



# The OpenCL<sup>™</sup> Extension Specification

Khronos<sup>®</sup> OpenCL Working Group

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# Chapter 1. Extensions Overview

*Extensions* are optional features which may be supported by OpenCL implementations. Extensions are not required to be supported by a conformant OpenCL implementation, but are expected to be widely available, and in some cases may define functionality that is likely to be required in a future revision of the OpenCL specification.

In the past, this document contained full specification language for Khronos-approved **KHR** extensions, described in terms of changes to the core OpenCL Specification. This extension language has now been integrated into the OpenCL 3.0 Specification, and can be read in context there.

The remaining parts of this document describe general issues in *using* extensions, such as [API Naming Conventions for Optional Extensions](#); OpenCL C [Compiler Directives for Optional Extensions](#); and [Getting OpenCL API Extension Function Pointers](#).

In addition, there is a section on [Extensions to the OpenCL SPIR-V Environment](#).

Finally, the [Quick Reference](#) appendix summarizes KHR extensions and links to them in the OpenCL API Specification. In some cases, extensions are mostly or entirely to the OpenCL C language rather than to the OpenCL API. Such extensions can be reached by following the links in the API Specification extension appendices.

## 1.1. Naming Convention for Optional Extensions

OpenCL extensions approved by the OpenCL working group use the following naming convention:

- A unique *name string* of the form "**cl\_khr\_<name>**" is associated with each extension. If the extension is supported by an implementation, this string will be present in the implementation's **CL\_PLATFORM\_EXTENSIONS** string or **CL\_DEVICE\_EXTENSIONS** string.
- All API functions defined by the extension will have names of the form **cl<function\_name>KHR**.
- All enumerants defined by the extension will have names of the form **CL\_<enum\_name>\_KHR**.

Functions and enumerants defined by extensions that are promoted to core features will have their **KHR** affix removed. OpenCL implementations of such later revisions must also export the name strings of promoted extensions in the **CL\_PLATFORM\_EXTENSIONS** or **CL\_DEVICE\_EXTENSIONS** string, and support the **KHR**-affixed versions of functions and enumerants as a transition aid.

Vendor extensions are strongly encouraged to follow a similar naming convention:

- A unique *name string* of the form "**cl\_<vendor\_name>\_<name>**" is associated with each extension. If the extension is supported by an implementation, this string will be present in the implementation's **CL\_PLATFORM\_EXTENSIONS** string or **CL\_DEVICE\_EXTENSIONS** string.
- All API functions defined by the vendor extension will have names of the form **cl<function\_name><vendor\_name>**.
- All enumerants defined by the vendor extension will have names of the form **CL\_<**

*enum\_name*>\_<*vendor\_name*>.

## 1.2. Compiler Directives for Optional Extensions

The **#pragma OPENCL EXTENSION** directive controls the behavior of the OpenCL compiler with respect to extensions. The **#pragma OPENCL EXTENSION** directive is defined as:

```
#pragma OPENCL EXTENSION <extension_name> : <behavior>
#pragma OPENCL EXTENSION all : <behavior>
```

where *extension\_name* is the name of the extension. The *extension\_name* will have names of the form **cl\_khr\_<name>** for an extension approved by the OpenCL working group and will have names of the form **cl\_<vendor\_name>\_<name>** for vendor extensions. The token **all** means that the behavior applies to all extensions supported by the compiler. The *behavior* can be set to one of the following values given by the table below.

| behavior       | Description  |
|----------------|--|
| <b>enable</b>  | Behave as specified by the extension <i>extension_name</i> .<br><br>Report an error on the <b>#pragma OPENCL EXTENSION</b> if the <i>extension_name</i> is not supported, or if <b>all</b> is specified.   |
| <b>disable</b> | Behave (including issuing errors and warnings) as if the extension <i>extension_name</i> is not part of the language definition.<br><br>If <b>all</b> is specified, then behavior must revert back to that of the non-extended core version of the language being compiled to.<br><br>Warn on the <b>#pragma OPENCL EXTENSION</b> if the extension <i>extension_name</i> is not supported. |

The **#pragma OPENCL EXTENSION** directive is a simple, low-level mechanism to set the behavior for each extension. It does not define policies such as which combinations are appropriate; those must be defined elsewhere. The order of directives matter in setting the behavior for each extension. Directives that occur later override those seen earlier. The **all** variant sets the behavior for all extensions, overriding all previously issued extension directives, but only if the *behavior* is set to **disable**.

The initial state of the compiler is as if the directive

```
#pragma OPENCL EXTENSION all : disable
```

was issued, telling the compiler that all error and warning reporting must be done according to this specification, ignoring any extensions.

Every extension which affects the OpenCL language semantics, syntax or adds built-in functions to

the language must create a preprocessor `#define` that matches the extension name string. This `#define` would be available in the language if and only if the extension is supported on a given implementation.

#### Example:

An extension which adds the extension string `"cl_khr_3d_image_writes"` should also add a preprocessor `#define` called `cl_khr_3d_image_writes`. A kernel can now use this preprocessor `#define` to do something like:

```
#ifdef cl_khr_3d_image_writes
    // do something using the extension
#else
    // do something else or #error!
#endif
```

## 1.3. Getting OpenCL API Extension Function Pointers

The function

```
void* clGetExtensionFunctionAddressForPlatform(cl_platform_id platform,
                                              const char *funcname)
```

returns the address of the extension function named by *funcname* for a given *platform*. The pointer returned should be cast to a function pointer type matching the extension function's definition defined in the appropriate extension specification and header file. A return value of `NULL` indicates that the specified function does not exist for the implementation or *platform* is not a valid platform. A non-`NULL` return value for `clGetExtensionFunctionAddressForPlatform` does not guarantee that an extension function is actually supported by the platform. The application must also make a corresponding query using `clGetPlatformInfo(platform, CL_PLATFORM_EXTENSIONS, ...)` or `clGetDeviceInfo(device, CL_DEVICE_EXTENSIONS, ...)` to determine if an extension is supported by the OpenCL implementation.

Since there is no way to qualify the query with a device, the function pointer returned must work for all implementations of that extension on different devices for a platform. The behavior of calling a device extension function on a device not supporting that extension is undefined.

`clGetExtensionFunctionAddressForPlatform` may not be used to query for core (non-extension) functions in OpenCL. For extension functions that may be queried using `clGetExtensionFunctionAddressForPlatform`, implementations may also choose to export those functions statically from the object libraries implementing those functions, however, portable applications cannot rely on this behavior.

Function pointer typedefs must be declared for all extensions that add API entrypoints. These typedefs are a required part of the extension interface, to be provided in an appropriate header (such as `cl_ext.h` if the extension is an OpenCL extension, or `cl_gl_ext.h` if the extension is an OpenCL / OpenGL sharing extension).

The following convention must be followed for all extensions affecting the host API:

```
#ifndef extension_name
#define extension_name 1

// all data typedefs, token #defines, prototypes, and
// function pointer typedefs for this extension

// function pointer typedefs must use the
// following naming convention

typedef return_type
    (CL_API_CALL *clExtensionFunctionNameTAG_fn)(...);

#endif // _extension_name_
```

where **TAG** can be **KHR**, **EXT** or **vendor-specific**.

Consider, for example, the **cl\_khr\_gl\_sharing** extension. This extension would add the following to **cl\_gl\_ext.h**:

```
#ifndef cl_khr_gl_sharing
#define cl_khr_gl_sharing 1

// all data typedefs, token #defines, prototypes, and
// function pointer typedefs for this extension
#define CL_INVALID_GL_SHAREGROUP_REFERENCE_KHR    -1000
#define CL_CURRENT_DEVICE_FOR_GL_CONTEXT_KHR      0x2006
#define CL_DEVICES_FOR_GL_CONTEXT_KHR             0x2007
#define CL_GL_CONTEXT_KHR                         0x2008
#define CL_EGL_DISPLAY_KHR                        0x2009
#define CL_GLX_DISPLAY_KHR                        0x200A
#define CL_WGL_HDC_KHR                            0x200B
#define CL_CGL_SHAREGROUP_KHR                    0x200C

// function pointer typedefs must use the
// following naming convention
typedef cl_int
    (CL_API_CALL *clGetGLContextInfoKHR_fn)(
        const cl_context_properties * /* properties */,
        cl_gl_context_info /* param_name */,
        size_t /* param_value_size */,
        void * /* param_value */,
        size_t /* param_value_size_ret */);

#endif // cl_khr_gl_sharing
```

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# Appendix A: Extensions Promoted to Core Features

## A.1. For OpenCL 1.1:

- The functionality previously described by `cl_khr_byte_addressable_store` is now part of the core feature set.
- The functionality previously described by `cl_khr_global_int32_base_atomics`, `cl_khr_global_int32_extended_atomics`, `cl_khr_local_int32_base_atomics`, and `cl_khr_local_int32_extended_atomics` is now part of the core feature set.

## A.2. For OpenCL 1.2:

- The functionality previously described by `cl_khr_fp64` is now an optional core feature.

## A.3. For OpenCL 2.0:

- The functionality described by `cl_khr_3d_image_writes` is part of the core feature set.
- The functionality described by `cl_khr_create_command_queue` is part of the core feature set.
- The functionality described by `cl_khr_depth_images` is now part of the core feature set.
- The functionality described by `cl_khr_image2d_from_buffer` is now part of the core feature set.

## A.4. For OpenCL 2.1:

- The functionality described by `cl_khr_il_program` is now part of the core feature set.
- The API functionality described by `cl_khr_subgroups` is now part of the core API feature set, but the built-in functions described by `cl_khr_subgroups` must still be accessed as an extension to the OpenCL 2.0 C Language specification.

## A.5. For OpenCL 3.0:

- The API functionality described by `cl_khr_extended_versioning` is now part of the core API feature set, with minor modifications.
- The built-in functions described by `cl_khr_subgroups` are now supported in OpenCL C 3.0 when the `{opengl_c_subgroups}` feature is supported.

# Appendix B: Deprecated Extensions

## B.1. For OpenCL 1.1:

- The `cl_khr_select_fprounding_mode` extension has been deprecated. Its use is no longer recommended.

# Appendix C: Quick Reference

Each extension in this table includes a link to the corresponding appendix in the OpenCL 3.0 API Specification, which provides a fuller description and references to the actual extension specification language in the API and C Language Specifications.

| Extension Name and Link                                | Brief Description  | Status                     |
|--|--|----------------------------|
| <a href="#">cl_khr_3d_image_writes</a>                 | Write to 3D images   | Core Feature in OpenCL 2.0 |
| <a href="#">cl_khr_async_work_group_copy_fence</a>     | Asynchronous Copy Fences   | Extension                  |
| <a href="#">cl_khr_byte_addressable_store</a>          | Read and write from 8-bit and 16-bit pointers                          | Core Feature in OpenCL 1.1 |
| <a href="#">cl_khr_command_buffer</a>                  | Record and Replay Commands   | Provisional Extension      |
| <a href="#">cl_khr_command_buffer_multi_device</a>     | Allow a command-buffer to contain commands targeting different devices | Provisional Extension      |
| <a href="#">cl_khr_command_buffer_mutable_dispatch</a> | Modify kernel execution commands between enqueues of a command-buffer  | Provisional Extension      |
| <a href="#">cl_khr_create_command_queue</a>            | API to Create Command-Queues with Properties                           | Core Feature in OpenCL 2.0 |
| <a href="#">cl_khr_d3d10_sharing</a>                   | Share Direct3D 10 Buffers and Textures with OpenCL                     | Extension                  |
| <a href="#">cl_khr_d3d11_sharing</a>                   | Share Direct3D 11 Buffers and Textures with OpenCL                     | Extension                  |
| <a href="#">cl_khr_depth_images</a>                    | Single Channel Depth Images  | Core Feature in OpenCL 2.0 |
| <a href="#">cl_khr_device_enqueue_local_arg_types</a>  | Pass Non-Void Local Pointers to Child Kernels                          | Extension                  |
| <a href="#">cl_khr_device_uuid</a>                     | Unique Device and Driver Identifier Queries                            | Extension                  |
| <a href="#">cl_khr_dx9_media_sharing</a>               | Share DirectX 9 Media Surfaces with OpenCL                             | Extension                  |
| <a href="#">cl_khr_egl_event</a>                       | Share EGL Sync Objects with OpenCL                                     | Extension                  |
| <a href="#">cl_khr_egl_image</a>                       | Share EGL Images with OpenCL   | Extension                  |
| <a href="#">cl_khr_extended_async_copies</a>           | 2D and 3D Async Copies   | Extension                  |
| <a href="#">cl_khr_extended_bit_ops</a>                | Bit Insert, Extract, and Reverse Operations                            | Extension                  |

| Extension Name and Link                              | Brief Description  | Status  |
|--|--|---|
| <a href="#">cl_khr_extended_versioning</a>           | Extend versioning of platform, devices, extensions, etc.       | Core Feature in OpenCL 3.0 (with minor changes) |
| <a href="#">cl_khr_external_memory</a>               | Common Functionality for External Memory Sharing               | Extension                                       |
| <a href="#">cl_khr_external_memory_dma_buf</a>       | dma_buf External Memory Handles                                | Extension                                       |
| <a href="#">cl_khr_external_memory_opaque_fd</a>     | Opaque File Descriptor External Memory Handles                 | Extension                                       |
| <a href="#">cl_khr_external_memory_win32</a>         | NT Handle External Memory Handles                              | Extension                                       |
| <a href="#">cl_khr_expect_assume</a>                 | Kernel Optimization Hints                                      | Extension                                       |
| <a href="#">cl_khr_external_semaphore</a>            | Common Functionality for External Semaphore Sharing            | Extension                                       |
| <a href="#">cl_khr_external_semaphore_opaque_fd</a>  | Opaque File Descriptor External Semaphore Handles              | Extension                                       |
| <a href="#">cl_khr_external_semaphore_sync_fd</a>    | Sync FD External Semaphore Handles                             | Extension                                       |
| <a href="#">cl_khr_external_semaphore_win32</a>      | NT Handle External Semaphore Handles                           | Provisional Extension                           |
| <a href="#">cl_khr_fp16</a>                          | Operations on 16-bit Floating-Point Values                     | Extension                                       |
| <a href="#">cl_khr_fp64</a>                          | Operations on 64-bit Floating-Point Values                     | Optional Core Feature in OpenCL 1.2             |
| <a href="#">cl_khr_gl_depth_images</a>               | Share OpenGL Depth Images with OpenCL                          | Extension                                       |
| <a href="#">cl_khr_gl_event</a>                      | Share OpenGL Fence Sync Objects with OpenCL                    | Extension                                       |
| <a href="#">cl_khr_gl_msaa_sharing</a>               | Share OpenGL MSAA Textures with OpenCL                         | Extension                                       |
| <a href="#">cl_khr_gl_sharing</a>                    | Sharing OpenGL Buffers and Textures with OpenCL                | Extension                                       |
| <a href="#">cl_khr_global_int32_base_atomics</a>     | Basic Atomic Operations on 32-bit Integers in Global Memory    | Core Feature in OpenCL 1.1                      |
| <a href="#">cl_khr_global_int32_extended_atomics</a> | Extended Atomic Operations on 32-bit Integers in Global Memory | Core Feature in OpenCL 1.1                      |
| <a href="#">cl_khr_icd</a>                           | Installable Client Drivers                                     | Extension                                       |

| Extension Name and Link                             | Brief Description  | Status  |
|---|--|---|
| <a href="#">cl_khr_il_program</a>                   | Support for Intermediate Language (IL) Programs (SPIR-V)                               | Core Feature in OpenCL 2.1                    |
| <a href="#">cl_khr_image2d_from_buffer</a>          | Create 2D Images from Buffers  | Core Feature in OpenCL 2.0                    |
| <a href="#">cl_khr_initialize_memory</a>            | Initialize Local and Private Memory on Allocation                                      | Extension                                     |
| <a href="#">cl_khr_int64_base_atomics</a>           | Basic Atomic Operations on 64-bit Integers in Global and Local Memory                  | Extension                                     |
| <a href="#">cl_khr_int64_extended_atomics</a>       | Extended Atomic Operations on 64-bit Integers in Global and Local Memory               | Extension                                     |
| <a href="#">cl_khr_local_int32_base_atomics</a>     | Basic Atomic Operations on 32-bit Integers in Local Memory                             | Core Feature in OpenCL 1.1                    |
| <a href="#">cl_khr_local_int32_extended_atomics</a> | Extended Atomic Operations on 32-bit Integers in Local Memory                          | Core Feature in OpenCL 1.1                    |
| <a href="#">cl_khr_integer_dot_product</a>          | Integer dot product operations   | Extension                                     |
| <a href="#">cl_khr_kernel_clock</a>                 | Sample Clock Values Within a Kernel  | Extension                                     |
| <a href="#">cl_khr_mipmap_image</a>                 | Create and Use Images with Mipmaps   | Extension                                     |
| <a href="#">cl_khr_pci_bus_info</a>                 | Query PCI Bus Information for an OpenCL Device   | Extension                                     |
| <a href="#">cl_khr_priority_hints</a>               | Create Command-Queues with Different Priorities  | Extension                                     |
| <a href="#">cl_khr_select_fprounding_mode</a>       | Set the Current Kernel Rounding Mode   | DEPRECATED                                    |
| <a href="#">cl_khr_semaphore</a>                    | Semaphore Synchronization Primitives   | Extension                                     |
| <a href="#">cl_khr_spir</a>                         | Standard Portable Intermediate Representation Programs                                 | Extension, Superseded by IL Programs / SPIR-V |
| <a href="#">cl_khr_spirv_extended_debug_info</a>    | Allows Use of the SPIR-V <a href="#">OpenCL.DebugInfo.100</a> Extended Instruction Set | Extension                                     |
| <a href="#">cl_khr_spirv_linkonce_odr</a>           | Allows Use of the SPIR-V <a href="#">SPV_KHR_linkonce_odr</a> Extension                | Extension                                     |

| Extension Name and Link                                 | Brief Description   | Status  |
|---|---|---|
| <a href="#">cl_khr_spirv_no_integer_wrap_decoration</a> | Allows Use of the SPIR-V SPV_KHR_no_integer_wrap_decoration Extension | Extension                                       |
| <a href="#">cl_khr_srgb_image_writes</a>                | Write to sRGB Images  | Extension                                       |
| <a href="#">cl_khr_subgroups</a>                        | Sub-Groupings of Work Items   | Core Feature in OpenCL 2.1 (with minor changes) |
| <a href="#">cl_khr_subgroup_ballot</a>                  | Exchange Ballots Among Sub-Groupings of Work Items                    | Extension                                       |
| <a href="#">cl_khr_subgroup_clustered_reduce</a>        | Clustered Reductions for Sub-Groupings of Work Items                  | Extension                                       |
| <a href="#">cl_khr_subgroup_extended_types</a>          | Additional Type Support for Sub-group Functions                       | Extension                                       |
| <a href="#">cl_khr_subgroup_named_barrier</a>           | Barriers for Subsets of a Work-group                                  | Extension                                       |
| <a href="#">cl_khr_subgroup_non_uniform_arithmetic</a>  | Sub-group Arithmetic Functions in Non-Uniform Control Flow            | Extension                                       |
| <a href="#">cl_khr_subgroup_non_uniform_vote</a>        | Hold Votes Among Sub-Groupings of Work Items                          | Extension                                       |
| <a href="#">cl_khr_subgroup_rotate</a>                  | Rotation Among Sub-Groupings of Work Items                            | Extension                                       |
| <a href="#">cl_khr_subgroup_shuffle</a>                 | General-Purpose Shuffles Among Sub-Groupings of Work Items            | Extension                                       |
| <a href="#">cl_khr_subgroup_shuffle_relative</a>        | Relative Shuffles Among Sub-Groupings of Work Items                   | Extension                                       |
| <a href="#">cl_khr_suggested_local_work_size</a>        | Query a Suggested Local Work Size                                     | Extension                                       |
| <a href="#">cl_khr_terminate_context</a>                | Terminate an OpenCL Context   | Extension                                       |
| <a href="#">cl_khr_throttle_hints</a>                   | Create Command-Queues with Different Throttle Policies                | Extension                                       |
| <a href="#">cl_khr_work_group_uniform_arithmetic</a>    | Work-group Uniform Arithmetic   | Extension                                       |