGE                         0xf8
/* Ethernet-over-HDMI: nobody ever does this... */
#define CEC_MSG_CDC_HEC_INQUIRE_STATE               0x00
#define CEC_MSG_CDC_HEC_REPORT_STATE                0x01

```

```

/* HEC Functionality State Operand (hec_func_state) */
#define CEC_OP_HEC_FUNC_STATE_NOT_SUPPORTED          0
#define CEC_OP_HEC_FUNC_STATE_INACTIVE               1
#define CEC_OP_HEC_FUNC_STATE_ACTIVE                2
#define CEC_OP_HEC_FUNC_STATE_ACTIVATION_FIELD       3
/* Host Functionality State Operand (host_func_state) */
#define CEC_OP_HOST_FUNC_STATE_NOT_SUPPORTED         0
#define CEC_OP_HOST_FUNC_STATE_INACTIVE              1
#define CEC_OP_HOST_FUNC_STATE_ACTIVE                2
/* ENC Functionality State Operand (enc_func_state) */
#define CEC_OP_ENC_FUNC_STATE_EXT_CON_NOT_SUPPORTED 0
#define CEC_OP_ENC_FUNC_STATE_EXT_CON_INACTIVE       1
#define CEC_OP_ENC_FUNC_STATE_EXT_CON_ACTIVE         2
/* CDC Error Code Operand (cdc_errcode) */
#define CEC_OP_CDC_ERROR_CODE_NONE                  0
#define CEC_OP_CDC_ERROR_CODE_CAP_UNSUPPORTED        1
#define CEC_OP_CDC_ERROR_CODE_WRONG_STATE           2
#define CEC_OP_CDC_ERROR_CODE_OTHER                 3
/* HEC Support Operand (hec_support) */
#define CEC_OP_HEC_SUPPORT_NO                       0
#define CEC_OP_HEC_SUPPORT_YES                      1
/* HEC Activation Operand (hec_activation) */
#define CEC_OP_HEC_ACTIVATION_ON                   0
#define CEC_OP_HEC_ACTIVATION_OFF                  1

#define CEC_MSG_CDC_HEC_SET_STATE_ADJACENT          0x02
#define CEC_MSG_CDC_HEC_SET_STATE                   0x03
/* HEC Set State Operand (hec_set_state) */
#define CEC_OP_HEC_SET_STATE_DEACTIVATE             0
#define CEC_OP_HEC_SET_STATE_ACTIVATE               1

#define CEC_MSG_CDC_HEC_REQUEST_DEACTIVATION        0x04
#define CEC_MSG_CDC_HEC_NOTIFY_ALIVE                0x05
#define CEC_MSG_CDC_HEC_DISCOVER                   0x06
/* Hotplug Detect messages */
#define CEC_MSG_CDC_HPD_SET_STATE                  0x10
/* HPD State Operand (hpd_state) */
#define CEC_OP_HPD_STATE_CP_EDID_DISABLE            0
#define CEC_OP_HPD_STATE_CP_EDID_ENABLE              1
#define CEC_OP_HPD_STATE_CP_EDID_DISABLE_ENABLE     2
#define CEC_OP_HPD_STATE_EDID_DISABLE               3
#define CEC_OP_HPD_STATE_EDID_ENABLE                4
#define CEC_OP_HPD_STATE_EDID_DISABLE_ENABLE         5
#define CEC_MSG_CDC_HPD_REPORT_STATE                0x11
/* HPD Error Code Operand (hpd_error) */
#define CEC_OP_HPD_ERROR_NONE                      0
#define CEC_OP_HPD_ERROR_INITIATOR_NOT_CAPABLE      1
#define CEC_OP_HPD_ERROR_INITIATOR_WRONG_STATE      2
#define CEC_OP_HPD_ERROR_OTHER                      3
#define CEC_OP_HPD_ERROR_NONE_NO_VIDEO              4

```

```

/* End of Messages */

/* Helper functions to identify the 'special' CEC devices */

static inline int cec_is_2nd_tv(const struct cec_log_addrs *las)
{
    /*
     * It is a second TV if the logical address is 14 or 15 and the
     * primary device type is a TV.
     */
    return las->num_log_addrs &&
           las->log_addr[0] >= CEC_LOG_ADDR_SPECIFIC &&
           las->primary_device_type[0] == CEC_OP_PRIM_DEVTYPE_TV;
}

static inline int cec_is_processor(const struct cec_log_addrs *las)
{
    /*
     * It is a processor if the logical address is 12-15 and the
     * primary device type is a Processor.
     */
    return las->num_log_addrs &&
           las->log_addr[0] >= CEC_LOG_ADDR_BACKUP_1 &&
           las->primary_device_type[0] == CEC_OP_PRIM_DEVTYPE_PROCESSOR;
}

static inline int cec_is_switch(const struct cec_log_addrs *las)
{
    /*
     * It is a switch if the logical address is 15 and the
     * primary device type is a Switch and the CDC-Only flag is not set.
     */
    return las->num_log_addrs == 1 &&
           las->log_addr[0] == CEC_LOG_ADDR_UNREGISTERED &&
           las->primary_device_type[0] == CEC_OP_PRIM_DEVTYPE_SWITCH &&
           !(las->flags & CEC_LOG_ADDRS_FL_CDC_ONLY);
}

static inline int cec_is_cdc_only(const struct cec_log_addrs *las)
{
    /*
     * It is a CDC-only device if the logical address is 15 and the
     * primary device type is a Switch and the CDC-Only flag is set.
     */
    return las->num_log_addrs == 1 &&
           las->log_addr[0] == CEC_LOG_ADDR_UNREGISTERED &&
           las->primary_device_type[0] == CEC_OP_PRIM_DEVTYPE_SWITCH &&
           (las->flags & CEC_LOG_ADDRS_FL_CDC_ONLY);
}

#endif

```

### 13.6.5 Revision and Copyright

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- Initial version.

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### 13.6.6 Revision History

#### revision

1.0.0 / 2016-03-17 (hv)

Initial revision

## 13.7 Generic Error Codes

Table 333: Generic error codes

EAGAIN (aka EWOULDBLOCK)	The ioctl can't be handled because the device is in state where it can't perform it. This could happen for example in case where device is sleeping and ioctl is performed to query statistics. It is also returned when the ioctl would need to wait for an event, but the device was opened in non-blocking mode.
EBADF	The file descriptor is not a valid.
EBUSY	The ioctl can't be handled because the device is busy. This is typically return while device is streaming, and an ioctl tried to change something that would affect the stream, or would require the usage of a hardware resource that was already allocated. The ioctl must not be retried without performing another action to fix the problem first (typically: stop the stream before retrying).
EFAULT	There was a failure while copying data from/to userspace, probably caused by an invalid pointer reference.
EINVAL	One or more of the ioctl parameters are invalid or out of the allowed range. This is a widely used error code. See the individual ioctl requests for specific causes.
ENODEV	Device not found or was removed.
ENOMEM	There's not enough memory to handle the desired operation.
ENOTTY	The ioctl is not supported by the file descriptor.
ENOSPC	On USB devices, the stream ioctl's can return this error, meaning that this request would overcommit the usb bandwidth reserved for periodic transfers (up to 80% of the USB bandwidth).
EPERM	Permission denied. Can be returned if the device needs write permission, or some special capabilities is needed (e. g. root)
EIO	I/O error. Typically used when there are problems communicating with a hardware device. This could indicate broken or flaky hardware. It's a 'Something is wrong, I give up!' type of error.
ENXIO	No device corresponding to this device special file exists.

---

**Note:**

1. This list is not exhaustive; ioctls may return other error codes. Since errors may have side effects such as a driver reset, applications should abort on unexpected errors, or otherwise assume that the device is in a bad state.
  2. Request-specific error codes are listed in the individual requests descriptions.
- 

## 13.8 Glossary

---

**Note:** The goal of this section is to standardize the terms used within the media userspace API documentation. This is Work In Progress.

---

### Bridge Driver

A *Device Driver* that implements the main logic to talk with media hardware.

### CEC API

#### Consumer Electronics Control API

An API designed to receive and transmit data via an HDMI CEC interface.

See *Part V - Consumer Electronics Control API*.

### Device Driver

Part of the Linux Kernel that implements support for a hardware component.

### Device Node

A character device node in the file system used to control and transfer data in and out of a Kernel driver.

### Digital TV API

#### Previously known as DVB API

An API designed to control a subset of the *Media Hardware* that implements digital TV (e.g. DVB, ATSC, ISDB, etc).

See *Part II - Digital TV API*.

### DSP

#### Digital Signal Processor

A specialized *Microprocessor*, with its architecture optimized for the operational needs of digital signal processing.

### FPGA

#### Field-programmable Gate Array

An *IC* circuit designed to be configured by a customer or a designer after manufacturing.

See [https://en.wikipedia.org/wiki/Field-programmable\\_gate\\_array](https://en.wikipedia.org/wiki/Field-programmable_gate_array).

### Hardware Component

A subset of the *Media Hardware*. For example an *I<sup>2</sup>C* or *SPI* device, or an *IP Block* inside an *SoC* or *FPGA*.

**Hardware Peripheral**

A group of *hardware components* that together make a larger user-facing functional peripheral. For instance, the *SoC ISP IP Block* and the external camera sensors together make a camera hardware peripheral.

Also known as *Peripheral*.

**I<sup>2</sup>C****Inter-Integrated Circuit**

A multi-master, multi-slave, packet switched, single-ended, serial computer bus used to control some hardware components like sub-device hardware components.

See <http://www.nxp.com/docs/en/user-guide/UM10204.pdf>.

**IC****Integrated circuit**

A set of electronic circuits on one small flat piece of semiconductor material, normally silicon.

Also known as chip.

**IP Block****Intellectual property core**

In electronic design a semiconductor intellectual property core, is a reusable unit of logic, cell, or integrated circuit layout design that is the intellectual property of one party. IP Blocks may be licensed to another party or can be owned and used by a single party alone.

See [https://en.wikipedia.org/wiki/Semiconductor\\_intellectual\\_property\\_core](https://en.wikipedia.org/wiki/Semiconductor_intellectual_property_core)).

**ISP****Image Signal Processor**

A specialized processor that implements a set of algorithms for processing image data. ISPs may implement algorithms for lens shading correction, demosaicing, scaling and pixel format conversion as well as produce statistics for the use of the control algorithms (e.g. automatic exposure, white balance and focus).

**Media API**

A set of userspace APIs used to control the media hardware. It is composed by:

- *CEC API*;
- *Digital TV API*;
- *MC API*;
- *RC API*; and
- *V4L2 API*.

See *Linux Media Infrastructure userspace API*.

**MC API****Media Controller API**

An API designed to expose and control the relationships between multimedia devices and sub-devices.

See *Part IV - Media Controller API*.

## MC-centric

[V4L2 Hardware](#) device driver that requires [MC API](#).

Such drivers have `V4L2_CAP_IO_MC` device\_caps field set (see [ioctl VIDIOC\\_QUERYCAP](#)).

See [Controlling a hardware peripheral via V4L2](#) for more details.

## Media Hardware

Subset of the hardware that is supported by the Linux Media API.

This includes audio and video capture and playback hardware, digital and analog TV, camera sensors, ISPs, remote controllers, codecs, HDMI Consumer Electronics Control, HDMI capture, etc.

## Microprocessor

Electronic circuitry that carries out the instructions of a computer program by performing the basic arithmetic, logical, control and input/output (I/O) operations specified by the instructions on a single integrated circuit.

## Peripheral

The same as [Hardware Peripheral](#).

## RC API

### Remote Controller API

An API designed to receive and transmit data from remote controllers.

See [Part III - Remote Controller API](#).

## SMBus

A subset of I<sup>2</sup>C, which defines a stricter usage of the bus.

## SPI

### Serial Peripheral Interface Bus

Synchronous serial communication interface specification used for short distance communication, primarily in embedded systems.

## SoC

### System on a Chip

An integrated circuit that integrates all components of a computer or other electronic systems.

## V4L2 API

### V4L2 userspace API

The userspace API defined in [Part I - Video for Linux API](#), which is used to control a V4L2 hardware.

## V4L2 Device Node

A [Device Node](#) that is associated to a V4L driver.

The V4L2 device node naming is specified at [V4L2 Device Node Naming](#).

## V4L2 Hardware

Part of the media hardware which is supported by the [V4L2 API](#).

## V4L2 Sub-device

V4L2 hardware components that aren't controlled by a [Bridge Driver](#). See [Sub-device Interface](#).

**Video-node-centric**

V4L2 device driver that doesn't require a media controller to be used.

Such drivers have the `V4L2_CAP_IO_MC` `device_caps` field unset (see `ioctl VID-IOC_QUERYCAP`).

**V4L2 Sub-device API**

Part of the [V4L2 API](#) which control *V4L2 sub-devices*, like sensors, HDMI receivers, scalers, deinterlacers.

See [Controlling a hardware peripheral via V4L2](#) for more details.

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## **13.10 Video4Linux (V4L) driver-specific documentation**

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### 13.10.1 ASPEED video driver

ASPEED Video Engine found on AST2400/2500/2600 SoC supports high performance video compressions with a wide range of video quality and compression ratio options. The adopted compressing algorithm is a modified JPEG algorithm.

There are 2 types of compressions in this IP.

- JPEG JFIF standard mode: for single frame and management compression
- ASPEED proprietary mode: for multi-frame and differential compression. Support 2-pass (high quality) video compression scheme (Patent pending by ASPEED). Provide visually lossless video compression quality or to reduce the network average loading under intranet KVM applications.

`VIDIOC_S_FMT` can be used to choose which format you want. `V4L2_PIX_FMT_JPEG` stands for JPEG JFIF standard mode; `V4L2_PIX_FMT_AJPG` stands for ASPEED proprietary mode.

More details on the ASPEED video hardware operations can be found in *chapter 6.2.16 KVM Video Driver* of `SDK_User_Guide` which available on [github](#).

The ASPEED video driver implements the following driver-specific control:

#### `V4L2_CID_ASPEED_HQ_MODE`

Enable/Disable ASPEED's High quality mode. This is a private control that can be used to enable high quality for aspeed proprietary mode.

(0)	ASPEED HQ mode is disabled.
(1)	ASPEED HQ mode is enabled.

#### `V4L2_CID_ASPEED_HQ_JPEG_QUALITY`

Define the quality of ASPEED's High quality mode. This is a private control that can be used to decide compression quality if High quality mode enabled . Higher the value, better the quality and bigger the size.

(1)	minimum
(12)	maximum
(1)	step
(1)	default

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### 13.10.2 Using camera sensor drivers

This section describes common practices for how the V4L2 sub-device interface is used to control the camera sensor drivers.

You may also find `media_writing_camera_sensor_drivers` useful.

#### Frame size

There are two distinct ways to configure the frame size produced by camera sensors.

#### Freely configurable camera sensor drivers

Freely configurable camera sensor drivers expose the device's internal processing pipeline as one or more sub-devices with different cropping and scaling configurations. The output size of the device is the result of a series of cropping and scaling operations from the device's pixel array's size.

An example of such a driver is the CCS driver.

#### Register list based drivers

Register list based drivers generally, instead of able to configure the device they control based on user requests, are limited to a number of preset configurations that combine a number of different parameters that on hardware level are independent. How a driver picks such configuration is based on the format set on a source pad at the end of the device's internal pipeline.

Most sensor drivers are implemented this way.

#### Frame interval configuration

There are two different methods for obtaining possibilities for different frame intervals as well as configuring the frame interval. Which one to implement depends on the type of the device.

#### Raw camera sensors

Instead of a high level parameter such as frame interval, the frame interval is a result of the configuration of a number of camera sensor implementation specific parameters. Luckily, these parameters tend to be the same for more or less all modern raw camera sensors.

The frame interval is calculated using the following equation:

```
frame interval = (analogue crop width + horizontal blanking) *  
                 (analogue crop height + vertical blanking) / pixel rate
```

The formula is bus independent and is applicable for raw timing parameters on large variety of devices beyond camera sensors. Devices that have no analogue crop, use the full source image size, i.e. pixel array size.

Horizontal and vertical blanking are specified by `V4L2_CID_HBLANK` and `V4L2_CID_VBLANK`, respectively. The unit of the `V4L2_CID_HBLANK` control is pixels and the unit of the `V4L2_CID_VBLANK` is lines. The pixel rate in the sensor's **pixel array** is specified by `V4L2_CID_PIXEL_RATE` in the same sub-device. The unit of that control is pixels per second.

Register list based drivers need to implement read-only sub-device nodes for the purpose. Devices that are not register list based need these to configure the device's internal processing pipeline.

The first entity in the linear pipeline is the pixel array. The pixel array may be followed by other entities that are there to allow configuring binning, skipping, scaling or digital crop, see `VIDIOC_SUBDEV_G_SELECTION`.

## USB cameras etc. devices

USB video class hardware, as well as many cameras offering a similar higher level interface natively, generally use the concept of frame interval (or frame rate) on device level in firmware or hardware. This means lower level controls implemented by raw cameras may not be used on uAPI (or even kAPI) to control the frame interval on these devices.

### Rotation, orientation and flipping

Some systems have the camera sensor mounted upside down compared to its natural mounting rotation. In such cases, drivers shall expose the information to userspace with the `V4L2_CID_CAMERA_SENSOR_ROTATION` control.

Sensor drivers shall also report the sensor's mounting orientation with the `V4L2_CID_CAMERA_SENSOR_ORIENTATION`.

Sensor drivers that have any vertical or horizontal flips embedded in the register programming sequences shall initialize the `V4L2_CID_HFLIP` and `V4L2_CID_VFLIP` controls with the values programmed by the register sequences. The default values of these controls shall be 0 (disabled). Especially these controls shall not be inverted, independently of the sensor's mounting rotation.

### 13.10.3 MIPI CCS camera sensor driver

The MIPI CCS camera sensor driver is a generic driver for **MIPI CCS** compliant camera sensors. It exposes three sub-devices representing the pixel array, the binner and the scaler.

As the capabilities of individual devices vary, the driver exposes interfaces based on the capabilities that exist in hardware.

## **Pixel Array sub-device**

The pixel array sub-device represents the camera sensor's pixel matrix, as well as analogue crop functionality present in many compliant devices. The analogue crop is configured using the V4L2\_SEL\_TGT\_CROP on the source pad (0) of the entity. The size of the pixel matrix can be obtained by getting the V4L2\_SEL\_TGT\_NATIVE\_SIZE target.

## **Binner**

The binner sub-device represents the binning functionality on the sensor. For that purpose, selection target V4L2\_SEL\_TGT\_COMPOSE is supported on the sink pad (0).

Additionally, if a device has no scaler or digital crop functionality, the source pad (1) exposes another digital crop selection rectangle that can only crop at the end of the lines and frames.

## **Scaler**

The scaler sub-device represents the digital crop and scaling functionality of the sensor. The V4L2 selection target V4L2\_SEL\_TGT\_CROP is used to configure the digital crop on the sink pad (0) when digital crop is supported. Scaling is configured using selection target V4L2\_SEL\_TGT\_COMPOSE on the sink pad (0) as well.

Additionally, if the scaler sub-device exists, its source pad (1) exposes another digital crop selection rectangle that can only crop at the end of the lines and frames.

## **Digital and analogue crop**

Digital crop functionality is referred to as cropping that effectively works by dropping some data on the floor. Analogue crop, on the other hand, means that the cropped information is never retrieved. In case of camera sensors, the analogue data is never read from the pixel matrix that are outside the configured selection rectangle that designates crop. The difference has an effect in device timing and likely also in power consumption.

## **Private controls**

The MIPI CCS driver implements a number of private controls under V4L2\_CID\_USER\_BASE\_CCS to control the MIPI CCS compliant camera sensors.

## **Analogue gain model**

The CCS defines an analogue gain model where the gain can be calculated using the following formula:

$$\text{gain} = m0 * x + c0 / (m1 * x + c1)$$

Either m0 or c0 will be zero. The constants that are device specific, can be obtained from the following controls:

V4L2_CID_CCS_ANALOGUE_GAIN_M0	V4L2_CID_CCS_ANALOGUE_GAIN_M1
V4L2_CID_CCS_ANALOGUE_GAIN_C0	V4L2_CID_CCS_ANALOGUE_GAIN_C1

The analogue gain ( $x$  in the formula) is controlled through `V4L2_CID_ANALOGUE_GAIN` in this case.

## Alternate analogue gain model

The CCS defines another analogue gain model called alternate analogue gain. In this case, the formula to calculate actual gain consists of linear and exponential parts:

$$\text{gain} = \text{linear} * 2^{\text{exponent}}$$

The `linear` and `exponent` factors can be set using the `V4L2_CID_CCS_ANALOGUE_LINEAR_GAIN` and `V4L2_CID_CCS_ANALOGUE_EXPONENTIAL_GAIN` controls, respectively

## Shading correction

The CCS standard supports lens shading correction. The feature can be controlled using `V4L2_CID_CCS_SHADING_CORRECTION`. Additionally, the luminance correction level may be changed using `V4L2_CID_CCS_LUMINANCE_CORRECTION_LEVEL`, where value 0 indicates no correction and 128 indicates correcting the luminance in corners to 10 % less than in the centre.

Shading correction needs to be enabled for luminance correction level to have an effect.

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### 13.10.4 The cx2341x driver

#### Non-compressed file format

The cx23416 can produce (and the cx23415 can also read) raw YUV output. The format of a YUV frame is 16x16 linear tiled NV12 (`V4L2_PIX_FMT_NV12_16L16`).

The format is YUV 4:2:0 which uses 1 Y byte per pixel and 1 U and V byte per four pixels.

The data is encoded as two macroblock planes, the first containing the Y values, the second containing UV macroblocks.

The Y plane is divided into blocks of 16x16 pixels from left to right and from top to bottom. Each block is transmitted in turn, line-by-line.

So the first 16 bytes are the first line of the top-left block, the second 16 bytes are the second line of the top-left block, etc. After transmitting this block the first line of the block on the right to the first block is transmitted, etc.

The UV plane is divided into blocks of 16x8 UV values going from left to right, top to bottom. Each block is transmitted in turn, line-by-line.

So the first 16 bytes are the first line of the top-left block and contain 8 UV value pairs (16 bytes in total). The second 16 bytes are the second line of 8 UV pairs of the top-left block, etc. After transmitting this block the first line of the block on the right to the first block is transmitted, etc.

The code below is given as an example on how to convert `V4L2_PIX_FMT_NV12_16L16` to separate Y, U and V planes. This code assumes frames of 720x576 (PAL) pixels.

The width of a frame is always 720 pixels, regardless of the actual specified width.

If the height is not a multiple of 32 lines, then the captured video is missing macroblocks at the end and is unusable. So the height must be a multiple of 32.

## Raw format c example

```
#include <stdio.h>
#include <stdlib.h>
#include <string.h>

static unsigned char frame[576*720*3/2];
static unsigned char framey[576*720];
static unsigned char frameu[576*720 / 4];
static unsigned char framev[576*720 / 4];

static void de_macro_y(unsigned char* dst, unsigned char *src, int dstride,
                      int w, int h)
{
    unsigned int y, x, i;

    // descramble Y plane
    // dstride = 720 = w
    // The Y plane is divided into blocks of 16x16 pixels
    // Each block is transmitted in turn, line-by-line.
    for (y = 0; y < h; y += 16) {
        for (x = 0; x < w; x += 16) {
            for (i = 0; i < 16; i++) {
                memcpy(dst + x + (y + i) * dstride, src, 16);
                src += 16;
            }
        }
    }
}

static void de_macro_uv(unsigned char *dstu, unsigned char *dstv, unsigned char *src,
                       int dstride, int w, int h)
{
    unsigned int y, x, i;

    // descramble U/V plane
    // dstride = 720 / 2 = w
    // The U/V values are interlaced (UVUV...).
    // Again, the UV plane is divided into blocks of 16x16 UV values.
    // Each block is transmitted in turn, line-by-line.
    for (y = 0; y < h; y += 16) {
        for (x = 0; x < w; x += 8) {
            for (i = 0; i < 16; i++) {
                int idx = x + (y + i) * dstride;

                dstu[idx+0] = src[0]; dstv[idx+0] = src[1];
                dstu[idx+1] = src[2]; dstv[idx+1] = src[3];
            }
        }
    }
}
```

```

        dstu[idx+2] = src[4]; dstv[idx+2] = src[5];
        dstu[idx+3] = src[6]; dstv[idx+3] = src[7];
        dstu[idx+4] = src[8]; dstv[idx+4] = src[9];
        dstu[idx+5] = src[10]; dstv[idx+5] = src[11];
        dstu[idx+6] = src[12]; dstv[idx+6] = src[13];
        dstu[idx+7] = src[14]; dstv[idx+7] = src[15];
        src += 16;
    }
}
}

//*****************************************************************************
int main(int argc, char **argv)
{
FILE *fin;
int i;

if (argc == 1) fin = stdin;
else fin = fopen(argv[1], "r");

if (fin == NULL) {
    fprintf(stderr, "cannot open input\n");
    exit(-1);
}
while (fread(frame, sizeof(frame), 1, fin) == 1) {
    de_macro_y(framey, frame, 720, 720, 576);
    de_macro_uv(frameu, framev, frame + 720 * 576, 720 / 2, 720 / 2, 576 / 2);
    fwrite(framey, sizeof(framey), 1, stdout);
    fwrite(framev, sizeof(framev), 1, stdout);
    fwrite(frameu, sizeof(frameu), 1, stdout);
}
fclose(fin);
return 0;
}

```

## Format of embedded V4L2\_MPEG\_STREAM\_VBI\_FMT\_IVTV VBI data

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This section describes the V4L2\_MPEG\_STREAM\_VBI\_FMT\_IVTV format of the VBI data embedded in an MPEG-2 program stream. This format is in part dictated by some hardware limitations of the ivtv driver (the driver for the Conexant cx23415/6 chips), in particular a maximum size for the VBI data. Anything longer is cut off when the MPEG stream is played back through the cx23415.

The advantage of this format is it is very compact and that all VBI data for all lines can be stored while still fitting within the maximum allowed size.

The stream ID of the VBI data is 0xBD. The maximum size of the embedded data is 4 +

$43 * 36$ , which is 4 bytes for a header and  $2 * 18$  VBI lines with a 1 byte header and a 42 bytes payload each. Anything beyond this limit is cut off by the cx23415/6 firmware. Besides the data for the VBI lines we also need 36 bits for a bitmask determining which lines are captured and 4 bytes for a magic cookie, signifying that this data package contains V4L2\_MPEG\_STREAM\_VBI\_FMT\_IVTV VBI data. If all lines are used, then there is no longer room for the bitmask. To solve this two different magic numbers were introduced:

'itv0': After this magic number two unsigned longs follow. Bits 0-17 of the first unsigned long denote which lines of the first field are captured. Bits 18-31 of the first unsigned long and bits 0-3 of the second unsigned long are used for the second field.

'ITV0': This magic number assumes all VBI lines are captured, i.e. it implicitly implies that the bitmasks are 0xffffffff and 0xf.

After these magic cookies (and the 8 byte bitmask in case of cookie 'itv0') the captured VBI lines start:

For each line the least significant 4 bits of the first byte contain the data type. Possible values are shown in the table below. The payload is in the following 42 bytes.

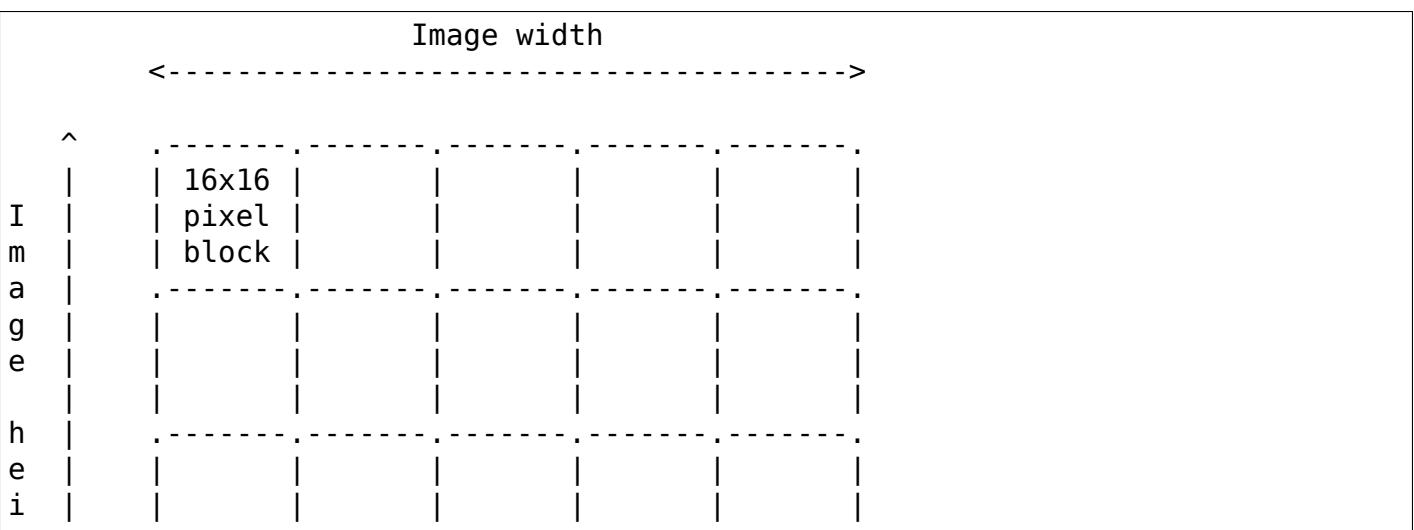
Here is the list of possible data types:

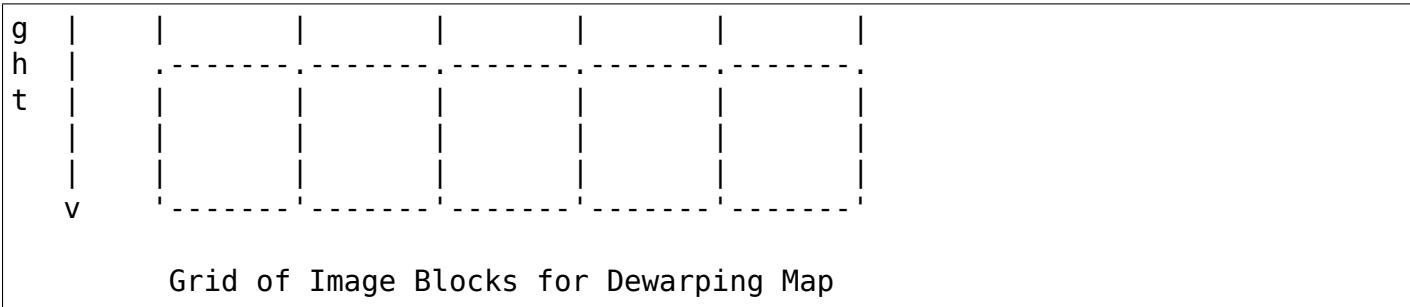
<code>#define IVTV_SLICED_TYPE_TELETEXT     ↳ for PAL)</code>	<code>0x1</code>	<code>// Teletext (uses lines 6-22)</code>
<code>#define IVTV_SLICED_TYPE_CC     ↳ NTSC)</code>	<code>0x4</code>	<code>// Closed Captions (line 21)</code>
<code>#define IVTV_SLICED_TYPE_WSS     ↳ PAL)</code>	<code>0x5</code>	<code>// Wide Screen Signal (line 23)</code>
<code>#define IVTV_SLICED_TYPE_VPS     ↳ (PAL) (line 16)</code>	<code>0x7</code>	<code>// Video Programming System</code>

### 13.10.5 DW100 dewarp driver

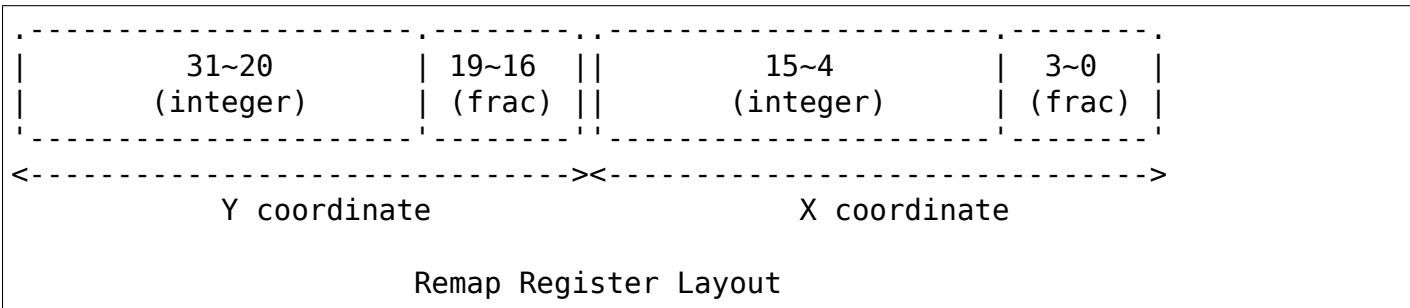
The Vivante DW100 Dewarp Processor IP core found on i.MX8MP SoC applies a programmable geometrical transformation on the input image to correct distortion introduced by lenses.

The transformation function is exposed by the hardware as a grid map with 16x16 pixel macroblocks indexed using X, Y vertex coordinates.





Each x, y coordinate register uses 16 bits to record the coordinate address in an unsigned 12.4 fixed point format (UQ12.4).



The dewarping map is set from applications using the V4L2\_CID\_DW100\_DEWARPING\_16x16\_VERTEX control. The control contains an array of u32 values storing (x, y) destination coordinates for each vertex of the grid. The x coordinate is stored in the 16 LSBs and the y coordinate in the 16 MSBs.

The number of elements in the array must match the image size:

```
elems = (DIV_ROUND_UP(width, 16) + 1) * (DIV_ROUND_UP(height, 16) + 1);
```

If the control has not been set by the application, the driver uses an identity map.

More details on the DW100 hardware operations can be found in *chapter 13.15 DeWarp* of IMX8MP reference manual.

The Vivante DW100 m2m driver implements the following driver-specific control:

#### **V4L2\_CID\_DW100\_DEWARPING\_16x16\_VERTEX\_MAP ( \_\_u32 array )**

Specifies to DW100 driver its dewarping map (aka LUT) blob as described in *chapter 13.15.2.3 Dewarping Remap* of IMX8MP reference manual as an U32 dynamic array. The image is divided into many small 16x16 blocks. If the width/height of the image is not divisible by 16, the size of the rightmost/bottommost block is the remainder. The dewarping map only saves the vertex coordinates of the block. The dewarping grid map is comprised of vertex coordinates for x and y. Each x, y coordinate register uses 16 bits (UQ12.4) to record the coordinate address, with the Y coordinate in the upper bits and X in the lower bits. The driver modifies the dimensions of this control when the sink format is changed, to reflect the new input resolution.

## 13.10.6 i.MX Video Capture Driver

### Events

#### ipuX\_csiY

This subdev can generate the following event when enabling the second IDMAC source pad:

- V4L2\_EVENT\_IMX\_FRAME\_INTERVAL\_ERROR

The user application can subscribe to this event from the ipuX\_csiY subdev node. This event is generated by the Frame Interval Monitor (see below for more on the FIM).

### Controls

#### Frame Interval Monitor in ipuX\_csiY

The adv718x decoders can occasionally send corrupt fields during NTSC/PAL signal re-sync (too little or too many video lines). When this happens, the IPU triggers a mechanism to re-establish vertical sync by adding 1 dummy line every frame, which causes a rolling effect from image to image, and can last a long time before a stable image is recovered. Or sometimes the mechanism doesn't work at all, causing a permanent split image (one frame contains lines from two consecutive captured images).

From experiment it was found that during image rolling, the frame intervals (elapsed time between two EOF's) drop below the nominal value for the current standard, by about one frame time (60 usec), and remain at that value until rolling stops.

While the reason for this observation isn't known (the IPU dummy line mechanism should show an increase in the intervals by 1 line time every frame, not a fixed value), we can use it to detect the corrupt fields using a frame interval monitor. If the FIM detects a bad frame interval, the ipuX\_csiY subdev will send the event V4L2\_EVENT\_IMX\_FRAME\_INTERVAL\_ERROR. Userland can register with the FIM event notification on the ipuX\_csiY subdev device node. Userland can issue a streaming restart when this event is received to correct the rolling/split image.

The ipuX\_csiY subdev includes custom controls to tweak some dials for FIM. If one of these controls is changed during streaming, the FIM will be reset and will continue at the new settings.

- V4L2\_CID\_IMX\_FIM\_ENABLE

Enable/disable the FIM.

- V4L2\_CID\_IMX\_FIM\_NUM

How many frame interval measurements to average before comparing against the nominal frame interval reported by the sensor. This can reduce noise caused by interrupt latency.

- V4L2\_CID\_IMX\_FIM\_TOLERANCE\_MIN

If the averaged intervals fall outside nominal by this amount, in microseconds, the V4L2\_EVENT\_IMX\_FRAME\_INTERVAL\_ERROR event is sent.

- V4L2\_CID\_IMX\_FIM\_TOLERANCE\_MAX

If any intervals are higher than this value, those samples are discarded and do not enter into the average. This can be used to discard really high interval errors that might be due to interrupt latency from high system load.

- `V4L2_CID_IMX_FIM_NUM_SKIP`

How many frames to skip after a FIM reset or stream restart before FIM begins to average intervals.

- `V4L2_CID_IMX_FIM_ICAP_CHANNEL / V4L2_CID_IMX_FIM_ICAP_EDGE`

These controls will configure an input capture channel as the method for measuring frame intervals. This is superior to the default method of measuring frame intervals via EOF interrupt, since it is not subject to uncertainty errors introduced by interrupt latency.

Input capture requires hardware support. A VSYNC signal must be routed to one of the i.MX6 input capture channel pads.

`V4L2_CID_IMX_FIM_ICAP_CHANNEL` configures which i.MX6 input capture channel to use. This must be 0 or 1.

`V4L2_CID_IMX_FIM_ICAP_EDGE` configures which signal edge will trigger input capture events. By default the input capture method is disabled with a value of `IRQ_TYPE_NONE`. Set this control to `IRQ_TYPE_EDGE_RISING`, `IRQ_TYPE_EDGE_FALLING`, or `IRQ_TYPE_EDGE_BOTH` to enable input capture, triggered on the given signal edge(s).

When input capture is disabled, frame intervals will be measured via EOF interrupt.

## File list

`drivers/staging/media/imx/` `include/media/imx.h` `include/linux/imx-media.h`

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## 13.10.7 Maxim Integrated MAX2175 RF to bits tuner driver

The MAX2175 driver implements the following driver-specific controls:

## **V4L2\_CID\_MAX2175\_I2S\_ENABLE**

Enable/Disable I2S output of the tuner. This is a private control that can be accessed only using the subdev interface. Refer to Documentation/driver-api/media/v4l2-controls.rst for more details.

(0)	I2S output is disabled.
(1)	I2S output is enabled.

## **V4L2\_CID\_MAX2175\_HSLS**

The high-side/low-side (HSLS) control of the tuner for a given band.

(0)	The LO frequency position is below the desired frequency.
(1)	The LO frequency position is above the desired frequency.

## **V4L2\_CID\_MAX2175\_RX\_MODE (menu)**

The Rx mode controls a number of preset parameters of the tuner like sample clock (sck), sampling rate etc. These multiple settings are provided under one single label called Rx mode in the datasheet. The list below shows the supported modes with a brief description.

<b>"Europe modes"</b>	
"FM 1.2" (0)	This configures FM band with a sample rate of 0.512 million samples/sec with a 10.24 MHz sck.
"DAB 1.2" (1)	This configures VHF band with a sample rate of 2.048 million samples/sec with a 32.768 MHz sck.
<b>"North America modes"</b>	
"FM 1.0" (0)	This configures FM band with a sample rate of 0.7441875 million samples/sec with a 14.88375 MHz sck.
"DAB 1.2" (1)	This configures FM band with a sample rate of 0.372 million samples/sec with a 7.441875 MHz sck.

### **13.10.8 NPCM video driver**

This driver is used to control the Video Capture/Differentiation (VCD) engine and Encoding Compression Engine (ECE) present on Nuvoton NPCM SoCs. The VCD can capture a frame from digital video input and compare two frames in memory, and the ECE can compress the frame data into HEXTILE format.

## Driver-specific Controls

### V4L2\_CID\_NPCM\_CAPTURE\_MODE

The VCD engine supports two modes:

- COMPLETE mode:

Capture the next complete frame into memory.

- DIFF mode:

Compare the incoming frame with the frame stored in memory, and updates the differentiated frame in memory.

Application can use V4L2\_CID\_NPCM\_CAPTURE\_MODE control to set the VCD mode with different control values (enum v4l2\_npcm\_capture\_mode):

- V4L2\_NPCM\_CAPTURE\_MODE\_COMPLETE: will set VCD to COMPLETE mode.
- V4L2\_NPCM\_CAPTURE\_MODE\_DIFF: will set VCD to DIFF mode.

### V4L2\_CID\_NPCM\_RECT\_COUNT

If using V4L2\_PIX\_FMT\_HEXTILE format, VCD will capture frame data and then ECE will compress the data into HEXTILE rectangles and store them in V4L2 video buffer with the layout defined in Remote Framebuffer Protocol:

(RFC 6143, <https://www.rfc-editor.org/rfc/rfc6143.html#section-7.6.1>)

No. of bytes	Type [Value]	Description
2	U16	x-position
2	U16	y-position
2	U16	width
2	U16	height
4	S32	encoding-type (5)
HEXTILE rectangle data		

Application can get the video buffer through VIDIOC\_DQBUF, and followed by calling V4L2\_CID\_NPCM\_RECT\_COUNT control to get the number of HEXTILE rectangles in this buffer.

## References

include/uapi/linux/npcm-video.h

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### 13.10.9 OMAP 3 Image Signal Processor (ISP) driver

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## Events

The OMAP 3 ISP driver does support the V4L2 event interface on CCDC and statistics (AEWB, AF and histogram) subdevs.

The CCDC subdev produces V4L2\_EVENT\_FRAME\_SYNC type event on HS\_VS interrupt which is used to signal frame start. Earlier version of this driver used V4L2\_EVENT\_OMAP3ISP\_HS\_VS for this purpose. The event is triggered exactly when the reception of the first line of the frame starts in the CCDC module. The event can be subscribed on the CCDC subdev.

(When using parallel interface one must pay account to correct configuration of the VS signal polarity. This is automatically correct when using the serial receivers.)

Each of the statistics subdevs is able to produce events. An event is generated whenever a statistics buffer can be dequeued by a user space application using the VIDIOC\_OMP3ISP\_STAT\_REQ IOCTL. The events available are:

- V4L2\_EVENT\_OMAP3ISP\_AEWB
- V4L2\_EVENT\_OMAP3ISP\_AF
- V4L2\_EVENT\_OMAP3ISP\_HIST

The type of the event data is struct omap3isp\_stat\_event\_status for these ioctls. If there is an error calculating the statistics, there will be an event as usual, but no related statistics buffer. In this case omap3isp\_stat\_event\_status.buf\_err is set to non-zero.

## Private IOCTLs

The OMAP 3 ISP driver supports standard V4L2 IOCTLs and controls where possible and practical. Much of the functions provided by the ISP, however, does not fall under the standard IOCTLs --- gamma tables and configuration of statistics collection are examples of such.

In general, there is a private ioctl for configuring each of the blocks containing hardware-dependent functions.

The following private IOCTLs are supported:

- VIDIOC\_OMP3ISP\_CCDC\_CFG

- VIDIOC\_OMAP3ISP\_PRV\_CFG
- VIDIOC\_OMAP3ISP\_AEWB\_CFG
- VIDIOC\_OMAP3ISP\_HIST\_CFG
- VIDIOC\_OMAP3ISP\_AF\_CFG
- VIDIOC\_OMAP3ISP\_STAT\_REQ
- VIDIOC\_OMAP3ISP\_STAT\_EN

The parameter structures used by these ioctls are described in include/linux/omap3isp.h. The detailed functions of the ISP itself related to a given ISP block is described in the Technical Reference Manuals (TRMs) --- see the end of the document for those.

While it is possible to use the ISP driver without any use of these private IOCTLs it is not possible to obtain optimal image quality this way. The AEWB, AF and histogram modules cannot be used without configuring them using the appropriate private IOCTLs.

## CCDC and preview block IOCTLs

The VIDIOC\_OMAP3ISP\_CCDC\_CFG and VIDIOC\_OMAP3ISP\_PRV\_CFG IOCTLs are used to configure, enable and disable functions in the CCDC and preview blocks, respectively. Both IOCTLs control several functions in the blocks they control. VIDIOC\_OMAP3ISP\_CCDC\_CFG IOCTL accepts a pointer to struct omap3isp\_ccdc\_update\_config as its argument. Similarly VIDIOC\_OMAP3ISP\_PRV\_CFG accepts a pointer to struct omap3isp\_prev\_update\_config. The definition of both structures is available in<sup>1</sup>.

The update field in the structures tells whether to update the configuration for the specific function and the flag tells whether to enable or disable the function.

The update and flag bit masks accept the following values. Each separate functions in the CCDC and preview blocks is associated with a flag (either disable or enable; part of the flag field in the structure) and a pointer to configuration data for the function.

Valid values for the update and flag fields are listed here for VIDIOC\_OMAP3ISP\_CCDC\_CFG. Values may be or'ed to configure more than one function in the same IOCTL call.

- OMAP3ISP\_CCDC\_ALAW
- OMAP3ISP\_CCDC\_LPF
- OMAP3ISP\_CCDC\_BLCLAMP
- OMAP3ISP\_CCDC\_BCOMP
- OMAP3ISP\_CCDC\_FPC
- OMAP3ISP\_CCDC\_CULL
- OMAP3ISP\_CCDC\_CONFIG\_LSC
- OMAP3ISP\_CCDC\_TBL\_LSC

The corresponding values for the VIDIOC\_OMAP3ISP\_PRV\_CFG are here:

- OMAP3ISP\_PREV\_LUMAENH
- OMAP3ISP\_PREV\_INVALAW

---

<sup>1</sup> include/linux/omap3isp.h

- OMAP3ISP\_PREV\_HRZ\_MED
- OMAP3ISP\_PREV\_CFA
- OMAP3ISP\_PREV\_CHROMA\_SUPP
- OMAP3ISP\_PREV\_WB
- OMAP3ISP\_PREV\_BLKADJ
- OMAP3ISP\_PREV\_RGB2RGB
- OMAP3ISP\_PREV\_COLOR\_CONV
- OMAP3ISP\_PREV\_YC\_LIMIT
- OMAP3ISP\_PREV\_DEFECT\_COR
- OMAP3ISP\_PREV\_GAMMABYPASS
- OMAP3ISP\_PREV\_DRK\_FRM\_CAPTURE
- OMAP3ISP\_PREV\_DRK\_FRM\_SUBTRACT
- OMAP3ISP\_PREV\_LENS\_SHADING
- OMAP3ISP\_PREV\_NF
- OMAP3ISP\_PREV\_GAMMA

The associated configuration pointer for the function may not be NULL when enabling the function. When disabling a function the configuration pointer is ignored.

### Statistic blocks IOCTLs

The statistics subdevs do offer more dynamic configuration options than the other subdevs. They can be enabled, disable and reconfigured when the pipeline is in streaming state.

The statistics blocks always get the input image data from the CCDC (as the histogram memory read isn't implemented). The statistics are dequeuable by the user from the statistics subdev nodes using private IOCTLs.

The private IOCTLs offered by the AEWB, AF and histogram subdevs are heavily reflected by the register level interface offered by the ISP hardware. There are aspects that are purely related to the driver implementation and these are discussed next.

### **VIDIOC\_OMAP3ISP\_STAT\_EN**

This private IOCTL enables/disables a statistic module. If this request is done before streaming, it will take effect as soon as the pipeline starts to stream. If the pipeline is already streaming, it will take effect as soon as the CCDC becomes idle.

## **VIDIOC\_OMAP3ISP\_AEWB\_CFG, VIDIOC\_OMAP3ISP\_HIST\_CFG and VIDIOC\_OMAP3ISP\_AF\_CFG**

Those IOCTLs are used to configure the modules. They require user applications to have an in-depth knowledge of the hardware. Most of the fields explanation can be found on OMAP's TRMs. The two following fields common to all the above configure private IOCTLs require explanation for better understanding as they are not part of the TRM.

omap3isp\_[h3a\_af/h3a\_aewb/hist]\_config.buf\_size:

The modules handle their buffers internally. The necessary buffer size for the module's data output depends on the requested configuration. Although the driver supports reconfiguration while streaming, it does not support a reconfiguration which requires bigger buffer size than what is already internally allocated if the module is enabled. It will return -EBUSY on this case. In order to avoid such condition, either disable/reconfigure/enable the module or request the necessary buffer size during the first configuration while the module is disabled.

The internal buffer size allocation considers the requested configuration's minimum buffer size and the value set on buf\_size field. If buf\_size field is out of [minimum, maximum] buffer size range, it's clamped to fit in there. The driver then selects the biggest value. The corrected buf\_size value is written back to user application.

omap3isp\_[h3a\_af/h3a\_aewb/hist]\_config.config\_counter:

As the configuration doesn't take effect synchronously to the request, the driver must provide a way to track this information to provide more accurate data. After a configuration is requested, the config\_counter returned to user space application will be an unique value associated to that request. When user application receives an event for buffer availability or when a new buffer is requested, this config\_counter is used to match a buffer data and a configuration.

## **VIDIOC\_OMAP3ISP\_STAT\_REQ**

Send to user space the oldest data available in the internal buffer queue and discards such buffer afterwards. The field omap3isp\_stat\_data.frame\_number matches with the video buffer's field\_count.

## **References**

### **13.10.10 ST VGXY61 camera sensor driver**

The ST VGXY61 driver implements the following controls:

#### **V4L2\_CID\_HDR\_SENSOR\_MODE**

Change the sensor HDR mode. A HDR picture is obtained by merging two captures of the same scene using two different exposure periods.

HDR linearize	The merger outputs a long exposure capture as long as it is not saturated.
HDR subtraction	This involves subtracting the short exposure frame from the long exposure frame.
No HDR	This mode is used for standard dynamic range (SDR) exposures.

### 13.10.11 THine THP7312 ISP driver

The THP7312 driver implements the following driver-specific controls:

#### V4L2\_CID\_THP7312\_LOW\_LIGHT\_COMPENSATION

Enable/Disable auto-adjustment, based on lighting conditions, of the frame rate when auto-exposure is enabled.

#### V4L2\_CID\_THP7312\_AUTO\_FOCUS\_METHOD

Set method of auto-focus. Only takes effect when auto-focus is enabled.

0	Contrast-based auto-focus
1	PDAF
2	Hybrid of contrast-based and PDAF

Supported values for the control depend on the camera sensor module connected to the THP7312. If the module doesn't have a focus lens actuator, this control will not be exposed by the THP7312 driver. If the module has a controllable focus lens but the sensor doesn't support PDAF, only the contrast-based auto-focus value will be valid. Otherwise all values for the controls will be supported.

#### V4L2\_CID\_THP7312\_NOISE\_REDUCTION\_AUTO

Enable/Disable auto noise reduction.

#### V4L2\_CID\_THP7312\_NOISE\_REDUCTION\_ABSOLUTE

Set the noise reduction strength, where 0 is the weakest and 10 is the strongest.

### 13.10.12 The Linux USB Video Class (UVC) driver

This file documents some driver-specific aspects of the UVC driver, such as driver-specific ioctls and implementation notes.

Questions and remarks can be sent to the Linux UVC development mailing list at [linux-media@vger.kernel.org](mailto:linux-media@vger.kernel.org).

#### Extension Unit (XU) support

##### Introduction

The UVC specification allows for vendor-specific extensions through extension units (XUs). The Linux UVC driver supports extension unit controls (XU controls) through two separate mechanisms:

- through mappings of XU controls to V4L2 controls
- through a driver-specific ioctl interface

The first one allows generic V4L2 applications to use XU controls by mapping certain XU controls onto V4L2 controls, which then show up during ordinary control enumeration.

The second mechanism requires uvcvideo-specific knowledge for the application to access XU controls but exposes the entire UVC XU concept to user space for maximum flexibility.

Both mechanisms complement each other and are described in more detail below.

## Control mappings

The UVC driver provides an API for user space applications to define so-called control mappings at runtime. These allow for individual XU controls or byte ranges thereof to be mapped to new V4L2 controls. Such controls appear and function exactly like normal V4L2 controls (i.e. the stock controls, such as brightness, contrast, etc.). However, reading or writing of such a V4L2 controls triggers a read or write of the associated XU control.

The ioctl used to create these control mappings is called UVCIOC\_CTRL\_MAP. Previous driver versions (before 0.2.0) required another ioctl to be used beforehand (UVCIOC\_CTRL\_ADD) to pass XU control information to the UVC driver. This is no longer necessary as newer uvcvideo versions query the information directly from the device.

For details on the UVCIOC\_CTRL\_MAP ioctl please refer to the section titled "IOCTL reference" below.

### 3. Driver specific XU control interface

For applications that need to access XU controls directly, e.g. for testing purposes, firmware upload, or accessing binary controls, a second mechanism to access XU controls is provided in the form of a driver-specific ioctl, namely UVCIOC\_CTRL\_QUERY.

A call to this ioctl allows applications to send queries to the UVC driver that directly map to the low-level UVC control requests.

In order to make such a request the UVC unit ID of the control's extension unit and the control selector need to be known. This information either needs to be hardcoded in the application or queried using other ways such as by parsing the UVC descriptor or, if available, using the media controller API to enumerate a device's entities.

Unless the control size is already known it is necessary to first make a UVC\_GET\_LEN requests in order to be able to allocate a sufficiently large buffer and set the buffer size to the correct value. Similarly, to find out whether UVC\_GET\_CUR or UVC\_SET\_CUR are valid requests for a given control, a UVC\_GET\_INFO request should be made. The bits 0 (GET supported) and 1 (SET supported) of the resulting byte indicate which requests are valid.

With the addition of the UVCIOC\_CTRL\_QUERY ioctl the UVCIOC\_CTRL\_GET and UVCIOC\_CTRL\_SET ioctls have become obsolete since their functionality is a subset of the former ioctl. For the time being they are still supported but application developers are encouraged to use UVCIOC\_CTRL\_QUERY instead.

For details on the UVCIOC\_CTRL\_QUERY ioctl please refer to the section titled "IOCTL reference" below.

## Security

The API doesn't currently provide a fine-grained access control facility. The UVCIOC\_CTRL\_ADD and UVCIOC\_CTRL\_MAP ioctls require super user permissions.

Suggestions on how to improve this are welcome.

## Debugging

In order to debug problems related to XU controls or controls in general it is recommended to enable the UVC\_TRACE\_CONTROL bit in the module parameter 'trace'. This causes extra output to be written into the system log.

## IOCTL reference

### **UVCIOC\_CTRL\_MAP - Map a UVC control to a V4L2 control**

Argument: struct uvc\_xu\_control\_mapping

#### **Description:**

This ioctl creates a mapping between a UVC control or part of a UVC control and a V4L2 control. Once mappings are defined, userspace applications can access vendor-defined UVC control through the V4L2 control API.

To create a mapping, applications fill the uvc\_xu\_control\_mapping structure with information about an existing UVC control defined with UVCIOC\_CTRL\_ADD and a new V4L2 control.

A UVC control can be mapped to several V4L2 controls. For instance, a UVC pan/tilt control could be mapped to separate pan and tilt V4L2 controls. The UVC control is divided into non overlapping fields using the 'size' and 'offset' fields and are then independently mapped to V4L2 control.

For signed integer V4L2 controls the data\_type field should be set to UVC\_CTRL\_DATA\_TYPE\_SIGNED. Other values are currently ignored.

#### **Return value:**

On success 0 is returned. On error -1 is returned and errno is set appropriately.

#### **ENOMEM**

Not enough memory to perform the operation.

#### **EPERM**

Insufficient privileges (super user privileges are required).

#### **EINVAL**

No such UVC control.

#### **EOVERFLOW**

The requested offset and size would overflow the UVC control.

#### **EEXIST**

Mapping already exists.

#### **Data types:**

```
* struct uvc_xu_control_mapping
{
    __u32    id          V4L2 control identifier
    __u8    name[32]      V4L2 control name
    __u8    entity[16]    UVC extension unit GUID
}
```

```

__u8    selector      UVC control selector
__u8    size          V4L2 control size (in bits)
__u8    offset        V4L2 control offset (in bits)
enum v4l2_ctrl_type
    v4l2_type     V4L2 control type
enum uvc_control_data_type
    data_type     UVC control data type
struct uvc_menu_info
    *menu_info    Array of menu entries (for menu controls only)
__u32   menu_count   Number of menu entries (for menu controls only)

* struct uvc_menu_info

__u32   value         Menu entry value used by the device
__u8    name[32]       Menu entry name

* enum uvc_control_data_type

UVC_CTRL_DATA_TYPE_RAW           Raw control (byte array)
UVC_CTRL_DATA_TYPE_SIGNED        Signed integer
UVC_CTRL_DATA_TYPE_UNSIGNED      Unsigned integer
UVC_CTRL_DATA_TYPE_BOOLEAN       Boolean
UVC_CTRL_DATA_TYPE_ENUM          Enumeration
UVC_CTRL_DATA_TYPE_BITMASK       Bitmask

```

## **UVCIOC\_CTRL\_QUERY - Query a UVC XU control**

Argument: struct uvc\_xu\_control\_query

### **Description:**

This ioctl queries a UVC XU control identified by its extension unit ID and control selector.

There are a number of different queries available that closely correspond to the low-level control requests described in the UVC specification. These requests are:

#### **UVC\_GET\_CUR**

Obtain the current value of the control.

#### **UVC\_GET\_MIN**

Obtain the minimum value of the control.

#### **UVC\_GET\_MAX**

Obtain the maximum value of the control.

#### **UVC\_GET\_DEF**

Obtain the default value of the control.

#### **UVC\_GET\_RES**

Query the resolution of the control, i.e. the step size of the allowed control values.

## **UVC\_GET\_LEN**

Query the size of the control in bytes.

## **UVC\_GET\_INFO**

Query the control information bitmap, which indicates whether get/set requests are supported.

## **UVC\_SET\_CUR**

Update the value of the control.

Applications must set the 'size' field to the correct length for the control. Exceptions are the UVC\_GET\_LEN and UVC\_GET\_INFO queries, for which the size must be set to 2 and 1, respectively. The 'data' field must point to a valid writable buffer big enough to hold the indicated number of data bytes.

Data is copied directly from the device without any driver-side processing. Applications are responsible for data buffer formatting, including little-endian/big-endian conversion. This is particularly important for the result of the UVC\_GET\_LEN requests, which is always returned as a little-endian 16-bit integer by the device.

## **Return value:**

On success 0 is returned. On error -1 is returned and errno is set appropriately.

## **ENOENT**

The device does not support the given control or the specified extension unit could not be found.

## **ENOBUFS**

The specified buffer size is incorrect (too big or too small).

## **EINVAL**

An invalid request code was passed.

## **EBADRQC**

The given request is not supported by the given control.

## **EFAULT**

The data pointer references an inaccessible memory area.

## **Data types:**

```
* struct uvc_xu_control_query
{
    __u8    unit          Extension unit ID
    __u8    selector      Control selector
    __u8    query         Request code to send to the device
    __u16   size          Control data size (in bytes)
    __u8    *data         Control value
```

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## NETLINK HANDBOOK

Netlink documentation for users.

### 14.1 Introduction to Netlink

Netlink is often described as an ioctl() replacement. It aims to replace fixed-format C structures as supplied to ioctl() with a format which allows an easy way to add or extend the arguments.

To achieve this Netlink uses a minimal fixed-format metadata header followed by multiple attributes in the TLV (type, length, value) format.

Unfortunately the protocol has evolved over the years, in an organic and undocumented fashion, making it hard to coherently explain. To make the most practical sense this document starts by describing netlink as it is used today and dives into more "historical" uses in later sections.

#### 14.1.1 Opening a socket

Netlink communication happens over sockets, a socket needs to be opened first:

```
fd = socket(AF_NETLINK, SOCK_RAW, NETLINK_GENERIC);
```

The use of sockets allows for a natural way of exchanging information in both directions (to and from the kernel). The operations are still performed synchronously when applications send() the request but a separate recv() system call is needed to read the reply.

A very simplified flow of a Netlink "call" will therefore look something like:

```
fd = socket(AF_NETLINK, SOCK_RAW, NETLINK_GENERIC);

/* format the request */
send(fd, &request, sizeof(request));
n = recv(fd, &response, RSP_BUFFER_SIZE);
/* interpret the response */
```

Netlink also provides natural support for "dumping", i.e. communicating to user space all objects of a certain type (e.g. dumping all network interfaces).

```
fd = socket(AF_NETLINK, SOCK_RAW, NETLINK_GENERIC);

/* format the dump request */
```

```

send(fd, &request, sizeof(request));
while (1) {
    n = recv(fd, &buffer, RSP_BUFFER_SIZE);
    /* one recv() call can read multiple messages, hence the loop below */
    for (nl_msg in buffer) {
        if (nl_msg.nlmsg_type == NLMSG_DONE)
            goto dump_finished;
        /* process the object */
    }
}
dump_finished:

```

The first two arguments of the socket() call require little explanation - it is opening a Netlink socket, with all headers provided by the user (hence NETLINK, RAW). The last argument is the protocol within Netlink. This field used to identify the subsystem with which the socket will communicate.

## Classic vs Generic Netlink

Initial implementation of Netlink depended on a static allocation of IDs to subsystems and provided little supporting infrastructure. Let us refer to those protocols collectively as **Classic Netlink**. The list of them is defined on top of the include/uapi/linux/netlink.h file, they include among others - general networking (NETLINK\_ROUTE), iSCSI (NETLINK\_ISCSI), and audit (NETLINK\_AUDIT).

**Generic Netlink** (introduced in 2005) allows for dynamic registration of subsystems (and subsystem ID allocation), introspection and simplifies implementing the kernel side of the interface.

The following section describes how to use Generic Netlink, as the number of subsystems using Generic Netlink outnumbers the older protocols by an order of magnitude. There are also no plans for adding more Classic Netlink protocols to the kernel. Basic information on how communicating with core networking parts of the Linux kernel (or another of the 20 subsystems using Classic Netlink) differs from Generic Netlink is provided later in this document.

### 14.1.2 Generic Netlink

In addition to the Netlink fixed metadata header each Netlink protocol defines its own fixed metadata header. (Similarly to how network headers stack - Ethernet > IP > TCP we have Netlink > Generic N. > Family.)

A Netlink message always starts with *struct nlmsghdr*, which is followed by a protocol-specific header. In case of Generic Netlink the protocol header is struct genlmsghdr.

The practical meaning of the fields in case of Generic Netlink is as follows:

```

struct nlmsghdr {
    __u32    nlmsg_len;      /* Length of message including headers */
    __u16    nlmsg_type;    /* Generic Netlink Family (subsystem) ID */
    __u16    nlmsg_flags;   /* Flags - request or dump */
    __u32    nlmsg_seq;     /* Sequence number */
    __u32    nlmsg_pid;     /* Port ID, set to 0 */
}

```

```

};

struct genlmsghdr {
    __u8    cmd;           /* Command, as defined by the Family */
    __u8    version;       /* Irrelevant, set to 1 */
    __u16   reserved;      /* Reserved, set to 0 */
};

/* TLV attributes follow... */

```

In Classic Netlink `nlmsghdr.nlmsg_type` used to identify which operation within the subsystem the message was referring to (e.g. get information about a netdev). Generic Netlink needs to mux multiple subsystems in a single protocol so it uses this field to identify the subsystem, and `genlmsghdr.cmd` identifies the operation instead. (See [Resolving the Family ID](#) for information on how to find the Family ID of the subsystem of interest.) Note that the first 16 values (0 - 15) of this field are reserved for control messages both in Classic Netlink and Generic Netlink. See [Netlink message types](#) for more details.

There are 3 usual types of message exchanges on a Netlink socket:

- performing a single action (do);
- dumping information (dump);
- getting asynchronous notifications (multicast).

Classic Netlink is very flexible and presumably allows other types of exchanges to happen, but in practice those are the three that get used.

Asynchronous notifications are sent by the kernel and received by the user sockets which subscribed to them. do and dump requests are initiated by the user. `nlmsghdr.nlmsg_flags` should be set as follows:

- for do: `NLM_F_REQUEST | NLM_F_ACK`
- for dump: `NLM_F_REQUEST | NLM_F_ACK | NLM_F_DUMP`

`nlmsghdr.nlmsg_seq` should be a set to a monotonically increasing value. The value gets echoed back in responses and doesn't matter in practice, but setting it to an increasing value for each message sent is considered good hygiene. The purpose of the field is matching responses to requests. Asynchronous notifications will have `nlmsghdr.nlmsg_seq` of 0.

`nlmsghdr.nlmsg_pid` is the Netlink equivalent of an address. This field can be set to 0 when talking to the kernel. See [nlmsg\\_pid](#) for the (uncommon) uses of the field.

The expected use for `genlmsghdr.version` was to allow versioning of the APIs provided by the subsystems. No subsystem to date made significant use of this field, so setting it to 1 seems like a safe bet.

## Netlink message types

As previously mentioned `nlmsghdr.nlmsg_type` carries protocol specific values but the first 16 identifiers are reserved (first subsystem specific message type should be equal to `NLMSG_MIN_TYPE` which is `0x10`).

There are only 4 Netlink control messages defined:

- `NLMSG_NOOP` - ignore the message, not used in practice;
- `NLMSG_ERROR` - carries the return code of an operation;
- `NLMSG_DONE` - marks the end of a dump;
- `NLMSG_OVERRUN` - socket buffer has overflowed, not used to date.

`NLMSG_ERROR` and `NLMSG_DONE` are of practical importance. They carry return codes for operations. Note that unless the `NLM_F_ACK` flag is set on the request Netlink will not respond with `NLMSG_ERROR` if there is no error. To avoid having to special-case this quirk it is recommended to always set `NLM_F_ACK`.

The format of `NLMSG_ERROR` is described by struct `nlmsgerr`:

```
-----|-----|-----|-----|-----|-----|-----|-----|
| struct nlmsghdr - response header |           |
-----|-----|-----|-----|-----|-----|-----|-----|
|     int error                      |           |
-----|-----|-----|-----|-----|-----|-----|-----|
| struct nlmsghdr - original request header |           |
-----|-----|-----|-----|-----|-----|-----|-----|
| ** optionally (1) payload of the request |           |
-----|-----|-----|-----|-----|-----|-----|-----|
| ** optionally (2) extended ACK          |           |
-----|-----|-----|-----|-----|-----|-----|-----|
```

There are two instances of `struct nlmsghdr` here, first of the response and second of the request. `NLMSG_ERROR` carries the information about the request which led to the error. This could be useful when trying to match requests to responses or re-parse the request to dump it into logs.

The payload of the request is not echoed in messages reporting success (`error == 0`) or if `NETLINK_CAP_ACK` `setsockopt()` was set. The latter is common and perhaps recommended as having to read a copy of every request back from the kernel is rather wasteful. The absence of request payload is indicated by `NLM_F_CAPPED` in `nlmsghdr.nlmsg_flags`.

The second optional element of `NLMSG_ERROR` are the extended ACK attributes. See [Extended ACK](#) for more details. The presence of extended ACK is indicated by `NLM_F_ACK_TLVS` in `nlmsghdr.nlmsg_flags`.

`NLMSG_DONE` is simpler, the request is never echoed but the extended ACK attributes may be present:

```
-----|-----|-----|-----|-----|-----|-----|-----|
| struct nlmsghdr - response header |           |
-----|-----|-----|-----|-----|-----|-----|-----|
|     int error                      |           |
-----|-----|-----|-----|-----|-----|-----|-----|
```

```
-----| ** optionally extended ACK |-----
```

Note that some implementations may issue custom NLMSG\_DONE messages in reply to do action requests. In that case the payload is implementation-specific and may also be absent.

## Resolving the Family ID

This section explains how to find the Family ID of a subsystem. It also serves as an example of Generic Netlink communication.

Generic Netlink is itself a subsystem exposed via the Generic Netlink API. To avoid a circular dependency Generic Netlink has a statically allocated Family ID (GENL\_ID\_CTRL which is equal to NLMSG\_MIN\_TYPE). The Generic Netlink family implements a command used to find out information about other families (CTRL\_CMD\_GETFAMILY).

To get information about the Generic Netlink family named for example "test1" we need to send a message on the previously opened Generic Netlink socket. The message should target the Generic Netlink Family (1), be a do (2) call to CTRL\_CMD\_GETFAMILY (3). A dump version of this call would make the kernel respond with information about *all* the families it knows about. Last but not least the name of the family in question has to be specified (4) as an attribute with the appropriate type:

```
struct nlmsghdr:
    __u32 nlmsg_len:      32
    __u16 nlmsg_type:     GENL_ID_CTRL           // (1)
    __u16 nlmsg_flags:    NLM_F_REQUEST | NLM_F_ACK // (2)
    __u32 nlmsg_seq:      1
    __u32 nlmsg_pid:      0

struct genlmsghdr:
    __u8 cmd:             CTRL_CMD_GETFAMILY    // (3)
    __u8 version:         2 /* or 1, doesn't matter */
    __u16 reserved:       0

struct nlaattr:                                // (4)
    __u16 nla_len:        10
    __u16 nla_type:       CTRL_ATTR_FAMILY_NAME
    char data:            test1\0

(padding:)
char data:          \0\0
```

The length fields in Netlink (nlmsghdr.nlmsg\_len and nlaattr.nla\_len) always *include* the header. Attribute headers in netlink must be aligned to 4 bytes from the start of the message, hence the extra \0\0 after CTRL\_ATTR\_FAMILY\_NAME. The attribute lengths *exclude* the padding.

If the family is found kernel will reply with two messages, the response with all the information about the family:

```
/* Message #1 - reply */
struct nlmsghdr:
    __u32 nlmsg_len:      136
    __u16 nlmsg_type:     GENL_ID_CTRL
    __u16 nlmsg_flags:    0
    __u32 nlmsg_seq:      1 /* echoed from our request */
    __u32 nlmsg_pid:      5831 /* The PID of our user space process */

struct genlmsghdr:
    __u8 cmd:             CTRL_CMD_GETFAMILY
    __u8 version:         2
    __u16 reserved:       0

struct nlaattr:
    __u16 nla_len:        10
    __u16 nla_type:       CTRL_ATTR_FAMILY_NAME
    char data:            test1\0

(padding:)
    data:                \0\0

struct nlaattr:
    __u16 nla_len:        6
    __u16 nla_type:       CTRL_ATTR_FAMILY_ID
    __u16:                123 /* The Family ID we are after */

(padding:)
    char data:            \0\0

struct nlaattr:
    __u16 nla_len:        9
    __u16 nla_type:       CTRL_ATTR_FAMILY_VERSION
    __u16:                1

/* ... etc, more attributes will follow. */
```

And the error code (success) since NLM\_F\_ACK had been set on the request:

```
/* Message #2 - the ACK */
struct nlmsghdr:
    __u32 nlmsg_len:      36
    __u16 nlmsg_type:     NLMSG_ERROR
    __u16 nlmsg_flags:    NLM_F_CAPPED /* There won't be a payload */
    __u32 nlmsg_seq:      1 /* echoed from our request */
    __u32 nlmsg_pid:      5831 /* The PID of our user space process */

int error:          0

struct nlmsghdr: /* Copy of the request header as we sent it */
    __u32 nlmsg_len:      32
    __u16 nlmsg_type:     GENL_ID_CTRL
```

```
__u16 nlmsg_flags: NLM_F_REQUEST | NLM_F_ACK
__u32 nlmsg_seq: 1
__u32 nlmsg_pid: 0
```

The order of attributes (struct nlattr) is not guaranteed so the user has to walk the attributes and parse them.

Note that Generic Netlink sockets are not associated or bound to a single family. A socket can be used to exchange messages with many different families, selecting the recipient family on message-by-message basis using the `nlmsghdr.nlmsg_type` field.

## Extended ACK

Extended ACK controls reporting of additional error/warning TLVs in `NLMSG_ERROR` and `NLMSG_DONE` messages. To maintain backward compatibility this feature has to be explicitly enabled by setting the `NETLINK_EXT_ACK` setsockopt() to 1.

Types of extended ack attributes are defined in `enum nlmsgerr_attrs`. The most commonly used attributes are `NLMSGERR_ATTR_MSG`, `NLMSGERR_ATTR_OFFSET` and `NLMSGERR_ATTR_MISS_*`.

`NLMSGERR_ATTR_MSG` carries a message in English describing the encountered problem. These messages are far more detailed than what can be expressed thru standard UNIX error codes.

`NLMSGERR_ATTR_OFFSET` points to the attribute which caused the problem.

`NLMSGERR_ATTR_MISS_TYPE` and `NLMSGERR_ATTR_MISS_NEST` inform about a missing attribute.

Extended ACKs can be reported on errors as well as in case of success. The latter should be treated as a warning.

Extended ACKs greatly improve the usability of Netlink and should always be enabled, appropriately parsed and reported to the user.

### 14.1.3 Advanced topics

#### Dump consistency

Some of the data structures kernel uses for storing objects make it hard to provide an atomic snapshot of all the objects in a dump (without impacting the fast-paths updating them).

Kernel may set the `NLM_F_DUMP_INTR` flag on any message in a dump (including the `NLMSG_DONE` message) if the dump was interrupted and may be inconsistent (e.g. missing objects). User space should retry the dump if it sees the flag set.

## Introspection

The basic introspection abilities are enabled by access to the Family object as reported in [Resolving the Family ID](#). User can query information about the Generic Netlink family, including which operations are supported by the kernel and what attributes the kernel understands. Family information includes the highest ID of an attribute kernel can parse, a separate command (CTRL\_CMD\_GETPOLICY) provides detailed information about supported attributes, including ranges of values the kernel accepts.

Querying family information is useful in cases when user space needs to make sure that the kernel has support for a feature before issuing a request.

### nlmsg\_pid

`nlmsghdr.nlmsg_pid` is the Netlink equivalent of an address. It is referred to as Port ID, sometimes Process ID because for historical reasons if the application does not select (`bind()`) to an explicit Port ID kernel will automatically assign it the ID equal to its Process ID (as reported by the `getpid()` system call).

Similarly to the `bind()` semantics of the TCP/IP network protocols the value of zero means "assign automatically", hence it is common for applications to leave the `nlmsghdr.nlmsg_pid` field initialized to 0.

The field is still used today in rare cases when kernel needs to send a unicast notification. User space application can use `bind()` to associate its socket with a specific PID, it then communicates its PID to the kernel. This way the kernel can reach the specific user space process.

This sort of communication is utilized in UMH (User Mode Helper)-like scenarios when kernel needs to trigger user space processing or ask user space for a policy decision.

## Multicast notifications

One of the strengths of Netlink is the ability to send event notifications to user space. This is a unidirectional form of communication (kernel -> user) and does not involve any control messages like `NLMSG_ERROR` or `NLMSG_DONE`.

For example the Generic Netlink family itself defines a set of multicast notifications about registered families. When a new family is added the sockets subscribed to the notifications will get the following message:

```
struct nlmsghdr:
    __u32 nlmsg_len:      136
    __u16 nlmsg_type:    GENL_ID_CTRL
    __u16 nlmsg_flags:   0
    __u32 nlmsg_seq:     0
    __u32 nlmsg_pid:     0

struct genlmsghdr:
    __u8 cmd:           CTRL_CMD_NEWFAMILY
    __u8 version:       2
    __u16 reserved:     0
```

```

struct nlaattr:
    __u16 nla_len:          10
    __u16 nla_type:        CTRL_ATTR_FAMILY_NAME
    char data:             test1\0

(padding:)
    data:                 \0\0

struct nlaattr:
    __u16 nla_len:          6
    __u16 nla_type:        CTRL_ATTR_FAMILY_ID
    __u16:                  123 /* The Family ID we are after */

(padding:)
    char data:             \0\0

struct nlaattr:
    __u16 nla_len:          9
    __u16 nla_type:        CTRL_ATTR_FAMILY_VERSION
    __u16:                  1

/* ... etc, more attributes will follow. */

```

The notification contains the same information as the response to the `CTRL_CMD_GETFAMILY` request.

The Netlink headers of the notification are mostly 0 and irrelevant. The `nlmsghdr.nlmsg_seq` may be either zero or a monotonically increasing notification sequence number maintained by the family.

To receive notifications the user socket must subscribe to the relevant notification group. Much like the Family ID, the Group ID for a given multicast group is dynamic and can be found inside the Family information. The `CTRL_ATTR_MCAST_GROUPS` attribute contains nests with names (`CTRL_ATTR_MCAST_GRP_NAME`) and IDs (`CTRL_ATTR_MCAST_GRP_ID`) of the groups family.

Once the Group ID is known a `setsockopt()` call adds the socket to the group:

```

unsigned int group_id;

/* .. find the group ID... */

setsockopt(fd, SOL_NETLINK, NETLINK_ADD_MEMBERSHIP,
           &group_id, sizeof(group_id));

```

The socket will now receive notifications.

It is recommended to use separate sockets for receiving notifications and sending requests to the kernel. The asynchronous nature of notifications means that they may get mixed in with the responses making the message handling much harder.

## Buffer sizing

Netlink sockets are datagram sockets rather than stream sockets, meaning that each message must be received in its entirety by a single `recv()`/`recvmsg()` system call. If the buffer provided by the user is too short, the message will be truncated and the `MSG_TRUNC` flag set in `struct msghdr` (`struct msghdr` is the second argument of the `recvmsg()` system call, *not* a Netlink header).

Upon truncation the remaining part of the message is discarded.

Netlink expects that the user buffer will be at least 8kB or a page size of the CPU architecture, whichever is bigger. Particular Netlink families may, however, require a larger buffer. 32kB buffer is recommended for most efficient handling of dumps (larger buffer fits more dumped objects and therefore fewer `recvmsg()` calls are needed).

### 14.1.4 Classic Netlink

The main differences between Classic and Generic Netlink are the dynamic allocation of subsystem identifiers and availability of introspection. In theory the protocol does not differ significantly, however, in practice Classic Netlink experimented with concepts which were abandoned in Generic Netlink (really, they usually only found use in a small corner of a single subsystem). This section is meant as an explainer of a few of such concepts, with the explicit goal of giving the Generic Netlink users the confidence to ignore them when reading the uAPI headers.

Most of the concepts and examples here refer to the `NETLINK_ROUTE` family, which covers much of the configuration of the Linux networking stack. Real documentation of that family, deserves a chapter (or a book) of its own.

## Families

Netlink refers to subsystems as families. This is a remnant of using sockets and the concept of protocol families, which are part of message demultiplexing in `NETLINK_ROUTE`.

Sadly every layer of encapsulation likes to refer to whatever it's carrying as "families" making the term very confusing:

1. `AF_NETLINK` is a bona fide socket protocol family
2. `AF_NETLINK`'s documentation refers to what comes after its own header (*struct nlmsghdr*) in a message as a "Family Header"
3. Generic Netlink is a family for `AF_NETLINK` (`struct genlmsghdr` follows *struct nlmsghdr*), yet it also calls its users "Families".

Note that the Generic Netlink Family IDs are in a different "ID space" and overlap with Classic Netlink protocol numbers (e.g. `NETLINK_CRYPTO` has the Classic Netlink protocol ID of 21 which Generic Netlink will happily allocate to one of its families as well).

## Strict checking

The NETLINK\_GET\_STRICT\_CHK socket option enables strict input checking in NETLINK\_ROUTE. It was needed because historically kernel did not validate the fields of structures it didn't process. This made it impossible to start using those fields later without risking regressions in applications which initialized them incorrectly or not at all.

NETLINK\_GET\_STRICT\_CHK declares that the application is initializing all fields correctly. It also opts into validating that message does not contain trailing data and requests that kernel rejects attributes with type higher than largest attribute type known to the kernel.

NETLINK\_GET\_STRICT\_CHK is not used outside of NETLINK\_ROUTE.

## Unknown attributes

Historically Netlink ignored all unknown attributes. The thinking was that it would free the application from having to probe what kernel supports. The application could make a request to change the state and check which parts of the request "stuck".

This is no longer the case for new Generic Netlink families and those opting in to strict checking. See enum netlink\_validation for validation types performed.

## Fixed metadata and structures

Classic Netlink made liberal use of fixed-format structures within the messages. Messages would commonly have a structure with a considerable number of fields after *struct nlmsghdr*. It was also common to put structures with multiple members inside attributes, without breaking each member into an attribute of its own.

This has caused problems with validation and extensibility and therefore using binary structures is actively discouraged for new attributes.

## Request types

NETLINK\_ROUTE categorized requests into 4 types NEW, DEL, GET, and SET. Each object can handle all or some of those requests (objects being netdevs, routes, addresses, qdiscs etc.) Request type is defined by the 2 lowest bits of the message type, so commands for new objects would always be allocated with a stride of 4.

Each object would also have its own fixed metadata shared by all request types (e.g. struct ifinfomsg for netdev requests, struct ifaddrmsg for address requests, struct tcmsg for qdisc requests).

Even though other protocols and Generic Netlink commands often use the same verbs in their message names (GET, SET) the concept of request types did not find wider adoption.

## Notification echo

`NLM_F_ECHO` requests for notifications resulting from the request to be queued onto the requesting socket. This is useful to discover the impact of the request.

Note that this feature is not universally implemented.

## Other request-type-specific flags

Classic Netlink defined various flags for its GET, NEW and DEL requests in the upper byte of `nlmsgh_flags` in *struct nlmsghdr*. Since request types have not been generalized the request type specific flags are rarely used (and considered deprecated for new families).

For GET - `NLM_F_ROOT` and `NLM_F_MATCH` are combined into `NLM_F_DUMP`, and not used separately. `NLM_F_ATOMIC` is never used.

For DEL - `NLM_F_NONREC` is only used by nftables and `NLM_F_BULK` only by FDB some operations.

The flags for NEW are used most commonly in classic Netlink. Unfortunately, the meaning is not crystal clear. The following description is based on the best guess of the intention of the authors, and in practice all families stray from it in one way or another. `NLM_F_REPLACE` asks to replace an existing object, if no matching object exists the operation should fail. `NLM_F_EXCL` has the opposite semantics and only succeeds if object already existed. `NLM_F_CREATE` asks for the object to be created if it does not exist, it can be combined with `NLM_F_REPLACE` and `NLM_F_EXCL`.

A comment in the main Netlink uAPI header states:

4.4BSD ADD	<code>NLM_F_CREATE NLM_F_EXCL</code>
4.4BSD CHANGE	<code>NLM_F_REPLACE</code>
True CHANGE	<code>NLM_F_CREATE NLM_F_REPLACE</code>
Append	<code>NLM_F_CREATE</code>
Check	<code>NLM_F_EXCL</code>

which seems to indicate that those flags predate request types. `NLM_F_REPLACE` without `NLM_F_CREATE` was initially used instead of SET commands. `NLM_F_EXCL` without `NLM_F_CREATE` was used to check if object exists without creating it, presumably predating GET commands.

`NLM_F_APPEND` indicates that if one key can have multiple objects associated with it (e.g. multiple next-hop objects for a route) the new object should be added to the list rather than replacing the entire list.

### 14.1.5 uAPI reference

#### struct `nlmsghdr`

fixed format metadata header of Netlink messages

#### Definition:

```
struct nlmsghdr {
    __u32 nlmsg_len;
    __u16 nlmsg_type;
```

```

__u16 nlmsg_flags;
__u32 nlmsg_seq;
__u32 nlmsg_pid;
};

```

## Members

### **nlmsg\_len**

Length of message including header

### **nlmsg\_type**

Message content type

### **nlmsg\_flags**

Additional flags

### **nlmsg\_seq**

Sequence number

### **nlmsg\_pid**

Sending process port ID

### **enum nlmsgerr\_attrs**

nlmsgerr attributes

## Constants

### **NLMSGERR\_ATTR\_UNUSED**

unused

### **NLMSGERR\_ATTR\_MSG**

error message string (string)

### **NLMSGERR\_ATTR\_OFFS**

offset of the invalid attribute in the original message, counting from the beginning of the header (u32)

### **NLMSGERR\_ATTR\_COOKIE**

arbitrary subsystem specific cookie to be used - in the success case - to identify a created object or operation or similar (binary)

### **NLMSGERR\_ATTR\_POLICY**

policy for a rejected attribute

### **NLMSGERR\_ATTR\_MISS\_TYPE**

type of a missing required attribute, NLMSGERR\_ATTR\_MISS\_NEST will not be present if the attribute was missing at the message level

### **NLMSGERR\_ATTR\_MISS\_NEST**

offset of the nest where attribute was missing

### **\_\_NLMSGERR\_ATTR\_MAX**

number of attributes

### **NLMSGERR\_ATTR\_MAX**

highest attribute number

### **enum netlink\_attribute\_type**

type of an attribute

## Constants

**NL\_ATTR\_TYPE\_INVALID**

unused

**NL\_ATTR\_TYPE\_FLAG**

flag attribute (present/not present)

**NL\_ATTR\_TYPE\_U8**

8-bit unsigned attribute

**NL\_ATTR\_TYPE\_U16**

16-bit unsigned attribute

**NL\_ATTR\_TYPE\_U32**

32-bit unsigned attribute

**NL\_ATTR\_TYPE\_U64**

64-bit unsigned attribute

**NL\_ATTR\_TYPE\_S8**

8-bit signed attribute

**NL\_ATTR\_TYPE\_S16**

16-bit signed attribute

**NL\_ATTR\_TYPE\_S32**

32-bit signed attribute

**NL\_ATTR\_TYPE\_S64**

64-bit signed attribute

**NL\_ATTR\_TYPE\_BINARY**

binary data, min/max length may be specified

**NL\_ATTR\_TYPE\_STRING**

string, min/max length may be specified

**NL\_ATTR\_TYPE\_NUL\_STRING**

NUL-terminated string, min/max length may be specified

**NL\_ATTR\_TYPE\_NESTED**

nested, i.e. the content of this attribute consists of sub-attributes. The nested policy and maxtype inside may be specified.

**NL\_ATTR\_TYPE\_NESTED\_ARRAY**

nested array, i.e. the content of this attribute contains sub-attributes whose type is irrelevant (just used to separate the array entries) and each such array entry has attributes again, the policy for those inner ones and the corresponding maxtype may be specified.

**NL\_ATTR\_TYPE\_BITFIELD32**

struct nla\_bitfield32 attribute

**NL\_ATTR\_TYPE\_SINT**

32-bit or 64-bit signed attribute, aligned to 4B

**NL\_ATTR\_TYPE\_UINT**

32-bit or 64-bit unsigned attribute, aligned to 4B

enum **netlink\_policy\_type\_attr**

policy type attributes

## Constants

**NL\_POLICY\_TYPE\_ATTR\_UNSPEC**

unused

**NL\_POLICY\_TYPE\_ATTR\_TYPE**

type of the attribute, *enum netlink\_attribute\_type* (U32)

**NL\_POLICY\_TYPE\_ATTR\_MIN\_VALUE\_S**

minimum value for signed integers (S64)

**NL\_POLICY\_TYPE\_ATTR\_MAX\_VALUE\_S**

maximum value for signed integers (S64)

**NL\_POLICY\_TYPE\_ATTR\_MIN\_VALUE\_U**

minimum value for unsigned integers (U64)

**NL\_POLICY\_TYPE\_ATTR\_MAX\_VALUE\_U**

maximum value for unsigned integers (U64)

**NL\_POLICY\_TYPE\_ATTR\_MIN\_LENGTH**

minimum length for binary attributes, no minimum if not given (U32)

**NL\_POLICY\_TYPE\_ATTR\_MAX\_LENGTH**

maximum length for binary attributes, no maximum if not given (U32)

**NL\_POLICY\_TYPE\_ATTR\_POLICY\_IDX**

sub policy for nested and nested array types (U32)

**NL\_POLICY\_TYPE\_ATTR\_POLICY\_MAXTYPE**

maximum sub policy attribute for nested and nested array types, this can in theory be < the size of the policy pointed to by the index, if limited inside the nesting (U32)

**NL\_POLICY\_TYPE\_ATTR\_BITFIELD32\_MASK**

valid mask for the bitfield32 type (U32)

**NL\_POLICY\_TYPE\_ATTR\_PAD**

pad attribute for 64-bit alignment

**NL\_POLICY\_TYPE\_ATTR\_MASK**

mask of valid bits for unsigned integers (U64)

**\_\_NL\_POLICY\_TYPE\_ATTR\_MAX**

number of attributes

**NL\_POLICY\_TYPE\_ATTR\_MAX**

highest attribute number

## 14.2 Using Netlink protocol specifications

This document is a quick starting guide for using Netlink protocol specifications. For more detailed description of the specs see [Netlink protocol specifications \(in YAML\)](#).

### 14.2.1 Simple CLI

Kernel comes with a simple CLI tool which should be useful when developing Netlink related code. The tool is implemented in Python and can use a YAML specification to issue Netlink requests to the kernel. Only Generic Netlink is supported.

The tool is located at `tools/net/ynl/cli.py`. It accepts a handful of arguments, the most important ones are:

- `--spec` - point to the spec file
- `--do $name / --dump $name` - issue request `$name`
- `--json $attrs` - provide attributes for the request
- `--subscribe $group` - receive notifications from `$group`

YAML specs can be found under `Documentation/netlink/specs/`.

Example use:

```
$ ./tools/net/ynl/cli.py --spec Documentation/netlink/specs/ethtool.yaml \
    --do rings-get \
    --json '{"header":{"dev-index": 18}}'
{'header': {'dev-index': 18, 'dev-name': 'en1np1'},
 'rx': 0,
 'rx-jumbo': 0,
 'rx-jumbo-max': 4096,
 'rx-max': 4096,
 'rx-mini': 0,
 'rx-mini-max': 4096,
 'tx': 0,
 'tx-max': 4096,
 'tx-push': 0}
```

The input arguments are parsed as JSON, while the output is only Python-pretty-printed. This is because some Netlink types can't be expressed as JSON directly. If such attributes are needed in the input some hacking of the script will be necessary.

The spec and Netlink internals are factored out as a standalone library - it should be easy to write Python tools / tests reusing code from `cli.py`.

### 14.2.2 Generating kernel code

`tools/net/ynl/ynl-regen.sh` scans the kernel tree in search of auto-generated files which need to be updated. Using this tool is the easiest way to generate / update auto-generated code.

By default code is re-generated only if spec is newer than the source, to force regeneration use `-f`.

`ynl-regen.sh` searches for YNL-GEN in the contents of files (note that it only scans files in the git index, that is only files tracked by git!) For instance the `fou_nl.c` kernel source contains:

```
/* Documentation/netlink/specs/fou.yaml */
/* YNL-GEN kernel source */
```

`ynl-regen.sh` will find this marker and replace the file with kernel source based on `fou.yaml`.

The simplest way to generate a new file based on a spec is to add the two marker lines like above to a file, add that file to git, and run the regeneration tool. Grep the tree for YNL-GEN to see other examples.

The code generation itself is performed by `tools/net/ynl/ynl-gen-c.py` but it takes a few arguments so calling it directly for each file quickly becomes tedious.

### 14.2.3 YNL lib

`tools/net/ynl/lib/` contains an implementation of a C library (based on `libmnl`) which integrates with code generated by `tools/net/ynl/ynl-gen-c.py` to create easy to use netlink wrappers.

#### YNL basics

The YNL library consists of two parts - the generic code (functions prefix by `ynl_`) and per-family auto-generated code (prefixed with the name of the family).

To create a YNL socket call `ynl_sock_create()` passing the family struct (family structs are exported by the auto-generated code). `ynl_sock_destroy()` closes the socket.

#### YNL requests

Steps for issuing YNL requests are best explained on an example. All the functions and types in this example come from the auto-generated code (for the `netdev` family in this case):

```
// 0. Request and response pointers
struct netdev_dev_get_req *req;
struct netdev_dev_get_rsp *d;

// 1. Allocate a request
req = netdev_dev_get_req_alloc();
// 2. Set request parameters (as needed)
netdev_dev_get_req_set_ifindex(req, ifindex);
```

```
// 3. Issues the request
d = netdev_dev_get(ys, req);
// 4. Free the request arguments
netdev_dev_get_req_free(req);
// 5. Error check (the return value from step 3)
if (!d) {
    // 6. Print the YNL-generated error
    fprintf(stderr, "YNL: %s\n", ys->err.msg);
    return -1;
}

// ... do stuff with the response @d

// 7. Free response
netdev_dev_get_rsp_free(d);
```

### YNL dumps

Performing dumps follows similar pattern as requests. Dumps return a list of objects terminated by a special marker, or NULL on error. Use `ynl_dump_foreach()` to iterate over the result.

### YNL notifications

YNL lib supports using the same socket for notifications and requests. In case notifications arrive during processing of a request they are queued internally and can be retrieved at a later time.

To subscribe to notifications use `ynl_subscribe()`. The notifications have to be read out from the socket, `ynl_socket_get_fd()` returns the underlying socket fd which can be plugged into appropriate asynchronous IO API like `poll`, or `select`.

Notifications can be retrieved using `ynl_ntf_dequeue()` and have to be freed using `ynl_ntf_free()`. Since we don't know the notification type upfront the notifications are returned as `struct ynl_ntf_base_type *` and user is expected to cast them to the appropriate full type based on the `cmd` member.

## 14.3 Netlink protocol specifications (in YAML)

Netlink protocol specifications are complete, machine readable descriptions of Netlink protocols written in YAML. The goal of the specifications is to allow separating Netlink parsing from user space logic and minimize the amount of hand written Netlink code for each new family, command, attribute. Netlink specs should be complete and not depend on any other spec or C header file, making it easy to use in languages which can't include kernel headers directly.

Internally kernel uses the YAML specs to generate:

- the C uAPI header
- documentation of the protocol as a ReST file - see Documentation/networking/netlink\_spec/index.rst

- policy tables for input attribute validation
- operation tables

YAML specifications can be found under [Documentation/netlink/specs/](#)

This document describes details of the schema. See [\*Using Netlink protocol specifications\*](#) for a practical starting guide.

All specs must be licensed under ((GPL-2.0 WITH Linux-syscall-note) OR BSD-3-Clause) to allow for easy adoption in user space code.

### 14.3.1 Compatibility levels

There are four schema levels for Netlink specs, from the simplest used by new families to the most complex covering all the quirks of the old ones. Each next level inherits the attributes of the previous level, meaning that user capable of parsing more complex genetlink schemas is also compatible with simpler ones. The levels are:

- `genetlink` - most streamlined, should be used by all new families
- `genetlink-c` - superset of `genetlink` with extra attributes allowing customization of define and enum type and value names; this schema should be equivalent to `genetlink` for all implementations which don't interact directly with C uAPI headers
- `genetlink-legacy` - Generic Netlink catch all schema supporting quirks of all old genetlink families, strange attribute formats, binary structures etc.
- `netlink-raw` - catch all schema supporting pre-Generic Netlink protocols such as `NETLINK_ROUTE`

The definition of the schemas (in `jsonschema`) can be found under [Documentation/netlink/](#).

### 14.3.2 Schema structure

YAML schema has the following conceptual sections:

- `globals`
- `definitions`
- `attributes`
- `operations`
- `multicast groups`

Most properties in the schema accept (or in fact require) a `doc` sub-property documenting the defined object.

The following sections describe the properties of the most modern `genetlink` schema. See the documentation of [`genetlink-c`](#) for information on how C names are derived from name properties.

See also [Documentation/core-api/netlink.rst](#) for information on the Netlink specification properties that are only relevant to the kernel space and not part of the user space API.

### 14.3.3 genetlink

#### Globals

Attributes listed directly at the root level of the spec file.

##### **name**

Name of the family. Name identifies the family in a unique way, since the Family IDs are allocated dynamically.

##### **protocol**

The schema level, default is `genetlink`, which is the only value allowed for new `genetlink` families.

#### definitions

Array of type and constant definitions.

##### **name**

Name of the type / constant.

##### **type**

One of the following types:

- `const` - a single, standalone constant
- `enum` - defines an integer enumeration, with values for each entry incrementing by 1, (e.g. 0, 1, 2, 3)
- `flags` - defines an integer enumeration, with values for each entry occupying a bit, starting from bit 0, (e.g. 1, 2, 4, 8)

##### **value**

The value for the `const`.

## **value-start**

The first value for enum and flags, allows overriding the default start value of 0 (for enum) and starting bit (for flags). For flags value-start selects the starting bit, not the shifted value. Sparse enumerations are not supported.

## **entries**

Array of names of the entries for enum and flags.

## **header**

For C-compatible languages, header which already defines this value. In case the definition is shared by multiple families (e.g. IFNAMSIZ) code generators for C-compatible languages may prefer to add an appropriate include instead of rendering a new definition.

## **attribute-sets**

This property contains information about netlink attributes of the family. All families have at least one attribute set, most have multiple. attribute-sets is an array, with each entry describing a single set.

Note that the spec is "flattened" and is not meant to visually resemble the format of the netlink messages (unlike certain ad-hoc documentation formats seen in kernel comments). In the spec subordinate attribute sets are not defined inline as a nest, but defined in a separate attribute set referred to with a nested-attributes property of the container.

Spec may also contain fractional sets - sets which contain a subset-of property. Such sets describe a section of a full set, allowing narrowing down which attributes are allowed in a nest or refining the validation criteria. Fractional sets can only be used in nests. They are not rendered to the uAPI in any fashion.

## **name**

Uniquely identifies the attribute set, operations and nested attributes refer to the sets by the name.

## **subset-of**

Re-defines a portion of another set (a fractional set). Allows narrowing down fields and changing validation criteria or even types of attributes depending on the nest in which they are contained. The value of each attribute in the fractional set is implicitly the same as in the main set.

## **attributes**

List of attributes in the set.

### **Attribute properties**

#### **name**

Identifies the attribute, unique within the set.

#### **type**

Netlink attribute type, see [\*Attribute types\*](#).

#### **value**

Numerical attribute ID, used in serialized Netlink messages. The `value` property can be skipped, in which case the attribute ID will be the value of the previous attribute plus one (recursively) and 1 for the first attribute in the attribute set.

Attributes (and operations) use 1 as the default value for the first entry (unlike enums in definitions which start from 0) because entry 0 is almost always reserved as undefined. Spec can explicitly set value to 0 if needed.

Note that the `value` of an attribute is defined only in its main set (not in subsets).

#### **enum**

For integer types specifies that values in the attribute belong to an `enum` or `flags` from the `definitions` section.

#### **enum-as-flags**

Treat `enum` as `flags` regardless of its type in `definitions`. When both `enum` and `flags` forms are needed `definitions` should contain an `enum` and attributes which need the `flags` form should use this attribute.

#### **nested-attributes**

Identifies the attribute space for attributes nested within given attribute. Only valid for complex attributes which may have sub-attributes.

## multi-attr (arrays)

Boolean property signifying that the attribute may be present multiple times. Allowing an attribute to repeat is the recommended way of implementing arrays (no extra nesting).

## byte-order

For integer types specifies attribute byte order - little-endian or big-endian.

## checks

Input validation constraints used by the kernel. User space should query the policy of the running kernel using Generic Netlink introspection, rather than depend on what is specified in the spec file.

The validation policy in the kernel is formed by combining the type definition (type and nested-attributes) and the checks.

## sub-type

Legacy families have special ways of expressing arrays. sub-type can be used to define the type of array members in case array members are not fully defined as attributes (in a bona fide attribute space). For instance a C array of u32 values can be specified with type: binary and sub-type: u32. Binary types and legacy array formats are described in more detail in [Netlink specification support for legacy Generic Netlink families](#).

## display-hint

Optional format indicator that is intended only for choosing the right formatting mechanism when displaying values of this type. Currently supported hints are hex, mac, fddi, ipv4, ipv6 and uuid.

## operations

This section describes messages passed between the kernel and the user space. There are three types of entries in this section - operations, notifications and events.

Operations describe the most common request - response communication. User sends a request and kernel replies. Each operation may contain any combination of the two modes familiar to netlink users - do and dump. do and dump in turn contain a combination of request and response properties. If no explicit message with attributes is passed in a given direction (e.g. a dump which does not accept filter, or a do of a SET operation to which the kernel responds with just the netlink error code) request or response section can be skipped. request and response sections list the attributes allowed in a message. The list contains only the names of attributes from a set referred to by the attribute-set property.

Notifications and events both refer to the asynchronous messages sent by the kernel to members of a multicast group. The difference between the two is that a notification shares its contents

with a GET operation (the name of the GET operation is specified in the `notify` property). This arrangement is commonly used for notifications about objects where the notification carries the full object definition.

Events are more focused and carry only a subset of information rather than full object state (a made up example would be a link state change event with just the interface name and the new link state). Events contain the `event` property. Events are considered less idiomatic for netlink and notifications should be preferred.

### **list**

The only property of operations for genetlink, holds the list of operations, notifications etc.

## **Operation properties**

### **name**

Identifies the operation.

### **value**

Numerical message ID, used in serialized Netlink messages. The same enumeration rules are applied as to [attribute values](#).

### **attribute-set**

Specifies the attribute set contained within the message.

### **do**

Specification for the `doit` request. Should contain `request`, `reply` or both of these properties, each holding a [Message attribute list](#).

### **dump**

Specification for the `dumpit` request. Should contain `request`, `reply` or both of these properties, each holding a [Message attribute list](#).

## notify

Designates the message as a notification. Contains the name of the operation (possibly the same as the operation holding this property) which shares the contents with the notification (do).

## event

Specification of attributes in the event, holds a *Message attribute list*. event property is mutually exclusive with notify.

## mcgrp

Used with event and notify, specifies which multicast group message belongs to.

### Message attribute list

request, reply and event properties have a single attributes property which holds the list of attribute names.

Messages can also define pre and post properties which will be rendered as pre\_doit and post\_doit calls in the kernel (these properties should be ignored by user space).

## mcast-groups

This section lists the multicast groups of the family.

### list

The only property of mcast-groups for genetlink, holds the list of groups.

### Multicast group properties

#### name

Uniquely identifies the multicast group in the family. Similarly to Family ID, Multicast Group ID needs to be resolved at runtime, based on the name.

### 14.3.4 Attribute types

This section describes the attribute types supported by the genetlink compatibility level. Refer to documentation of different levels for additional attribute types.

#### Common integer types

`sint` and `uint` represent signed and unsigned 64 bit integers. If the value can fit on 32 bits only 32 bits are carried in netlink messages, otherwise full 64 bits are carried. Note that the payload is only aligned to 4B, so the full 64 bit value may be unaligned!

Common integer types should be preferred over fix-width types in majority of cases.

#### Fix-width integer types

Fixed-width integer types include: `u8`, `u16`, `u32`, `u64`, `s8`, `s16`, `s32`, `s64`.

Note that types smaller than 32 bit should be avoided as using them does not save any memory in Netlink messages (due to alignment). See [pad](#) for padding of 64 bit attributes.

The payload of the attribute is the integer in host order unless `byte-order` specifies otherwise.

64 bit values are usually aligned by the kernel but it is recommended that the user space is able to deal with unaligned values.

#### **pad**

Special attribute type used for padding attributes which require alignment bigger than standard 4B alignment required by netlink (e.g. 64 bit integers). There can only be a single attribute of the `pad` type in any attribute set and it should be automatically used for padding when needed.

#### **flag**

Attribute with no payload, its presence is the entire information.

#### **binary**

Raw binary data attribute, the contents are opaque to generic code.

#### **string**

Character string. Unless `checks` has `unterminated-ok` set to `true` the string is required to be null terminated. `max-len` in `checks` indicates the longest possible string, if not present the length of the string is unbounded.

Note that `max-len` does not count the terminating character.

## nest

Attribute containing other (nested) attributes. `nested-attributes` specifies which attribute set is used inside.

## 14.4 Netlink spec C code generation

This document describes how Netlink specifications are used to render C code (uAPI, policies etc.). It also defines the additional properties allowed in older families by the `genetlink-c` protocol level, to control the naming.

For brevity this document refers to name properties of various objects by the object type. For example `$attr` is the value of `name` in an attribute, and `$family` is the name of the family (the global `name` property).

The upper case is used to denote literal values, e.g. `$family-CMD` means the concatenation of `$family`, a dash character, and the literal `CMD`.

The names of `#defines` and enum values are always converted to upper case, and with dashes (-) replaced by underscores (\_).

If the constructed name is a C keyword, an extra underscore is appended (do -> do\\_).

### 14.4.1 Globals

`c-family-name` controls the name of the `#define` for the family name, default is `$family-FAMILY-NAME`.

`c-version-name` controls the name of the `#define` for the version of the family, default is `$family-FAMILY-VERSION`.

`max-by-define` selects if max values for enums are defined as a `#define` rather than inside the enum.

### 14.4.2 Definitions

#### Constants

Every constant is rendered as a `#define`. The name of the constant is `$family-$constant` and the value is rendered as a string or integer according to its type in the spec.

#### Enums and flags

Enums are named `$family-$enum`. The full name can be set directly or suppressed by specifying the `enum-name` property. Default entry name is `$family-$enum-$entry`. If `name-prefix` is specified it replaces the `$family-$enum` portion of the entry name.

Boolean `render-max` controls creation of the max values (which are enabled by default for attribute enums).

### **14.4.3 Attributes**

Each attribute set (excluding fractional sets) is rendered as an enum.

Attribute enums are traditionally unnamed in netlink headers. If naming is desired `enum-name` can be used to specify the name.

The default attribute name prefix is `$family-A` if the name of the set is the same as the name of the family and `$family-A-$set` if the names differ. The prefix can be overridden by the `name-prefix` property of a set. The rest of the section will refer to the prefix as `$pfx`.

Attributes are named `$pfx-$attribute`.

Attribute enums end with two special values `__$pfx-MAX` and `$pfx-MAX` which are used for sizing attribute tables. These two names can be specified directly with the `attr-cnt-name` and `attr-max-name` properties respectively.

If `max-by-define` is set to `true` at the global level `attr-max-name` will be specified as a `#define` rather than an enum value.

### **14.4.4 Operations**

Operations are named `$family-CMD-$operation`. If `name-prefix` is specified it replaces the `$family-CMD` portion of the name.

Similarly to attribute enums operation enums end with special count and max attributes. For operations those attributes can be renamed with `cmd-cnt-name` and `cmd-max-name`. Max will be a define if `max-by-define` is true.

### **14.4.5 Multicast groups**

Each multicast group gets a define rendered into the kernel uAPI header. The name of the define is `$family-MGRP-$group`, and can be overwritten with the `c-define-name` property.

### **14.4.6 Code generation**

uAPI header is assumed to come from `<linux/$family.h>` in the default header search path. It can be changed using the `uapi-header` global property.

## **14.5 Netlink specification support for legacy Generic Netlink families**

This document describes the many additional quirks and properties required to describe older Generic Netlink families which form the `genetlink-legacy` protocol level.

## 14.5.1 Specification

### Globals

Attributes listed directly at the root level of the spec file.

### version

Generic Netlink family version, default is 1.

version has historically been used to introduce family changes which may break backwards compatibility. Since compatibility breaking changes are generally not allowed version is very rarely used.

### Attribute type nests

New Netlink families should use `multi-attr` to define arrays. Older families (e.g. genetlink control family) attempted to define array types reusing attribute type to carry information.

For reference the `multi-attr` array may look like this:

```
[ARRAY-ATTR]
[INDEX (optionally)]
[MEMBER1]
[MEMBER2]
[SOME-OTHER-ATTR]
[ARRAY-ATTR]
[INDEX (optionally)]
[MEMBER1]
[MEMBER2]
```

where `ARRAY-ATTR` is the array entry type.

### array-nest

`array-nest` creates the following structure:

```
[SOME-OTHER-ATTR]
[ARRAY-ATTR]
[ENTRY]
[MEMBER1]
[MEMBER2]
[ENTRY]
[MEMBER1]
[MEMBER2]
```

It wraps the entire array in an extra attribute (hence limiting its size to 64kB). The `ENTRY` nests are special and have the index of the entry as their type instead of normal attribute type.

## type-value

type-value is a construct which uses attribute types to carry information about a single object (often used when array is dumped entry-by-entry).

type-value can have multiple levels of nesting, for example genetlink's policy dumps create the following structures:

```
[POLICY-IDX]
 [ATTR-IDX]
 [POLICY-INFO-ATTR1]
 [POLICY-INFO-ATTR2]
```

Where the first level of nest has the policy index as it's attribute type, it contains a single nest which has the attribute index as its type. Inside the attr-index nest are the policy attributes. Modern Netlink families should have instead defined this as a flat structure, the nesting serves no good purpose here.

## 14.5.2 Operations

### Enum (message ID) model

#### unified

Modern families use the unified message ID model, which uses a single enumeration for all messages within family. Requests and responses share the same message ID. Notifications have separate IDs from the same space. For example given the following list of operations:

```
-  
  name: a  
  value: 1  
  do: ...  
  
-  
  name: b  
  do: ...  
  
-  
  name: c  
  value: 4  
  notify: a  
  
-  
  name: d  
  do: ...
```

Requests and responses for operation a will have the ID of 1, the requests and responses of b - 2 (since there is no explicit value it's previous operation + 1). Notification c will use the ID of 4, operation d 5 etc.

## directional

The directional model splits the ID assignment by the direction of the message. Messages from and to the kernel can't be confused with each other so this conserves the ID space (at the cost of making the programming more cumbersome).

In this case `value` attribute should be specified in the `request` `reply` sections of the operations (if an operation has both `do` and `dump` the IDs are shared, `value` should be set in `do`). For notifications the `value` is provided at the `op` level but it only allocates a `reply` (i.e. a "from-kernel" ID). Let's look at an example:

```

-
  name: a
  do:
    request:
      value: 2
      attributes: ...
    reply:
      value: 1
      attributes: ...
-
  name: b
  notify: a
-
  name: c
  notify: a
  value: 7
-
  name: d
  do: ...
-
```

In this case `a` will use 2 when sending the message to the kernel and expects message with ID 1 in response. Notification `b` allocates a "from-kernel" ID which is 2. `c` allocates "from-kernel" ID of 7. If operation `d` does not set `values` explicitly in the spec it will be allocated 3 for the request (`a` is the previous operation with a `request` section and the value of 2) and 8 for response (`c` is the previous operation in the "from-kernel" direction).

### 14.5.3 Other quirks

#### Structures

Legacy families can define C structures both to be used as the contents of an attribute and as a fixed message header. Structures are defined in `definitions` and referenced in operations or attributes.

## members

- name - The attribute name of the struct member
- type - One of the scalar types u8, u16, u32, u64, s8, s16, s32, s64, string, binary or bitfield32.
- byte-order - big-endian or little-endian
- doc, enum, enum-as-flags, display-hint - Same as for *attribute definitions*

Note that structures defined in YAML are implicitly packed according to C conventions. For example, the following struct is 4 bytes, not 6 bytes:

```
struct {
    u8 a;
    u16 b;
    u8 c;
}
```

Any padding must be explicitly added and C-like languages should infer the need for explicit padding from whether the members are naturally aligned.

Here is the struct definition from above, declared in YAML:

```
definitions:
  -
    name: message-header
    type: struct
    members:
      -
        name: a
        type: u8
      -
        name: b
        type: u16
      -
        name: c
        type: u8
```

## Fixed Headers

Fixed message headers can be added to operations using fixed-header. The default fixed-header can be set in operations and it can be set or overridden for each operation.

```
operations:
  fixed-header: message-header
  list:
    -
      name: get
      fixed-header: custom-header
      attribute-set: message-attrs
```

## Attributes

A binary attribute can be interpreted as a C structure using a `struct` property with the name of the structure definition. The `struct` property implies sub-type: `struct` so it is not necessary to specify a sub-type.

### **attribute-sets:**

```

name: stats-attrs
attributes:

    name: stats
    type: binary
    struct: vport-stats

```

## C Arrays

Legacy families also use binary attributes to encapsulate C arrays. The sub-type is used to identify the type of scalar to extract.

### **attributes:**

```

name: ports
type: binary
sub-type: u32

```

## Multi-message DO

New Netlink families should never respond to a DO operation with multiple replies, with `NLM_F_MULTI` set. Use a filtered dump instead.

At the spec level we can define a `dumps` property for the `do`, perhaps with values of `combine` and `multi-object` depending on how the parsing should be implemented (parse into a single reply vs list of objects i.e. pretty much a dump).

## 14.6 Netlink specification support for raw Netlink families

This document describes the additional properties required by raw Netlink families such as `NETLINK_ROUTE` which use the netlink-raw protocol specification.

### 14.6.1 Specification

The netlink-raw schema extends the [genetlink-legacy](#) schema with properties that are needed to specify the protocol numbers and multicast IDs used by raw netlink families. See [Classic Netlink](#) for more information. The raw netlink families also make use of type-specific sub-messages.

#### Globals

##### protonum

The `protonum` property is used to specify the protocol number to use when opening a netlink socket.

```
# SPDX-License-Identifier: ((GPL-2.0 WITH Linux-syscall-note) OR BSD-3-Clause)

name: rt-addr
protocol: netlink-raw
protonum: 0          # part of the NETLINK_ROUTE protocol
```

#### Multicast group properties

##### value

The `value` property is used to specify the group ID to use for multicast group registration.

```
mcast-groups:
  list:
    -
      name: rtnlgrp-ipv4-ifaddr
      value: 5
    -
      name: rtnlgrp-ipv6-ifaddr
      value: 9
    -
      name: rtnlgrp-mctp-ifaddr
      value: 34
```

#### Sub-messages

Several raw netlink families such as `rt_link` and `tc` use attribute nesting as an abstraction to carry module specific information.

Conceptually it looks as follows:

```
[OUTER NEST OR MESSAGE LEVEL]
[GENERIC ATTR 1]
[GENERIC ATTR 2]
[GENERIC ATTR 3]
[GENERIC ATTR - wrapper]
```

```
[MODULE SPECIFIC ATTR 1]
[MODULE SPECIFIC ATTR 2]
```

The GENERIC ATTRs at the outer level are defined in the core (or rt\_link or core TC), while specific drivers, TC classifiers, qdiscs etc. can carry their own information wrapped in the GENERIC ATTR - wrapper. Even though the example above shows attributes nesting inside the wrapper, the modules generally have full freedom to define the format of the nest. In practice the payload of the wrapper attr has very similar characteristics to a netlink message. It may contain a fixed header / structure, netlink attributes, or both. Because of those shared characteristics we refer to the payload of the wrapper attribute as a sub-message.

A sub-message attribute uses the value of another attribute as a selector key to choose the right sub-message format. For example if the following attribute has already been decoded:

```
{ "kind": "gre" }
```

and we encounter the following attribute spec:

```
-  
  name: data  
  type: sub-message  
  sub-message: linkinfo-data-msg  
  selector: kind
```

Then we look for a sub-message definition called linkinfo-data-msg and use the value of the kind attribute i.e. gre as the key to choose the correct format for the sub-message:

```
sub-messages:  
  name: linkinfo-data-msg  
  formats:  
  
    -  
      value: bridge  
      attribute-set: linkinfo-bridge-attrs  
  
    -  
      value: gre  
      attribute-set: linkinfo-gre-attrs  
  
    -  
      value: geneve  
      attribute-set: linkinfo-geneve-attrs
```

This would decode the attribute value as a sub-message with the attribute-set called linkinfo-gre-attrs as the attribute space.

A sub-message can have an optional fixed-header followed by zero or more attributes from an attribute-set. For example the following tc-options-msg sub-message defines message formats that use a mixture of fixed-header, attribute-set or both together:

```
sub-messages:  
  -  
    name: tc-options-msg  
    formats:  
      -
```

```
value: bfifo
fixed-header: tc-fifo-qopt

-
value: cake
attribute-set: tc-cake-attrs

-
value: netem
fixed-header: tc-netem-qopt
attribute-set: tc-netem-attrs
```

Note that a selector attribute must appear in a netlink message before any sub-message attributes that depend on it.

**See also:**

- Documentation/core-api/netlink.rst
- Documentation/networking/netlink\_spec/index.rst

## **PLATFORM PROFILE SELECTION (E.G. /SYS/FIRMWARE/ACPI/PLATFORM\_PROFILE)**

On modern systems the platform performance, temperature, fan and other hardware related characteristics are often dynamically configurable. The platform configuration is often automatically adjusted to the current conditions by some automatic mechanism (which may very well live outside the kernel).

These auto platform adjustment mechanisms often can be configured with one of several platform profiles, with either a bias towards low power operation or towards performance.

The purpose of the platform\_profile attribute is to offer a generic sysfs API for selecting the platform profile of these automatic mechanisms.

Note that this API is only for selecting the platform profile, it is NOT a goal of this API to allow monitoring the resulting performance characteristics. Monitoring performance is best done with device/vendor specific tools such as e.g. turbostat.

Specifically when selecting a high performance profile the actual achieved performance may be limited by various factors such as: the heat generated by other components, room temperature, free air flow at the bottom of a laptop, etc. It is explicitly NOT a goal of this API to let userspace know about any sub-optimal conditions which are impeding reaching the requested performance level.

Since numbers on their own cannot represent the multiple variables that a profile will adjust (power consumption, heat generation, etc) this API uses strings to describe the various profiles. To make sure that userspace gets a consistent experience the sysfs-platform\_profile ABI document defines a fixed set of profile names. Drivers *must* map their internal profile representation onto this fixed set.

If there is no good match when mapping then a new profile name may be added. Drivers which wish to introduce new profile names must:

1. Explain why the existing profile names cannot be used.
2. Add the new profile name, along with a clear description of the expected behaviour, to the sysfs-platform\_profile ABI documentation.



## VDUSE - "VDPA DEVICE IN USERSPACE"

vDPA (virtio data path acceleration) device is a device that uses a datapath which complies with the virtio specifications with vendor specific control path. vDPA devices can be both physically located on the hardware or emulated by software. VDUSE is a framework that makes it possible to implement software-emulated vDPA devices in userspace. And to make the device emulation more secure, the emulated vDPA device's control path is handled in the kernel and only the data path is implemented in the userspace.

Note that only virtio block device is supported by VDUSE framework now, which can reduce security risks when the userspace process that implements the data path is run by an unprivileged user. The support for other device types can be added after the security issue of corresponding device driver is clarified or fixed in the future.

### 16.1 Create/Destroy VDUSE devices

VDUSE devices are created as follows:

1. Create a new VDUSE instance with ioctl(VDUSE\_CREATE\_DEV) on /dev/vduse/control.
2. Setup each virtqueue with ioctl(VDUSE\_VQ\_SETUP) on /dev/vduse/\$NAME.
3. Begin processing VDUSE messages from /dev/vduse/\$NAME. The first messages will arrive while attaching the VDUSE instance to vDPA bus.
4. Send the VDPA\_CMD\_DEV\_NEW netlink message to attach the VDUSE instance to vDPA bus.

VDUSE devices are destroyed as follows:

1. Send the VDPA\_CMD\_DEV\_DEL netlink message to detach the VDUSE instance from vDPA bus.
2. Close the file descriptor referring to /dev/vduse/\$NAME.
3. Destroy the VDUSE instance with ioctl(VDUSE\_DESTROY\_DEV) on /dev/vduse/control.

The netlink messages can be sent via vdpa tool in iproute2 or use the below sample codes:

```
static int netlink_add_vduse(const char *name, enum vdpa_command cmd)
{
    struct nl_sock *nlsock;
    struct nl_msg *msg;
    int famid;
```

```

nlsock = nl_socket_alloc();
if (!nlsock)
    return -ENOMEM;

if (genl_connect(nlsock))
    goto free_sock;

famid = genl_ctrl_resolve(nlsock, VDPA_GENL_NAME);
if (famid < 0)
    goto close_sock;

msg = nlmsg_alloc();
if (!msg)
    goto close_sock;

if (!genlmsg_put(msg, NL_AUTO_PORT, NL_AUTO_SEQ, famid, 0, 0, cmd, 0))
    goto nla_put_failure;

NLA_PUT_STRING(msg, VDPA_ATTR_DEV_NAME, name);
if (cmd == VDPA_CMD_DEV_NEW)
    NLA_PUT_STRING(msg, VDPA_ATTR_MGMTDEV_DEV_NAME, "vduse");

if (nl_send_sync(nlsock, msg))
    goto close_sock;

nl_close(nlsock);
nl_socket_free(nlsock);

return 0;
nla_put_failure:
    nlmsg_free(msg);
close_sock:
    nl_close(nlsock);
free_sock:
    nl_socket_free(nlsock);
    return -1;
}

```

## 16.2 How VDUSE works

As mentioned above, a VDUSE device is created by `ioctl(VDUSE_CREATE_DEV)` on `/dev/vduse/control`. With this ioctl, userspace can specify some basic configuration such as device name (uniquely identify a VDUSE device), virtio features, virtio configuration space, the number of virtqueues and so on for this emulated device. Then a char device interface (`/dev/vduse/$NAME`) is exported to userspace for device emulation. Userspace can use the `VDUSE_VQ_SETUP` ioctl on `/dev/vduse/$NAME` to add per-virtqueue configuration such as the max size of virtqueue to the device.

After the initialization, the VDUSE device can be attached to vDPA bus via the

VDPA\_CMD\_DEV\_NEW netlink message. Userspace needs to read()/write() on /dev/vduse/\$NAME to receive/reply some control messages from/to VDUSE kernel module as follows:

```
static int vduse_message_handler(int dev_fd)
{
    int len;
    struct vduse_dev_request req;
    struct vduse_dev_response resp;

    len = read(dev_fd, &req, sizeof(req));
    if (len != sizeof(req))
        return -1;

    resp.request_id = req.request_id;

    switch (req.type) {

        /* handle different types of messages */

    }

    len = write(dev_fd, &resp, sizeof(resp));
    if (len != sizeof(resp))
        return -1;

    return 0;
}
```

There are now three types of messages introduced by VDUSE framework:

- VDUSE\_GET\_VQ\_STATE: Get the state for virtqueue, userspace should return avail index for split virtqueue or the device/driver ring wrap counters and the avail and used index for packed virtqueue.
- VDUSE\_SET\_STATUS: Set the device status, userspace should follow the virtio spec: <https://docs.oasis-open.org/virtio/virtio/v1.1/virtio-v1.1.html> to process this message. For example, fail to set the FEATURES\_OK device status bit if the device can not accept the negotiated virtio features get from the VDUSE\_DEV\_GET\_FEATURES ioctl.
- VDUSE\_UPDATE\_IOTLB: Notify userspace to update the memory mapping for specified IOVA range, userspace should firstly remove the old mapping, then setup the new mapping via the VDUSE\_IOTLB\_GET\_FD ioctl.

After DRIVER\_OK status bit is set via the VDUSE\_SET\_STATUS message, userspace is able to start the dataplane processing as follows:

1. Get the specified virtqueue's information with the VDUSE\_VQ\_GET\_INFO ioctl, including the size, the IOVAs of descriptor table, available ring and used ring, the state and the ready status.
2. Pass the above IOVAs to the VDUSE\_IOTLB\_GET\_FD ioctl so that those IOVA regions can be mapped into userspace. Some sample codes is shown below:

```

static int perm_to_prot(uint8_t perm)
{
    int prot = 0;

    switch (perm) {
    case VDUSE_ACCESS_W0:
        prot |= PROT_WRITE;
        break;
    case VDUSE_ACCESS_R0:
        prot |= PROT_READ;
        break;
    case VDUSE_ACCESS_RW:
        prot |= PROT_READ | PROT_WRITE;
        break;
    }

    return prot;
}

static void *iova_to_va(int dev_fd, uint64_t iova, uint64_t *len)
{
    int fd;
    void *addr;
    size_t size;
    struct vduse_iotlb_entry entry;

    entry.start = iova;
    entry.last = iova;

    /*
     * Find the first IOVA region that overlaps with the specified
     * range [start, last] and return the corresponding file descriptor.
     */
    fd = ioctl(dev_fd, VDUSE_IOTLB_GET_FD, &entry);
    if (fd < 0)
        return NULL;

    size = entry.last - entry.start + 1;
    *len = entry.last - iova + 1;
    addr = mmap(0, size, perm_to_prot(entry.perm), MAP_SHARED,
               fd, entry.offset);
    close(fd);
    if (addr == MAP_FAILED)
        return NULL;

    /*
     * Using some data structures such as linked list to store
     * the iotlb mapping. The munmap(2) should be called for the
     * cached mapping when the corresponding VDUSE_UPDATE_IOTLB
     * message is received or the device is reset.
    */
}

```

```
 */  
  
    return addr + iova - entry.start;  
}
```

3. Setup the kick eventfd for the specified virtqueues with the VDUSE\_VQ\_SETUP\_KICKFD ioctl. The kick eventfd is used by VDUSE kernel module to notify userspace to consume the available ring. This is optional since userspace can choose to poll the available ring instead.
4. Listen to the kick eventfd (optional) and consume the available ring. The buffer described by the descriptors in the descriptor table should be also mapped into userspace via the VDUSE\_IOTLB\_GET\_FD ioctl before accessing.
5. Inject an interrupt for specific virtqueue with the VDUSE\_INJECT\_VQ\_IRQ ioctl after the used ring is filled.

For more details on the uAPI, please see include/uapi/linux/vduse.h.



## FUTEX2

### Author

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futex, or fast user mutex, is a set of syscalls to allow userspace to create performant synchronization mechanisms, such as mutexes, semaphores and conditional variables in userspace. C standard libraries, like glibc, uses it as a means to implement more high level interfaces like pthreads.

futex2 is a followup version of the initial futex syscall, designed to overcome limitations of the original interface.

## 17.1 User API

### 17.1.1 `futex_waitv()`

Wait on an array of futexes, wake on any:

```
futex_waitv(struct futex_waitv *waiters, unsigned int nr_futexes,
            unsigned int flags, struct timespec *timeout, clockid_t clockid)

struct futex_waitv {
    __u64 val;
    __u64 uaddr;
    __u32 flags;
    __u32 __reserved;
};
```

Userspace sets an array of struct futex\_waitv (up to a max of 128 entries), using `uaddr` for the address to wait for, `val` for the expected value and `flags` to specify the type (e.g. private) and size of futex. `__reserved` needs to be 0, but it can be used for future extension. The pointer for the first item of the array is passed as `waiters`. An invalid address for `waiters` or for any `uaddr` returns -EFAULT.

If userspace has 32-bit pointers, it should do a explicit cast to make sure the upper bits are zeroed. `uintptr_t` does the tricky and it works for both 32/64-bit pointers.

`nr_futexes` specifies the size of the array. Numbers out of [1, 128] interval will make the syscall return -EINVAL.

The `flags` argument of the syscall needs to be 0, but it can be used for future extension.

For each entry in `waiters` array, the current value at `uaddr` is compared to `val`. If it's different, the syscall undo all the work done so far and return `-EAGAIN`. If all tests and verifications succeeds, syscall waits until one of the following happens:

- The timeout expires, returning `-ETIMEOUT`.
- A signal was sent to the sleeping task, returning `-ERESTARTSYS`.
- Some futex at the list was woken, returning the index of some waked futex.

An example of how to use the interface can be found at `tools/testing/selftests/futex/functional/futex_waitv.c`.

### **17.1.2 Timeout**

`struct timespec *timeout` argument is an optional argument that points to an absolute timeout. You need to specify the type of clock being used at `clockid` argument. `CLOCK_MONOTONIC` and `CLOCK_REALTIME` are supported. This syscall accepts only 64bit `timespec` structs.

### **17.1.3 Types of futex**

A futex can be either private or shared. Private is used for processes that shares the same memory space and the virtual address of the futex will be the same for all processes. This allows for optimizations in the kernel. To use private futexes, it's necessary to specify `FUTEX_PRIVATE_FLAG` in the futex flag. For processes that doesn't share the same memory space and therefore can have different virtual addresses for the same futex (using, for instance, a file-backed shared memory) requires different internal mechanisms to be get properly enqueued. This is the default behavior, and it works with both private and shared futexes.

Futexes can be of different sizes: 8, 16, 32 or 64 bits. Currently, the only supported one is 32 bit sized futex, and it need to be specified using `FUTEX_32` flag.

## **LINUX SECURITY MODULES**

**Author**

Casey Schaufler

**Date**

July 2023

Linux security modules (LSM) provide a mechanism to implement additional access controls to the Linux security policies.

The various security modules may support any of these attributes:

`LSM_ATTR_CURRENT` is the current, active security context of the process. The proc filesystem provides this value in `/proc/self/attr/current`. This is supported by the SELinux, Smack and AppArmor security modules. Smack also provides this value in `/proc/self/attr/smack/current`. AppArmor also provides this value in `/proc/self/attr/apparmor/current`.

`LSM_ATTR_EXEC` is the security context of the process at the time the current image was executed. The proc filesystem provides this value in `/proc/self/attr/exec`. This is supported by the SELinux and AppArmor security modules. AppArmor also provides this value in `/proc/self/attr/apparmor/exec`.

`LSM_ATTR_FSCREATE` is the security context of the process used when creating file system objects. The proc filesystem provides this value in `/proc/self/attr/fscreate`. This is supported by the SELinux security module.

`LSM_ATTR_KEYCREATE` is the security context of the process used when creating key objects. The proc filesystem provides this value in `/proc/self/attr/keycreate`. This is supported by the SELinux security module.

`LSM_ATTR_PREV` is the security context of the process at the time the current security context was set. The proc filesystem provides this value in `/proc/self/attr/prev`. This is supported by the SELinux and AppArmor security modules. AppArmor also provides this value in `/proc/self/attr/apparmor/prev`.

`LSM_ATTR_SOCKCREATE` is the security context of the process used when creating socket objects. The proc filesystem provides this value in `/proc/self/attr/sockcreate`. This is supported by the SELinux security module.

## 18.1 Kernel interface

### 18.1.1 Set a security attribute of the current process

```
long sys_lsm_set_self_attr(unsigned int attr, struct lsm_ctx __user *ctx, size_t size, u32 flags)
```

Set current task's security module attribute

#### Parameters

**unsigned int attr**

which attribute to set

**struct lsm\_ctx \_\_user \* ctx**

the LSM contexts

**size\_t size**

size of **ctx**

**u32 flags**

reserved for future use

#### Description

Sets the calling task's LSM context. On success this function returns 0. If the attribute specified cannot be set a negative value indicating the reason for the error is returned.

### 18.1.2 Get the specified security attributes of the current process

```
long sys_lsm_get_self_attr(unsigned int attr, struct lsm_ctx __user *ctx, size_t __user *size, u32 flags)
```

Return current task's security module attributes

#### Parameters

**unsigned int attr**

which attribute to return

**struct lsm\_ctx \_\_user \* ctx**

the user-space destination for the information, or NULL

**size\_t \_\_user \* size**

pointer to the size of space available to receive the data

**u32 flags**

special handling options. `LSM_FLAG_SINGLE` indicates that only attributes associated with the LSM identified in the passed **ctx** be reported.

#### Description

Returns the calling task's LSM contexts. On success this function returns the number of **ctx** array elements. This value may be zero if there are no LSM contexts assigned. If **size** is insufficient to contain the return data -E2BIG is returned and **size** is set to the minimum required size. In all other cases a negative value indicating the error is returned.

```
long sys_lsm_list_modules(u64 __user *ids, size_t __user *size, u32 flags)
```

Return a list of the active security modules

## Parameters

### u64 \_\_user \* ids

the LSM module ids

### size\_t \_\_user \* size

pointer to size of **ids**, updated on return

### u32 flags

reserved for future use, must be zero

## Description

Returns a list of the active LSM ids. On success this function returns the number of **ids** array elements. This value may be zero if there are no LSMs active. If **size** is insufficient to contain the return data -E2BIG is returned and **size** is set to the minimum required size. In all other cases a negative value indicating the error is returned.

## 18.2 Additional documentation

- Documentation/security/lsm.rst
- Documentation/security/lsm-development.rst



## TEE (TRUSTED EXECUTION ENVIRONMENT) USERSPACE API

include/uapi/linux/tee.h defines the generic interface to a TEE.

User space (the client) connects to the driver by opening /dev/tee[0-9]\* or /dev/teepriv[0-9]\*.

- TEE\_IOC\_SHM\_ALLOC allocates shared memory and returns a file descriptor which user space can mmap. When user space doesn't need the file descriptor any more, it should be closed. When shared memory isn't needed any longer it should be unmapped with munmap() to allow the reuse of memory.
- TEE\_IOC\_VERSION lets user space know which TEE this driver handles and its capabilities.
- TEE\_IOC\_OPEN\_SESSION opens a new session to a Trusted Application.
- TEE\_IOC\_INVOKE invokes a function in a Trusted Application.
- TEE\_IOC\_CANCEL may cancel an ongoing TEE\_IOC\_OPEN\_SESSION or TEE\_IOC\_INVOKE.
- TEE\_IOC\_CLOSE\_SESSION closes a session to a Trusted Application.

There are two classes of clients, normal clients and supplicants. The latter is a helper process for the TEE to access resources in Linux, for example file system access. A normal client opens /dev/tee[0-9]\* and a supplicant opens /dev/teepriv[0-9].

Much of the communication between clients and the TEE is opaque to the driver. The main job for the driver is to receive requests from the clients, forward them to the TEE and send back the results. In the case of supplicants the communication goes in the other direction, the TEE sends requests to the supplicant which then sends back the result.



## **ISA PLUG & PLAY SUPPORT**

### **20.1 Interface /proc/isapnp**

The interface was removed in kernel 2.5.53. See pnp.rst for more details.

### **20.2 Interface /proc/bus/isapnp**

This directory allows access to ISA PnP cards and logical devices. The regular files contain the contents of ISA PnP registers for a logical device.



## **DELL SYSTEMS MANAGEMENT BASE DRIVER**

### **21.1 Overview**

The Dell Systems Management Base Driver provides a sysfs interface for systems management software such as Dell OpenManage to perform system management interrupts and host control actions (system power cycle or power off after OS shutdown) on certain Dell systems.

Dell OpenManage requires this driver on the following Dell PowerEdge systems: 300, 1300, 1400, 400SC, 500SC, 1500SC, 1550, 600SC, 1600SC, 650, 1655MC, 700, and 750. Other Dell software such as the open source libsmbios project is expected to make use of this driver, and it may include the use of this driver on other Dell systems.

The Dell libsmbios project aims towards providing access to as much BIOS information as possible. See <http://linux.dell.com/libsmbios/main/> for more information about the libsmbios project.

### **21.2 System Management Interrupt**

On some Dell systems, systems management software must access certain management information via a system management interrupt (SMI). The SMI data buffer must reside in 32-bit address space, and the physical address of the buffer is required for the SMI. The driver maintains the memory required for the SMI and provides a way for the application to generate the SMI. The driver creates the following sysfs entries for systems management software to perform these system management interrupts:

```
/sys/devices/platform/dcdbas/smi_data
/sys/devices/platform/dcdbas/smi_data_buf_phys_addr
/sys/devices/platform/dcdbas/smi_data_buf_size
/sys/devices/platform/dcdbas/smi_request
```

Systems management software must perform the following steps to execute a SMI using this driver:

- 1) Lock smi\_data.
- 2) Write system management command to smi\_data.
- 3) Write "1" to smi\_request to generate a calling interface SMI or "2" to generate a raw SMI.
- 4) Read system management command response from smi\_data.
- 5) Unlock smi\_data.

## 21.3 Host Control Action

Dell OpenManage supports a host control feature that allows the administrator to perform a power cycle or power off of the system after the OS has finished shutting down. On some Dell systems, this host control feature requires that a driver perform a SMI after the OS has finished shutting down.

The driver creates the following sysfs entries for systems management software to schedule the driver to perform a power cycle or power off host control action after the system has finished shutting down:

```
/sys/devices/platform/dcdbas/host_control_action /sys/devices/platform/dcdbas/host_control_smi_type  
/sys/devices/platform/dcdbas/host_control_on_shutdown
```

Dell OpenManage performs the following steps to execute a power cycle or power off host control action using this driver:

- 1) Write host control action to be performed to host\_control\_action.
- 2) Write type of SMI that driver needs to perform to host\_control\_smi\_type.
- 3) Write "1" to host\_control\_on\_shutdown to enable host control action.
- 4) Initiate OS shutdown. (Driver will perform host control SMI when it is notified that the OS has finished shutting down.)

## 21.4 Host Control SMI Type

The following table shows the value to write to host\_control\_smi\_type to perform a power cycle or power off host control action:

PowerEdge System	Host Control SMI Type
300	HC_SMITYPE_TYPE1
1300	HC_SMITYPE_TYPE1
1400	HC_SMITYPE_TYPE2
500SC	HC_SMITYPE_TYPE2
1500SC	HC_SMITYPE_TYPE2
1550	HC_SMITYPE_TYPE2
600SC	HC_SMITYPE_TYPE2
1600SC	HC_SMITYPE_TYPE2
650	HC_SMITYPE_TYPE2
1655MC	HC_SMITYPE_TYPE2
700	HC_SMITYPE_TYPE3
750	HC_SMITYPE_TYPE3

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