

# Xenomai RTDM skin API

## 2.4.91

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# Chapter 1

## Deprecated List

Global [rtbm\\_task\\_sleep\\_until](#) Use rtbm\_task\_sleep\_abs instead!



# Chapter 2

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# Chapter 5

## Module Documentation

### 5.1 CAN Devices

Collaboration diagram for CAN Devices:



#### Data Structures

- struct [can\\_bittime\\_std](#)  
*Standard bit-time parameters according to Bosch.*
- struct [can\\_bittime\\_btr](#)  
*Hardware-specific BTR bit-times.*
- struct [can\\_bittime](#)  
*Custom CAN bit-time definition.*
- struct [can\\_filter](#)  
*Filter for reception of CAN messages.*
- struct [sockaddr\\_can](#)  
*Socket address structure for the CAN address family.*
- struct [can\\_frame](#)  
*Raw CAN frame.*

#### Files

- file [rtcan.h](#)  
*Real-Time Driver Model for RT-Socket-CAN, CAN device profile header.*

## Defines

- `#define AF_CAN` 29  
*CAN address family.*
- `#define PF_CAN` AF\_CAN  
*CAN protocol family.*
- `#define SOL_CAN_RAW` 103  
*CAN socket levels.*

## Typedefs

- `typedef uint32_t can_id_t`  
*Type of CAN id (see `CAN_xxx_MASK` and `CAN_xxx_FLAG`).*
- `typedef can_id_t can_err_mask_t`  
*Type of CAN error mask.*
- `typedef uint32_t can_baudrate_t`  
*Baudrate definition in bits per second.*
- `typedef enum CAN_BITTIME_TYPE can_bittime_type_t`  
*See `CAN_BITTIME_TYPE`.*
- `typedef enum CAN_MODE can_mode_t`  
*See `CAN_MODE`.*
- `typedef int can_ctrlmode_t`  
*See `CAN_CTRLMODE`.*
- `typedef enum CAN_STATE can_state_t`  
*See `CAN_STATE`.*
- `typedef struct can_filter can_filter_t`  
*Filter for reception of CAN messages.*
- `typedef struct can_frame can_frame_t`  
*Raw CAN frame.*

## Enumerations

- `enum CAN_BITTIME_TYPE { CAN_BITTIME_STD, CAN_BITTIME_BTR }`  
*Supported CAN bit-time types.*

## CAN operation modes

Modes into which CAN controllers can be set

- enum `CAN_MODE` { `CAN_MODE_STOP` = 0, `CAN_MODE_START`, `CAN_MODE_SLEEP` }

## CAN controller states

States a CAN controller can be in.

- enum `CAN_STATE` {  
    `CAN_STATE_ACTIVE` = 0, `CAN_STATE_BUS_WARNING`, `CAN_STATE_BUS_PASSIVE`,  
    `CAN_STATE_BUS_OFF`,  
    `CAN_STATE_SCANNING_BAUDRATE`,    `CAN_STATE_STOPPED`,    `CAN_STATE_SLEEPING` }

## CAN ID masks

Bit masks for masking CAN IDs

- #define `CAN_EFF_MASK` 0x1FFFFFFF  
    *Bit mask for extended CAN IDs.*
- #define `CAN_SFF_MASK` 0x000007FF  
    *Bit mask for standard CAN IDs.*

## CAN ID flags

Flags within a CAN ID indicating special CAN frame attributes

- #define `CAN_EFF_FLAG` 0x80000000  
    *Extended frame.*
- #define `CAN_RTR_FLAG` 0x40000000  
    *Remote transmission frame.*
- #define `CAN_ERR_FLAG` 0x20000000  
    *Error frame (see [Errors](#)), not valid in struct `can_filter`.*
- #define `CAN_INV_FILTER` `CAN_ERR_FLAG`  
    *Invert CAN filter definition, only valid in struct `can_filter`.*

## Particular CAN protocols

Possible protocols for the PF\_CAN protocol family

Currently only the RAW protocol is supported.

- #define [CAN\\_RAW](#) 1  
*Raw protocol of PF\_CAN, applicable to socket type SOCK\_RAW.*

## CAN controller modes

Special CAN controllers modes, which can be or'ed together.

### Note:

These modes are hardware-dependent. Please consult the hardware manual of the CAN controller for more detailed information.

- #define [CAN\\_CTRLMODE\\_LISTENONLY](#) 0x1
- #define [CAN\\_CTRLMODE\\_LOOPBACK](#) 0x2

## Timestamp switches

Arguments to pass to [RTCAN\\_RTIOC\\_TAKE\\_TIMESTAMP](#)

- #define [RTCAN\\_TAKE\\_NO\\_TIMESTAMPS](#) 0  
*Switch off taking timestamps.*
- #define [RTCAN\\_TAKE\\_TIMESTAMPS](#) 1  
*Do take timestamps.*

## RAW socket options

Setting and getting CAN RAW socket options.

- #define [CAN\\_RAW\\_FILTER](#) 0x1  
*CAN filter definition.*
- #define [CAN\\_RAW\\_ERR\\_FILTER](#) 0x2  
*CAN error mask.*
- #define [CAN\\_RAW\\_LOOPBACK](#) 0x3  
*CAN TX loopback.*
- #define [CAN\\_RAW\\_RECV\\_OWN\\_MSGS](#) 0x4  
*CAN receive own messages.*



## IOCTLs

### CAN device IOCTLs

- #define [SIOCGIFINDEX](#) defined\_by\_kernel\_header\_file  
*Get CAN interface index by name.*
- #define [SIOCSCANBAUDRATE](#) \_IOW(RTIOC\_TYPE\_CAN, 0x01, struct ifreq)  
*Set baud rate.*
- #define [SIOCGCANBAUDRATE](#) \_IOWR(RTIOC\_TYPE\_CAN, 0x02, struct ifreq)  
*Get baud rate.*
- #define [SIOCSCANCUSTOMBITTIME](#) \_IOW(RTIOC\_TYPE\_CAN, 0x03, struct ifreq)  
*Set custom bit time parameter.*
- #define [SIOCGCANCUSTOMBITTIME](#) \_IOWR(RTIOC\_TYPE\_CAN, 0x04, struct ifreq)  
*Get custom bit-time parameters.*
- #define [SIOCSCANMODE](#) \_IOW(RTIOC\_TYPE\_CAN, 0x05, struct ifreq)  
*Set operation mode of CAN controller.*
- #define [SIOCGCANSTATE](#) \_IOWR(RTIOC\_TYPE\_CAN, 0x06, struct ifreq)  
*Get current state of CAN controller.*
- #define [SIOCSCANCTRLMODE](#) \_IOW(RTIOC\_TYPE\_CAN, 0x07, struct ifreq)  
*Set special controller modes.*
- #define [SIOCGCANCTRLMODE](#) \_IOWR(RTIOC\_TYPE\_CAN, 0x08, struct ifreq)  
*Get special controller modes.*
- #define [RTCAN\\_RTIOC\\_TAKE\\_TIMESTAMP](#) \_IOW(RTIOC\_TYPE\_CAN, 0x09, int)  
*Enable or disable storing a high precision timestamp upon reception of a CAN frame.*
- #define [RTCAN\\_RTIOC\\_RCV\\_TIMEOUT](#) \_IOW(RTIOC\_TYPE\_CAN, 0x0A, nanosecs\_rel\_t)  
*Specify a reception timeout for a socket.*
- #define [RTCAN\\_RTIOC\\_SND\\_TIMEOUT](#) \_IOW(RTIOC\_TYPE\_CAN, 0x0B, nanosecs\_rel\_t)  
*Specify a transmission timeout for a socket.*

## Error mask

Error class (mask) in `can_id` field of struct [can\\_frame](#) to be used with [CAN\\_RAW\\_ERR\\_FILTER](#).

**Note:** Error reporting is hardware dependent and most CAN controllers report less detailed error conditions than the SJA1000.

**Note:** In case of a bus-off error condition ([CAN\\_ERR\\_BUSOFF](#)), the CAN controller is **not** restarted automatically. It is the application's responsibility to react appropriately, e.g. calling [CAN\\_MODE\\_START](#).

**Note:** Bus error interrupts ([CAN\\_ERR\\_BUSERROR](#)) are enabled when an application is calling a [Recv](#) function on a socket listening on bus errors (using [CAN\\_RAW\\_ERR\\_FILTER](#)). After one bus error has occurred, the interrupt will be disabled to allow the application time for error processing and to efficiently avoid bus error interrupt flooding.

- `#define CAN_ERR_TX_TIMEOUT 0x00000001U`  
*TX timeout (netdevice driver).*
- `#define CAN_ERR_LOSTARB 0x00000002U`  
*Lost arbitration (see [data\[0\]](#)).*
- `#define CAN_ERR_CRTL 0x00000004U`  
*Controller problems (see [data\[1\]](#)).*
- `#define CAN_ERR_PROT 0x00000008U`  
*Protocol violations (see [data\[2\]](#), [data\[3\]](#)).*
- `#define CAN_ERR_TRX 0x00000010U`  
*Transceiver status (see [data\[4\]](#)).*
- `#define CAN_ERR_ACK 0x00000020U`  
*Received no ACK on transmission.*
- `#define CAN_ERR_BUSOFF 0x00000040U`  
*Bus off.*
- `#define CAN_ERR_BUSERROR 0x00000080U`  
*Bus error (may flood!).*
- `#define CAN_ERR_RESTARTED 0x00000100U`  
*Controller restarted.*
- `#define CAN_ERR_MASK 0x1FFFFFFFU`  
*Omit EFF, RTR, ERR flags.*

## Arbitration lost error

Error in the `data[0]` field of struct [can\\_frame](#).

- `#define CAN_ERR_LOSTARB_UNSPEC 0x00`  
*unspecified*

## Controller problems

Error in the data[1] field of struct `can_frame`.

- #define `CAN_ERR_CTRL_UNSPEC` 0x00  
*unspecified*
- #define `CAN_ERR_CTRL_RX_OVERFLOW` 0x01  
*RX buffer overflow.*
- #define `CAN_ERR_CTRL_TX_OVERFLOW` 0x02  
*TX buffer overflow.*
- #define `CAN_ERR_CTRL_RX_WARNING` 0x04  
*reached warning level for RX errors*
- #define `CAN_ERR_CTRL_TX_WARNING` 0x08  
*reached warning level for TX errors*
- #define `CAN_ERR_CTRL_RX_PASSIVE` 0x10  
*reached passive level for RX errors*
- #define `CAN_ERR_CTRL_TX_PASSIVE` 0x20  
*reached passive level for TX errors*

## Protocol error type

Error in the data[2] field of struct `can_frame`.

- #define `CAN_ERR_PROT_UNSPEC` 0x00  
*unspecified*
- #define `CAN_ERR_PROT_BIT` 0x01  
*single bit error*
- #define `CAN_ERR_PROT_FORM` 0x02  
*frame format error*
- #define `CAN_ERR_PROT_STUFF` 0x04  
*bit stuffing error*
- #define `CAN_ERR_PROT_BIT0` 0x08  
*unable to send dominant bit*
- #define `CAN_ERR_PROT_BIT1` 0x10  
*unable to send recessive bit*
- #define `CAN_ERR_PROT_OVERLOAD` 0x20

*bus overload*

- #define `CAN_ERR_PROT_ACTIVE` 0x40  
*active error announcement*
- #define `CAN_ERR_PROT_TX` 0x80  
*error occurred on transmission*

## Protocol error location

Error in the data[3] field of struct `can_frame`.

- #define `CAN_ERR_PROT_LOC_UNSPEC` 0x00  
*unspecified*
- #define `CAN_ERR_PROT_LOC_SOF` 0x03  
*start of frame*
- #define `CAN_ERR_PROT_LOC_ID28_21` 0x02  
*ID bits 28 - 21 (SFF: 10 - 3).*
- #define `CAN_ERR_PROT_LOC_ID20_18` 0x06  
*ID bits 20 - 18 (SFF: 2 - 0 ).*
- #define `CAN_ERR_PROT_LOC_SRTR` 0x04  
*substitute RTR (SFF: RTR)*
- #define `CAN_ERR_PROT_LOC_IDE` 0x05  
*identifier extension*
- #define `CAN_ERR_PROT_LOC_ID17_13` 0x07  
*ID bits 17-13.*
- #define `CAN_ERR_PROT_LOC_ID12_05` 0x0F  
*ID bits 12-5.*
- #define `CAN_ERR_PROT_LOC_ID04_00` 0x0E  
*ID bits 4-0.*
- #define `CAN_ERR_PROT_LOC_RTR` 0x0C  
*RTR.*
- #define `CAN_ERR_PROT_LOC_RES1` 0x0D  
*reserved bit 1*
- #define `CAN_ERR_PROT_LOC_RES0` 0x09  
*reserved bit 0*

- #define [CAN\\_ERR\\_PROT\\_LOC\\_DLC](#) 0x0B  
*data length code*
- #define [CAN\\_ERR\\_PROT\\_LOC\\_DATA](#) 0x0A  
*data section*
- #define [CAN\\_ERR\\_PROT\\_LOC\\_CRC\\_SEQ](#) 0x08  
*CRC sequence.*
- #define [CAN\\_ERR\\_PROT\\_LOC\\_CRC\\_DEL](#) 0x18  
*CRC delimiter.*
- #define [CAN\\_ERR\\_PROT\\_LOC\\_ACK](#) 0x19  
*ACK slot.*
- #define [CAN\\_ERR\\_PROT\\_LOC\\_ACK\\_DEL](#) 0x1B  
*ACK delimiter.*
- #define [CAN\\_ERR\\_PROT\\_LOC\\_EOF](#) 0x1A  
*end of frame*
- #define [CAN\\_ERR\\_PROT\\_LOC\\_INTERM](#) 0x12  
*intermission*

## Protocol error location

Error in the data[4] field of struct [can\\_frame](#).

- #define [CAN\\_ERR\\_TRX\\_UNSPEC](#) 0x00  
*0000 0000*
- #define [CAN\\_ERR\\_TRX\\_CANH\\_NO\\_WIRE](#) 0x04  
*0000 0100*
- #define [CAN\\_ERR\\_TRX\\_CANH\\_SHORT\\_TO\\_BAT](#) 0x05  
*0000 0101*
- #define [CAN\\_ERR\\_TRX\\_CANH\\_SHORT\\_TO\\_VCC](#) 0x06  
*0000 0110*
- #define [CAN\\_ERR\\_TRX\\_CANH\\_SHORT\\_TO\\_GND](#) 0x07  
*0000 0111*
- #define [CAN\\_ERR\\_TRX\\_CANL\\_NO\\_WIRE](#) 0x40  
*0100 0000*
- #define [CAN\\_ERR\\_TRX\\_CANL\\_SHORT\\_TO\\_BAT](#) 0x50  
*0101 0000*

- #define [CAN\\_ERR\\_TRX\\_CANL\\_SHORT\\_TO\\_VCC](#) 0x60  
0110 0000
- #define [CAN\\_ERR\\_TRX\\_CANL\\_SHORT\\_TO\\_GND](#) 0x70  
0111 0000
- #define [CAN\\_ERR\\_TRX\\_CANL\\_SHORT\\_TO\\_CANH](#) 0x80  
1000 0000

### 5.1.1 Detailed Description

This is the common interface a RTDM-compliant CAN device has to provide. Feel free to report bugs and comments on this profile to the "Socketcan" mailing list ([Socketcan-core@lists.berlios.de](mailto:Socketcan-core@lists.berlios.de)) or directly to the authors ([wg@grandegger.com](mailto:wg@grandegger.com) or [Sebastian.Smolorz@stud.uni-hannover.de](mailto:Sebastian.Smolorz@stud.uni-hannover.de)).

**Profile Revision:** 2

#### Device Characteristics

[Device Flags](#): RTDM\_PROTOCOL\_DEVICE

[Protocol Family](#): PF\_CAN

[Socket Type](#): SOCK\_RAW

[Device Class](#): RTDM\_CLASS\_CAN

#### Supported Operations

##### Socket

Environments: non-RT (RT optional)

Specific return values:

- -EPROTONOSUPPORT (Protocol is not supported by the driver. See [CAN protocols](#) for possible protocols.)

##### Close

Blocking calls to any of the [Send](#) or [Receive](#) functions will be unblocked when the socket is closed and return with an error.

Environments: non-RT (RT optional)

Specific return values: none

##### IOCTL

Mandatory Environments: see [below](#)

Specific return values: see [below](#)

##### Bind

Binds a socket to one or all CAN devices (see struct [sockaddr\\_can](#)). If a filter list has been defined with setsockopt (see [Sockopts](#)), it will be used upon reception of CAN frames to decide whether the bound socket will receive a frame. If no filter has been defined, the socket will receive **all** CAN frames on the specified interface(s).

Binding to special interface index 0 will make the socket receive CAN frames from all CAN interfaces.

Binding to an interface index is also relevant for the [Send](#) functions because they will transmit a message over the interface the socket is bound to when no socket address is given to them.

Environments: non-RT (RT optional)

Specific return values:

- -EFAULT (It was not possible to access user space memory area at the specified address.)
- -ENOMEM (Not enough memory to fulfill the operation)
- -EINVAL (Invalid address family, or invalid length of address structure)
- -ENODEV (Invalid CAN interface index)
- -ENOSPC (No enough space for filter list)
- -EBADF (Socket is about to be closed)
- -EAGAIN (Too many receivers. Old binding (if any) is still active. Close some sockets and try again.)

#### Setsockopt, Getsockopt

These functions allow to set and get various socket options. Currently, only CAN raw sockets are supported.

Supported Levels and Options:

- Level **SOL\_CAN\_RAW** : CAN RAW protocol (see [CAN\\_RAW](#))
  - Option [CAN\\_RAW\\_FILTER](#) : CAN filter list
  - Option [CAN\\_RAW\\_ERR\\_FILTER](#) : CAN error mask
  - Option [CAN\\_RAW\\_LOOPBACK](#) : CAN TX loopback to local sockets

Environments: non-RT (RT optional)

Specific return values: see links to options above.

#### Recv, Recvfrom, Recvmsg

These functions receive CAN messages from a socket. Only one message per call can be received, so only one buffer with the correct length must be passed. For **SOCK\_RAW**, this is the size of struct [can\\_frame](#).

Unlike a call to one of the [Send](#) functions, a Recv function will not return with an error if an interface is down (due to bus-off or setting of stop mode) or in sleep mode. Moreover, in such a case there may still be some CAN messages in the socket buffer which could be read out successfully.

It is possible to receive a high precision timestamp with every CAN message. The condition is a former instruction to the socket via [RTCAN\\_RTIOC\\_TAKE\\_TIMESTAMP](#). The timestamp will be copied to the `msg_control` buffer of struct `msghdr` if it points to a valid memory location with size of [nanosecs\\_abs\\_t](#). If this is a NULL pointer the timestamp will be discarded silently.

**Note:** A `msg_controllen` of 0 upon completion of the function call indicates that no timestamp is available for that message.

Supported Flags [in]:

- **MSG\_DONTWAIT** (By setting this flag the operation will only succeed if it would not block, i.e. if there is a message in the socket buffer. This flag takes precedence over a timeout specified by [RTCAN\\_RTIOC\\_RCV\\_TIMEOUT](#).)
- **MSG\_PEEK** (Receive a message but leave it in the socket buffer. The next receive operation will get that message again.)

Supported Flags [out]: none

Environments: RT (non-RT optional)

Specific return values:

- Non-negative value (Indicating the successful reception of a CAN message. For **SOCK\_RAW**, this is the size of struct [can\\_frame](#) regardless of the actual size of the payload.)
- -EFAULT (It was not possible to access user space memory area at one of the specified addresses.)
- -EINVAL (Unsupported flag detected, or invalid length of socket address buffer, or invalid length of message control buffer)

- -EMSGSIZE (Zero or more than one iovec buffer passed, or buffer too small)
- -EAGAIN (No data available in non-blocking mode)
- -EBADF (Socket was closed.)
- -EINTR (Operation was interrupted explicitly or by signal.)
- -ETIMEDOUT (Timeout)

### Send, Sendto, Sendmsg

These functions send out CAN messages. Only one message per call can be transmitted, so only one buffer with the correct length must be passed. For `SOCK_RAW`, this is the size of struct [can\\_frame](#).

The following only applies to `SOCK_RAW`: If a socket address of struct [sockaddr\\_can](#) is given, only `can_ifindex` is used. It is also possible to omit the socket address. Then the interface the socket is bound to will be used for sending messages.

If an interface goes down (due to bus-off or setting of stop mode) all senders that were blocked on this interface will be woken up.

Supported Flags:

- `MSG_DONTWAIT` (By setting this flag the transmit operation will only succeed if it would not block. This flag takes precedence over a timeout specified by `RTCAN_-RTIOC_SND_TIMEOUT`.)

Environments: RT (non-RT optional)

Specific return values:

- Non-negative value equal to given buffer size (Indicating the successful completion of the function call. See also note.)
- `-EOPNOTSUPP` (`MSG_OOB` flag is not supported.)
- `-EINVAL` (Unsupported flag detected *or*: Invalid length of socket address *or*: Invalid address family *or*: Data length code of CAN frame not between 0 and 15 *or*: CAN standard frame has got an ID not between 0 and 2031)
- `-EMSGSIZE` (Zero or more than one buffer passed or invalid size of buffer)
- `-EFAULT` (It was not possible to access user space memory area at one of the specified addresses.)
- `-ENXIO` (Invalid CAN interface index - 0 is not allowed here - or socket not bound or rather bound to all interfaces.)
- `-ENETDOWN` (Controller is bus-off or in stopped state.)
- `-ECOMM` (Controller is sleeping)
- `-EAGAIN` (Cannot transmit without blocking but a non-blocking call was requested.)
- `-EINTR` (Operation was interrupted explicitly or by signal)
- `-EBADF` (Socket was closed.)
- `-ETIMEDOUT` (Timeout)

**Note:** A successful completion of the function call does not implicate a successful transmission of the message.

## 5.1.2 Define Documentation

### 5.1.2.1 #define CAN\_CTRLMODE\_LISTENONLY 0x1

Listen-Only mode

In this mode the CAN controller would give no acknowledge to the CAN-bus, even if a message is received successfully and messages would not be transmitted. This mode might be useful for bus-monitoring, hot-plugging or throughput analysis.



**Examples:**

[rtcanconfig.c](#).

**5.1.2.2 #define CAN\_CTRLMODE\_LOOPBACK 0x2**

Loopback mode

In this mode the CAN controller does an internal loop-back, a message is transmitted and simultaneously received. That mode can be used for self test operation.

**Examples:**

[rtcanconfig.c](#).

**5.1.2.3 #define CAN\_ERR\_LOSTARB\_UNSPEC 0x00**

unspecified

else bit number in bitstream

**5.1.2.4 #define CAN\_RAW\_ERR\_FILTER 0x2**

CAN error mask.

A CAN error mask (see [Errors](#)) can be set with `setsockopt`. This mask is then used to decide if error frames are delivered to this socket in case of error conditions. The error frames are marked with the `CAN_ERR_FLAG` of `CAN_XXX_FLAG` and must be handled by the application properly. A detailed description of the errors can be found in the `can_id` and the data fields of struct `can_frame` (see [Errors](#) for further details).

**Parameters:**

- ← *level* `SOL_CAN_RAW`
- ← *optname* `CAN_RAW_ERR_FILTER`
- ← *optval* Pointer to error mask of type `can_err_mask_t`.
- ← *optlen* Size of error mask: `sizeof(can_err_mask_t)`.

Environments: non-RT (RT optional)

Specific return values:

- -EFAULT (It was not possible to access user space memory area at the specified address.)
- -EINVAL (Invalid length "optlen")

**Examples:**

[rtcanrecv.c](#).

### 5.1.2.5 #define CAN\_RAW\_FILTER 0x1

CAN filter definition.

A CAN raw filter list with elements of struct [can\\_filter](#) can be installed with `setsockopt`. This list is used upon reception of CAN frames to decide whether the bound socket will receive a frame. An empty filter list can also be defined using `optlen = 0`, which is recommended for write-only sockets.

If the socket was already bound with [Bind](#), the old filter list gets replaced with the new one. Be aware that already received, but not read out CAN frames may stay in the socket buffer.

#### Parameters:

- ← *level* **SOL\_CAN\_RAW**
- ← *optname* **CAN\_RAW\_FILTER**
- ← *optval* Pointer to array of struct [can\\_filter](#).
- ← *optlen* Size of filter list: `count * sizeof( struct can_filter)`.  
Environments: non-RT (RT optional)  
Specific return values:
  - -EFAULT (It was not possible to access user space memory area at the specified address.)
  - -ENOMEM (Not enough memory to fulfill the operation)
  - -EINVAL (Invalid length "optlen")
  - -ENOSPC (No space to store filter list, check RT-Socket-CAN kernel parameters)

#### Examples:

[rtcan\\_rtt.c](#), [rtcanrecv.c](#), and [rtcansend.c](#).

### 5.1.2.6 #define CAN\_RAW\_LOOPBACK 0x3

CAN TX loopback.

The TX loopback to other local sockets can be selected with this `setsockopt`.

#### Note:

The TX loopback feature must be enabled in the kernel and then the loopback to other local TX sockets is enabled by default.

#### Parameters:

- ← *level* **SOL\_CAN\_RAW**
- ← *optname* **CAN\_RAW\_LOOPBACK**
- ← *optval* Pointer to integer value.
- ← *optlen* Size of int: `sizeof(int)`.

Environments: non-RT (RT optional)

Specific return values:

- -EFAULT (It was not possible to access user space memory area at the specified address.)

- -EINVAL (Invalid length "optlen")
- -EOPNOTSUPP (not supported, check RT-Socket-CAN kernel parameters).

**Examples:**

[rtcansend.c](#).

**5.1.2.7 #define CAN\_RAW\_RECV\_OWN\_MSGS 0x4**

CAN receive own messages.

Not supported by RT-Socket-CAN, but defined for compatibility with Socket-CAN.

**5.1.2.8 #define RTCAN\_RTIOC\_RCV\_TIMEOUT \_IOW(RTIOC\_TYPE\_CAN, 0x0A, nanosecs\_rel\_t)**

Specify a reception timeout for a socket.

Defines a timeout for all receive operations via a socket which will take effect when one of the [receive functions](#) is called without the MSG\_DONTWAIT flag set.

The default value for a newly created socket is an infinite timeout.

**Note:**

The setting of the timeout value is not done atomically to avoid locks. Please set the value before receiving messages from the socket.

**Parameters:**

← *arg* Pointer to [nanosecs\\_rel\\_t](#) variable. The value is interpreted as relative timeout in nanoseconds in case of a positive value. See [Timeouts](#) for special timeouts.

**Returns:**

0 on success, otherwise:

- -EFAULT: It was not possible to access user space memory area at the specified address.

**Environments:**

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

**Examples:**

[rtcanrecv.c](#).

#### 5.1.2.9 `#define RTCAN_RTIOC_SND_TIMEOUT_IOW(RTIOC_TYPE_CAN, 0x0B, nanosecs_rel_t)`

Specify a transmission timeout for a socket.

Defines a timeout for all send operations via a socket which will take effect when one of the [send functions](#) is called without the MSG\_DONTWAIT flag set.

The default value for a newly created socket is an infinite timeout.

##### Note:

The setting of the timeout value is not done atomically to avoid locks. Please set the value before sending messages to the socket.

##### Parameters:

← *arg* Pointer to [nanosecs\\_rel\\_t](#) variable. The value is interpreted as relative timeout in nanoseconds in case of a positive value. See [Timeouts](#) for special timeouts.

##### Returns:

0 on success, otherwise:

- -EFAULT: It was not possible to access user space memory area at the specified address.

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

##### Examples:

[rtcansend.c](#).

#### 5.1.2.10 `#define RTCAN_RTIOC_TAKE_TIMESTAMP_IOW(RTIOC_TYPE_CAN, 0x09, int)`

Enable or disable storing a high precision timestamp upon reception of a CAN frame.

A newly created socket takes no timestamps by default.

##### Parameters:

← *arg* int variable, see [Timestamp switches](#)

##### Returns:

0 on success.

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

**Note:**

Activating taking timestamps only has an effect on newly received CAN messages from the bus. Frames that already are in the socket buffer do not have timestamps if it was deactivated before. See [Receive](#) for more details.

Rescheduling: never.

**Examples:**

[rtcanrecv.c](#).

**5.1.2.11 #define SIOCGCANBAUDRATE\_IOWR(RTIOC\_TYPE\_CAN, 0x02, struct ifreq)**

Get baud rate.

**Parameters:**

↔ *arg* Pointer to interface request structure buffer (struct ifreq from linux/if.h). ifr\_name must hold a valid CAN interface name, ifr\_ifru will be filled with an instance of [can\\_baudrate\\_t](#).

**Returns:**

0 on success, otherwise:

- -EFAULT: It was not possible to access user space memory area at the specified address.
- -ENODEV: No device with specified name exists.
- -EINVAL: No baud rate was set yet.

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

**5.1.2.12 #define SIOCGCANCTRLMODE\_IOWR(RTIOC\_TYPE\_CAN, 0x08, struct ifreq)**

Get special controller modes.

**Parameters:**

↔ *arg* Pointer to interface request structure buffer (struct ifreq from linux/if.h). ifr\_name must hold a valid CAN interface name, ifr\_ifru must be filled with an instance of [can\\_ctrlmode\\_t](#).

**Returns:**

0 on success, otherwise:

- -EFAULT: It was not possible to access user space memory area at the specified address.
- -ENODEV: No device with specified name exists.
- -EINVAL: No baud rate was set yet.

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: possible.

#### 5.1.2.13 `#define SIOCGCANCUSTOMBITTIME _IOWR(RTIOC_TYPE_CAN, 0x04, struct ifreq)`

Get custom bit-time parameters.

**Parameters:**

↔ *arg* Pointer to interface request structure buffer (`struct ifreq` from `linux/if.h`). `ifr_name` must hold a valid CAN interface name, `ifr_ifru` will be filled with an instance of struct [can\\_bittime](#).

**Returns:**

0 on success, otherwise:

- -EFAULT: It was not possible to access user space memory area at the specified address.
- -ENODEV: No device with specified name exists.
- -EINVAL: No baud rate was set yet.

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

#### 5.1.2.14 #define SIOCGCANSTATE \_IOWR(RTIOC\_TYPE\_CAN, 0x06, struct ifreq)

Get current state of CAN controller.

States are divided into main states and additional error indicators. A CAN controller is always in exactly one main state. CAN bus errors are registered by the CAN hardware and collected by the driver. There is one error indicator (bit) per error type. If this IOCTL is triggered the error types which occurred since the last call of this IOCTL are reported and thereafter the error indicators are cleared. See also [CAN controller states](#).

##### Parameters:

↔ *arg* Pointer to interface request structure buffer (struct ifreq from linux/if.h). ifr\_name must hold a valid CAN interface name, ifr\_ifru will be filled with an instance of [can\\_mode\\_t](#).

##### Returns:

0 on success, otherwise:

- -EFAULT: It was not possible to access user space memory area at the specified address.
- -ENODEV: No device with specified name exists.

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: possible.

#### 5.1.2.15 #define SIOCGIFINDEX defined\_by\_kernel\_header\_file

Get CAN interface index by name.

##### Parameters:

↔ *arg* Pointer to interface request structure buffer (struct ifreq from linux/if.h). If ifr\_name holds a valid CAN interface name ifr\_ifindex will be filled with the corresponding interface index.

##### Returns:

0 on success, otherwise:

- -EFAULT: It was not possible to access user space memory area at the specified address.
- -ENODEV: No device with specified name exists.

Environments:

This service can be called from:

- Kernel module initialization/cleanup code

- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

**Examples:**

[rtcan\\_rtt.c](#), [rtcanconfig.c](#), [rtcanrecv.c](#), and [rtcansend.c](#).

#### 5.1.2.16 #define SIOCSCANBAUDRATE\_IOW(RTIOC\_TYPE\_CAN, 0x01, struct ifreq)

Set baud rate.

The baudrate must be specified in bits per second. The driver will try to calculate resonable CAN bit-timing parameters. You can use [SIOCSCANCUSTOMBITTIME](#) to set custom bit-timing.

**Parameters:**

← *arg* Pointer to interface request structure buffer (`struct ifreq` from `linux/if.h`). `ifr_name` must hold a valid CAN interface name, `ifr_ifru` must be filled with an instance of [can\\_baudrate\\_t](#).

**Returns:**

0 on success, otherwise:

- -EFAULT: It was not possible to access user space memory area at the specified address.
- -ENODEV: No device with specified name exists.
- -EINVAL: No valid baud rate, see [can\\_baudrate\\_t](#).
- -EDOM : Baud rate not possible.
- -EAGAIN: Request could not be successfully fulfilled. Try again.

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

**Note:**

Setting the baud rate is a configuration task. It should be done deliberately or otherwise CAN messages will likely be lost.

Rescheduling: possible.

**Examples:**

[rtcanconfig.c](#).



#### 5.1.2.17 #define SIOCSCANCTRLMODE \_IOW(RTIOC\_TYPE\_CAN, 0x07, struct ifreq)

Set special controller modes.

Various special controller modes could be or'ed together (see [CAN\\_CTRLMODE](#) for further information).

##### Parameters:

← *arg* Pointer to interface request structure buffer (struct ifreq from linux/if.h). ifr\_name must hold a valid CAN interface name, ifr\_ifru must be filled with an instance of [can\\_ctrlmode\\_t](#).

##### Returns:

0 on success, otherwise:

- -EFAULT: It was not possible to access user space memory area at the specified address.
- -ENODEV: No device with specified name exists.
- -EINVAL: No valid baud rate, see [can\\_baudrate\\_t](#).
- -EAGAIN: Request could not be successfully fulfilled. Try again.

##### Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

##### Note:

Setting special controller modes is a configuration task. It should be done deliberately or otherwise CAN messages will likely be lost.

Rescheduling: possible.

##### Examples:

[rtcanconfig.c](#).

#### 5.1.2.18 #define SIOCSCANCUSTOMBITTIME \_IOW(RTIOC\_TYPE\_CAN, 0x03, struct ifreq)

Set custom bit time parameter.

Custem-bit time could be defined in various formats (see struct [can\\_bittime](#)).

##### Parameters:

← *arg* Pointer to interface request structure buffer (struct ifreq from linux/if.h). ifr\_name must hold a valid CAN interface name, ifr\_ifru must be filled with an instance of struct [can\\_bittime](#).

**Returns:**

0 on success, otherwise:

- -EFAULT: It was not possible to access user space memory area at the specified address.
- -ENODEV: No device with specified name exists.
- -EINVAL: No valid baud rate, see [can\\_baudrate\\_t](#).
- -EAGAIN: Request could not be successfully fulfilled. Try again.

**Environments:**

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

**Note:**

Setting the bit-time is a configuration task. It should be done deliberately or otherwise CAN messages will likely be lost.

Rescheduling: possible.

**Examples:**

[rtcanconfig.c](#).

**5.1.2.19 #define SIOCSCANMODE\_IOW(RTIOC\_TYPE\_CAN, 0x05, struct ifreq)**

Set operation mode of CAN controller.

See [CAN controller modes](#) for available modes.

**Parameters:**

← *arg* Pointer to interface request structure buffer (`struct ifreq` from `linux/if.h`). `ifr_name` must hold a valid CAN interface name, `ifr_ifru` must be filled with an instance of [can\\_mode\\_t](#).

**Returns:**

0 on success, otherwise:

- -EFAULT: It was not possible to access user space memory area at the specified address.
- -ENODEV: No device with specified name exists.
- -EAGAIN: ([CAN\\_MODE\\_START](#), [CAN\\_MODE\\_STOP](#)) Could not successfully set mode, hardware is busy. Try again.
- -EINVAL: ([CAN\\_MODE\\_START](#)) Cannot start controller, set baud rate first.
- -ENETDOWN: ([CAN\\_MODE\\_SLEEP](#)) Cannot go into sleep mode because controller is stopped or bus off.
- -EOPNOTSUPP: unknown mode

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

**Note:**

Setting a CAN controller into normal operation after a bus-off can take some time (128 occurrences of 11 consecutive recessive bits). In such a case, although this IOCTL will return immediately with success and [SIOCGCANSTATE](#) will report [CAN\\_STATE\\_ACTIVE](#), bus-off recovery may still be in progress.

If a controller is bus-off, setting it into stop mode will return no error but the controller remains bus-off.

Rescheduling: possible.

**Examples:**

[rtcanconfig.c](#).

#### 5.1.2.20 #define SOL\_CAN\_RAW 103

CAN socket levels.

Used for [Sockopts](#) for the particular protocols.

**Examples:**

[rtcan\\_rtt.c](#), [rtcanrecv.c](#), and [rtcansend.c](#).

### 5.1.3 Typedef Documentation

#### 5.1.3.1 typedef struct can\_filter can\_filter\_t

Filter for reception of CAN messages.

This filter works as follows: A received CAN ID is AND'ed bitwise with [can\\_mask](#) and then compared to [can\\_id](#). This also includes the [CAN\\_EFF\\_FLAG](#) and [CAN\\_RTR\\_FLAG](#) of [CAN\\_XXX\\_FLAG](#). If this comparison is true, the message will be received by the socket. The logic can be inverted with the [can\\_id](#) flag [CAN\\_INV\\_FILTER](#):

```
if (can_id & CAN_INV_FILTER) {
    if ((received_can_id & can_mask) != (can_id & ~CAN_INV_FILTER))
        accept-message;
} else {
    if ((received_can_id & can_mask) == can_id)
        accept-message;
}
```

Multiple filters can be arranged in a filter list and set with [Sockopts](#). If one of these filters matches a CAN ID upon reception of a CAN frame, this frame is accepted.

### 5.1.3.2 typedef struct can\_frame can\_frame\_t

Raw CAN frame.

Central structure for receiving and sending CAN frames.

## 5.1.4 Enumeration Type Documentation

### 5.1.4.1 enum CAN\_BITTIME\_TYPE

Supported CAN bit-time types.

**Enumerator:**

*CAN\_BITTIME\_STD* Standard bit-time definition according to Bosch.

*CAN\_BITTIME\_BTR* Hardware-specific BTR bit-time definition.

### 5.1.4.2 enum CAN\_MODE

**Enumerator:**

*CAN\_MODE\_STOP* Set controller in Stop mode (no reception / transmission possible)

*CAN\_MODE\_START* Set controller into normal operation.

Coming from stopped mode or bus off, the controller begins with no errors in [CAN\\_STATE\\_ACTIVE](#).

*CAN\_MODE\_SLEEP* Set controller into Sleep mode.

This is only possible if the controller is not stopped or bus-off.

Notice that sleep mode will only be entered when there is no bus activity. If the controller detects bus activity while "sleeping" it will go into operating mode again.

To actively leave sleep mode again trigger *CAN\_MODE\_START*.

### 5.1.4.3 enum CAN\_STATE

**Enumerator:**

*CAN\_STATE\_ACTIVE* CAN controller is error active.

*CAN\_STATE\_BUS\_WARNING* CAN controller is error active, warning level is reached.

*CAN\_STATE\_BUS\_PASSIVE* CAN controller is error passive.

*CAN\_STATE\_BUS\_OFF* CAN controller went into Bus Off.

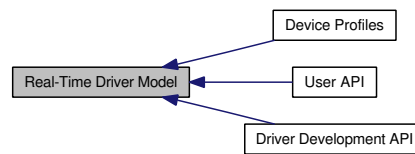
*CAN\_STATE\_SCANNING\_BAUDRATE* CAN controller is scanning to get the baudrate.

*CAN\_STATE\_STOPPED* CAN controller is in stopped mode.

*CAN\_STATE\_SLEEPING* CAN controller is in Sleep mode.

## 5.2 Real-Time Driver Model

Collaboration diagram for Real-Time Driver Model:



### Modules

- [User API](#)
- [Driver Development API](#)
- [Device Profiles](#)

### Typedefs

- typedef uint64\_t [nanosecs\\_abs\\_t](#)  
*RTDM type for representing absolute dates.*
- typedef int64\_t [nanosecs\\_rel\\_t](#)  
*RTDM type for representing relative intervals.*

### API Versioning

- #define [RTDM\\_API\\_VER](#) 7  
*Common user and driver API version.*
- #define [RTDM\\_API\\_MIN\\_COMPAT\\_VER](#) 6  
*Minimum API revision compatible with the current release.*

### RTDM\_TIMEOUT\_XXX

Special timeout values

- #define [RTDM\\_TIMEOUT\\_INFINITE](#) 0  
*Block forever.*
- #define [RTDM\\_TIMEOUT\\_NONE](#) (-1)  
*Any negative timeout means non-blocking.*

### 5.2.1 Detailed Description

The Real-Time Driver Model (RTDM) provides a unified interface to both users and developers of real-time device drivers. Specifically, it addresses the constraints of mixed RT/non-RT systems like Xenomai. RTDM conforms to POSIX semantics (IEEE Std 1003.1) where available and applicable.

**API Revision:** 7

### 5.2.2 Define Documentation

#### 5.2.2.1 `#define RTDM_TIMEOUT_INFINITE 0`

Block forever.

#### 5.2.2.2 `#define RTDM_TIMEOUT_NONE (-1)`

Any negative timeout means non-blocking.

### 5.2.3 Typedef Documentation

#### 5.2.3.1 `typedef uint64_t nanosecs_abs_t`

RTDM type for representing absolute dates.

Its base type is a 64 bit unsigned integer. The unit is 1 nanosecond.

**Examples:**

[rtcanrecv.c](#).

#### 5.2.3.2 `typedef int64_t nanosecs_rel_t`

RTDM type for representing relative intervals.

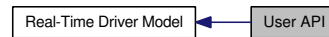
Its base type is a 64 bit signed integer. The unit is 1 nanosecond. Relative intervals can also encode the special timeouts "infinite" and "non-blocking", see [RTDM\\_TIMEOUT\\_XXX](#).

**Examples:**

[rtcanrecv.c](#), and [rtcansend.c](#).

## 5.3 User API

Collaboration diagram for User API:



### Files

- file [rtdm.h](#)  
*Real-Time Driver Model for Xenomai, user API header.*

### Functions

- int [rt\\_dev\\_open](#) (const char \*path, int oflag,...)  
*Open a device.*
- int [rt\\_dev\\_socket](#) (int protocol\_family, int socket\_type, int protocol)  
*Create a socket.*
- int [rt\\_dev\\_close](#) (int fd)  
*Close a device or socket.*
- int [rt\\_dev\\_ioctl](#) (int fd, int request,...)  
*Issue an IOCTL.*
- ssize\_t [rt\\_dev\\_read](#) (int fd, void \*buf, size\_t nbyte)  
*Read from device.*
- ssize\_t [rt\\_dev\\_write](#) (int fd, const void \*buf, size\_t nbyte)  
*Write to device.*
- ssize\_t [rt\\_dev\\_recvmmsg](#) (int fd, struct msghdr \*msg, int flags)  
*Receive message from socket.*
- ssize\_t [rt\\_dev\\_rcvfrom](#) (int fd, void \*buf, size\_t len, int flags, struct sockaddr \*from, socklen\_t \*fromlen)  
*Receive message from socket.*
- ssize\_t [rt\\_dev\\_rcv](#) (int fd, void \*buf, size\_t len, int flags)  
*Receive message from socket.*
- ssize\_t [rt\\_dev\\_sendmsg](#) (int fd, const struct msghdr \*msg, int flags)  
*Transmit message to socket.*
- ssize\_t [rt\\_dev\\_sendto](#) (int fd, const void \*buf, size\_t len, int flags, const struct sockaddr \*to, socklen\_t tolen)

*Transmit message to socket.*

- `ssize_t rt_dev_send` (int fd, const void \*buf, size\_t len, int flags)  
*Transmit message to socket.*
- `int rt_dev_bind` (int fd, const struct sockaddr \*my\_addr, socklen\_t addrlen)  
*Bind to local address.*
- `int rt_dev_connect` (int fd, const struct sockaddr \*serv\_addr, socklen\_t addrlen)  
*Connect to remote address.*
- `int rt_dev_listen` (int fd, int backlog)  
*Listen for incoming connection requests.*
- `int rt_dev_accept` (int fd, struct sockaddr \*addr, socklen\_t \*addrlen)  
*Accept a connection requests.*
- `int rt_dev_shutdown` (int fd, int how)  
*Shut down parts of a connection.*
- `int rt_dev_getsockopt` (int fd, int level, int optname, void \*optval, socklen\_t \*optlen)  
*Get socket option.*
- `int rt_dev_setsockopt` (int fd, int level, int optname, const void \*optval, socklen\_t optlen)  
*Set socket option.*
- `int rt_dev_getsockname` (int fd, struct sockaddr \*name, socklen\_t \*namelen)  
*Get local socket address.*
- `int rt_dev_getpeername` (int fd, struct sockaddr \*name, socklen\_t \*namelen)  
*Get socket destination address.*

### 5.3.1 Detailed Description

This is the upper interface of RTDM provided to application programs both in kernel and user space. Note that certain functions may not be implemented by every device. Refer to the [Device Profiles](#) for precise information.

### 5.3.2 Function Documentation

#### 5.3.2.1 `int rt_dev_accept` (int *fd*, struct sockaddr \* *addr*, socklen\_t \* *addrlen*)

Accept a connection requests.

##### Parameters:

- ← *fd* File descriptor as returned by `rt_dev_socket()`
- *addr* Buffer for remote address



↔ *addrlen* Address buffer size

**Returns:**

0 on success, otherwise negative error code

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**See also:**

`accept()` in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

**5.3.2.2 int rt\_dev\_bind (int *fd*, const struct sockaddr \* *my\_addr*, socklen\_t *addrlen*)**

Bind to local address.

**Parameters:**

↔ *fd* File descriptor as returned by `rt_dev_socket()`

↔ *my\_addr* Address buffer

↔ *addrlen* Address buffer size

**Returns:**

0 on success, otherwise negative error code

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**See also:**

`bind()` in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

**Examples:**

[rtcanrecv.c](#), and [rtcansend.c](#).

**5.3.2.3 int rt\_dev\_close (int *fd*)**

Close a device or socket.

**Parameters:**

↔ *fd* File descriptor as returned by `rt_dev_open()` or `rt_dev_socket()`

**Returns:**

0 on success, otherwise a negative error code.

**Note:**

If the matching `rt_dev_open()` or `rt_dev_socket()` call took place in non-real-time context, `rt_dev_close()` must be issued within non-real-time as well. Otherwise, the call will fail.

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**See also:**

`close()` in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

**5.3.2.4 int rt\_dev\_connect (int *fd*, const struct sockaddr \* *serv\_addr*, socklen\_t *addrlen*)**

Connect to remote address.

**Parameters:**

- ← *fd* File descriptor as returned by `rt_dev_socket()`
- ← *serv\_addr* Address buffer
- ← *addrlen* Address buffer size

**Returns:**

0 on success, otherwise negative error code

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**See also:**

`connect()` in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

**5.3.2.5 int rt\_dev\_getpeername (int *fd*, struct sockaddr \* *name*, socklen\_t \* *namelen*)**

Get socket destination address.

**Parameters:**

- ← *fd* File descriptor as returned by `rt_dev_socket()`
- *name* Address buffer
- ↔ *namelen* Address buffer size

**Returns:**

0 on success, otherwise negative error code

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**See also:**

getpeername() in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

**5.3.2.6 int rt\_dev\_getsockname (int *fd*, struct sockaddr \* *name*, socklen\_t \* *namelen*)**

Get local socket address.

**Parameters:**

- ← *fd* File descriptor as returned by rt\_dev\_socket()
- *name* Address buffer
- ↔ *namelen* Address buffer size

**Returns:**

0 on success, otherwise negative error code

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**See also:**

getsockname() in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

**5.3.2.7 int rt\_dev\_getsockopt (int *fd*, int *level*, int *optname*, void \* *optval*, socklen\_t \* *optlen*)**

Get socket option.

**Parameters:**

- ← *fd* File descriptor as returned by rt\_dev\_socket()
- ← *level* Addressed stack level
- ← *optname* Option name ID
- *optval* Value buffer
- ↔ *optlen* Value buffer size

**Returns:**

0 on success, otherwise negative error code

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**See also:**

getsockopt() in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

### 5.3.2.8 `int rt_dev_ioctl (int fd, int request, ...)`

Issue an IOCTL.

**Parameters:**

- ← *fd* File descriptor as returned by `rt_dev_open()` or `rt_dev_socket()`
- ← *request* IOCTL code
- ... Optional third argument, depending on IOCTL function (void \* or unsigned long)

**Returns:**

Positiv value on success, otherwise negative error code

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**See also:**

`ioctl()` in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

### 5.3.2.9 `int rt_dev_listen (int fd, int backlog)`

Listen for incomming connection requests.

**Parameters:**

- ← *fd* File descriptor as returned by `rt_dev_socket()`
- ← *backlog* Maximum queue length

**Returns:**

0 on success, otherwise negative error code

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**See also:**

`listen()` in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

### 5.3.2.10 `int rt_dev_open (const char * path, int oflag, ...)`

Open a device.

**Parameters:**

- ← *path* Device name

← *oflag* Open flags  
... Further parameters will be ignored.

**Returns:**

Positive file descriptor value on success, otherwise a negative error code.

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**See also:**

`open()` in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

**5.3.2.11 `ssize_t rt_dev_read (int fd, void * buf, size_t nbyte)`**

Read from device.

**Parameters:**

← *fd* File descriptor as returned by `rt_dev_open()`  
→ *buf* Input buffer  
← *nbyte* Number of bytes to read

**Returns:**

Number of bytes read, otherwise negative error code

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**See also:**

`read()` in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

**5.3.2.12 `ssize_t rt_dev_recv (int fd, void * buf, size_t len, int flags)`**

Receive message from socket.

**Parameters:**

← *fd* File descriptor as returned by `rt_dev_socket()`  
→ *buf* Message buffer  
← *len* Message buffer size  
← *flags* Message flags

**Returns:**

Number of bytes received, otherwise negative error code

**Environments:**

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**See also:**

recv() in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

### 5.3.2.13 ssize\_t rt\_dev\_recvfrom (int *fd*, void \* *buf*, size\_t *len*, int *flags*, struct sockaddr \* *from*, socklen\_t \* *fromlen*)

Receive message from socket.

**Parameters:**

- ← *fd* File descriptor as returned by rt\_dev\_socket()
- *buf* Message buffer
- ← *len* Message buffer size
- ← *flags* Message flags
- *from* Buffer for message sender address
- ↔ *fromlen* Address buffer size

**Returns:**

Number of bytes received, otherwise negative error code

**Environments:**

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**See also:**

recvfrom() in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

### 5.3.2.14 ssize\_t rt\_dev\_recvmsg (int *fd*, struct msghdr \* *msg*, int *flags*)

Receive message from socket.

**Parameters:**

- ← *fd* File descriptor as returned by rt\_dev\_socket()
- ↔ *msg* Message descriptor
- ← *flags* Message flags

**Returns:**

Number of bytes received, otherwise negative error code

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**See also:**

recvmsg() in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

**5.3.2.15 ssize\_t rt\_dev\_send (int *fd*, const void \* *buf*, size\_t *len*, int *flags*)**

Transmit message to socket.

**Parameters:**

← *fd* File descriptor as returned by rt\_dev\_socket()

← *buf* Message buffer

← *len* Message buffer size

← *flags* Message flags

**Returns:**

Number of bytes sent, otherwise negative error code

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**See also:**

send() in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

**Examples:**

[rtcansend.c](#).

**5.3.2.16 ssize\_t rt\_dev\_sendmsg (int *fd*, const struct msghdr \* *msg*, int *flags*)**

Transmit message to socket.

**Parameters:**

← *fd* File descriptor as returned by rt\_dev\_socket()

← *msg* Message descriptor

← *flags* Message flags

**Returns:**

Number of bytes sent, otherwise negative error code

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**See also:**

sendmsg() in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

**5.3.2.17 ssize\_t rt\_dev\_sendto (int *fd*, const void \* *buf*, size\_t *len*, int *flags*, const struct sockaddr \* *to*, socklen\_t *tolen*)**

Transmit message to socket.

**Parameters:**

- ← *fd* File descriptor as returned by rt\_dev\_socket()
- ← *buf* Message buffer
- ← *len* Message buffer size
- ← *flags* Message flags
- ← *to* Buffer for message destination address
- ← *tolen* Address buffer size

**Returns:**

Number of bytes sent, otherwise negative error code

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**See also:**

sendto() in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

**Examples:**

[rtcansend.c](#).

**5.3.2.18 int rt\_dev\_setsockopt (int *fd*, int *level*, int *optname*, const void \* *optval*, socklen\_t *optlen*)**

Set socket option.

**Parameters:**

- ← *fd* File descriptor as returned by rt\_dev\_socket()



- ← *level* Addressed stack level
- ← *optname* Option name ID
- ← *optval* Value buffer
- ← *optlen* Value buffer size

**Returns:**

0 on success, otherwise negative error code

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**See also:**

setsockopt() in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

**Examples:**

[rtcanrecv.c](#), and [rtcansend.c](#).

**5.3.2.19 int rt\_dev\_shutdown (int *fd*, int *how*)**

Shut down parts of a connection.

**Parameters:**

- ← *fd* File descriptor as returned by rt\_dev\_socket()
- ← *how* Specifies the part to be shut down (SHUT\_XXX)

**Returns:**

0 on success, otherwise negative error code

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**See also:**

shutdown() in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

**5.3.2.20 int rt\_dev\_socket (int *protocol\_family*, int *socket\_type*, int *protocol*)**

Create a socket.

**Parameters:**

- ← *protocol\_family* Protocol family (PF\_XXX)

← *socket\_type* Socket type (SOCK\_XXX)

← *protocol* Protocol ID, 0 for default

**Returns:**

Positive file descriptor value on success, otherwise a negative error code.

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**See also:**

socket() in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

### 5.3.2.21 ssize\_t rt\_dev\_write (int *fd*, const void \* *buf*, size\_t *nbyte*)

Write to device.

**Parameters:**

← *fd* File descriptor as returned by rt\_dev\_open()

← *buf* Output buffer

← *nbyte* Number of bytes to write

**Returns:**

Number of bytes written, otherwise negative error code

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**See also:**

write() in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

## 5.4 Serial Devices

Collaboration diagram for Serial Devices:



### Data Structures

- struct [rtser\\_config](#)  
*Serial device configuration.*
- struct [rtser\\_status](#)  
*Serial device status.*
- struct [rtser\\_event](#)  
*Additional information about serial device events.*

### Files

- file [rtserial.h](#)  
*Real-Time Driver Model for Xenomai, serial device profile header.*

### Defines

- #define [RTSER\\_RTIOC\\_BREAK\\_CTL](#) \_IOR(RTIOC\_TYPE\_SERIAL, 0x06, int)  
*Set or clear break on UART output line.*

### RTSER\_BREAK\_xxx

Break control

- typedef struct [rtser\\_config](#) [rtser\\_config\\_t](#)  
*Serial device configuration.*
- typedef struct [rtser\\_status](#) [rtser\\_status\\_t](#)  
*Serial device status.*
- typedef struct [rtser\\_event](#) [rtser\\_event\\_t](#)  
*Additional information about serial device events.*
- #define [RTSER\\_BREAK\\_CLR](#) 0x00  
*Serial device configuration.*

- #define [RTSER\\_BREAK\\_SET](#) 0x01  
*Serial device configuration.*
- #define [RTIOC\\_TYPE\\_SERIAL](#) RTDM\_CLASS\_SERIAL  
*Serial device configuration.*

## RTSER\_DEF\_BAUD

Default baud rate

- #define [RTSER\\_DEF\\_BAUD](#) 9600

## RTSER\_xxx\_PARITY

Number of parity bits

- #define [RTSER\\_NO\\_PARITY](#) 0x00
- #define [RTSER\\_ODD\\_PARITY](#) 0x01
- #define [RTSER\\_EVEN\\_PARITY](#) 0x03
- #define [RTSER\\_DEF\\_PARITY](#) [RTSER\\_NO\\_PARITY](#)

## RTSER\_xxx\_BITS

Number of data bits

- #define [RTSER\\_5\\_BITS](#) 0x00
- #define [RTSER\\_6\\_BITS](#) 0x01
- #define [RTSER\\_7\\_BITS](#) 0x02
- #define [RTSER\\_8\\_BITS](#) 0x03
- #define [RTSER\\_DEF\\_BITS](#) [RTSER\\_8\\_BITS](#)

## RTSER\_xxx\_STOPB

Number of stop bits

- #define [RTSER\\_1\\_STOPB](#) 0x00  
*valid only in combination with 5 data bits*
- #define [RTSER\\_1\\_5\\_STOPB](#) 0x01  
*valid only in combination with 5 data bits*
- #define [RTSER\\_2\\_STOPB](#) 0x01  
*valid only in combination with 5 data bits*
- #define [RTSER\\_DEF\\_STOPB](#) [RTSER\\_1\\_STOPB](#)  
*valid only in combination with 5 data bits*

## RTSER\_xxx\_HAND

Handshake mechanisms

- `#define RTSER_NO_HAND 0x00`
- `#define RTSER_RTSCTS_HAND 0x01`
- `#define RTSER_DEF_HAND RTSER_NO_HAND`

## RTSER\_FIFO\_xxx

Reception FIFO interrupt threshold

- `#define RTSER_FIFO_DEPTH_1 0x00`
- `#define RTSER_FIFO_DEPTH_4 0x40`
- `#define RTSER_FIFO_DEPTH_8 0x80`
- `#define RTSER_FIFO_DEPTH_14 0xC0`
- `#define RTSER_DEF_FIFO_DEPTH RTSER_FIFO_DEPTH_1`

## RTSER\_TIMEOUT\_xxx

Special timeout values, see also [RTDM\\_TIMEOUT\\_xxx](#)

- `#define RTSER_TIMEOUT_INFINITE RTDM_TIMEOUT_INFINITE`
- `#define RTSER_TIMEOUT_NONE RTDM_TIMEOUT_NONE`
- `#define RTSER_DEF_TIMEOUT RTDM_TIMEOUT_INFINITE`

## RTSER\_xxx\_TIMESTAMP\_HISTORY

Timestamp history control

- `#define RTSER_RX_TIMESTAMP_HISTORY 0x01`
- `#define RTSER_DEF_TIMESTAMP_HISTORY 0x00`

## RTSER\_EVENT\_xxx

Events bits

- `#define RTSER_EVENT_RXPEND 0x01`
- `#define RTSER_EVENT_ERRPEND 0x02`
- `#define RTSER_EVENT_MODEMHI 0x04`
- `#define RTSER_EVENT_MODEMLO 0x08`
- `#define RTSER_DEF_EVENT_MASK 0x00`

## RTSER\_SET\_xxx

Configuration mask bits

- `#define RTSER_SET_BAUD 0x0001`
- `#define RTSER_SET_PARITY 0x0002`
- `#define RTSER_SET_DATA_BITS 0x0004`
- `#define RTSER_SET_STOP_BITS 0x0008`
- `#define RTSER_SET_HANDSHAKE 0x0010`
- `#define RTSER_SET_FIFO_DEPTH 0x0020`
- `#define RTSER_SET_TIMEOUT_RX 0x0100`
- `#define RTSER_SET_TIMEOUT_TX 0x0200`
- `#define RTSER_SET_TIMEOUT_EVENT 0x0400`
- `#define RTSER_SET_TIMESTAMP_HISTORY 0x0800`
- `#define RTSER_SET_EVENT_MASK 0x1000`

## RTSER\_LSR\_xxx

Line status bits

- `#define RTSER_LSR_DATA 0x01`
- `#define RTSER_LSR_OVERRUN_ERR 0x02`
- `#define RTSER_LSR_PARITY_ERR 0x04`
- `#define RTSER_LSR_FRAMING_ERR 0x08`
- `#define RTSER_LSR_BREAK_IND 0x10`
- `#define RTSER_LSR_THR_EMPTY 0x20`
- `#define RTSER_LSR_TRANSM_EMPTY 0x40`
- `#define RTSER_LSR_FIFO_ERR 0x80`
- `#define RTSER_SOFT_OVERRUN_ERR 0x0100`

## RTSER\_MSR\_xxx

Modem status bits

- `#define RTSER_MSR_DCTS 0x01`
- `#define RTSER_MSR_DDSD 0x02`
- `#define RTSER_MSR_TERI 0x04`
- `#define RTSER_MSR_DDCD 0x08`
- `#define RTSER_MSR_CTS 0x10`
- `#define RTSER_MSR_DSR 0x20`
- `#define RTSER_MSR_RI 0x40`
- `#define RTSER_MSR_DCD 0x80`

## RTSER\_MCR\_xxx

Modem control bits

- #define RTSER\_MCR\_DTR 0x01
- #define RTSER\_MCR\_RTS 0x02
- #define RTSER\_MCR\_OUT1 0x04
- #define RTSER\_MCR\_OUT2 0x08
- #define RTSER\_MCR\_LOOP 0x10

## Sub-Classes of RTDM\_CLASS\_SERIAL

- #define RTDM\_SUBCLASS\_16550A 0

## IOCTLs

Serial device IOCTLs

- #define RTSER\_RTIOC\_GET\_CONFIG \_IOR(RTIOC\_TYPE\_SERIAL, 0x00, struct rtser\_config)  
*Get serial device configuration.*
- #define RTSER\_RTIOC\_SET\_CONFIG \_IOW(RTIOC\_TYPE\_SERIAL, 0x01, struct rtser\_config)  
*Set serial device configuration.*
- #define RTSER\_RTIOC\_GET\_STATUS \_IOR(RTIOC\_TYPE\_SERIAL, 0x02, struct rtser\_status)  
*Get serial device status.*
- #define RTSER\_RTIOC\_GET\_CONTROL \_IOR(RTIOC\_TYPE\_SERIAL, 0x03, int)  
*Get serial device's modem control register.*
- #define RTSER\_RTIOC\_SET\_CONTROL \_IOW(RTIOC\_TYPE\_SERIAL, 0x04, int)  
*Set serial device's modem control register.*
- #define RTSER\_RTIOC\_WAIT\_EVENT \_IOR(RTIOC\_TYPE\_SERIAL, 0x05, struct rtser\_event)  
*Wait on serial device events according to previously set mask.*

### 5.4.1 Detailed Description

This is the common interface a RTDM-compliant serial device has to provide. Feel free to comment on this profile via the Xenomai mailing list ([Xenomai-core@gna.org](mailto:Xenomai-core@gna.org)) or directly to the author ([jan.kiszka@web.de](mailto:jan.kiszka@web.de)).

**Profile Revision: 2**

## Device Characteristics

**Device Flags:** RTDM\_NAMED\_DEVICE, RTDM\_EXCLUSIVE

**Device Name:** "rtser<N>", N >= 0

**Device Class:** RTDM\_CLASS\_SERIAL

## Supported Operations

### Open

Environments: non-RT (RT optional)

Specific return values: none

### Close

Environments: non-RT (RT optional)

Specific return values: none

### IOCTL

Mandatory Environments: see [below](#)

Specific return values: see [below](#)

### Read

Environments: RT (non-RT optional)

Specific return values:

- -ETIMEDOUT
- -EINTR (interrupted explicitly or by signal)
- -EAGAIN (no data available in non-blocking mode)
- -EBADF (device has been closed while reading)
- -EIO (hardware error or broken bit stream)

### Write

Environments: RT (non-RT optional)

Specific return values:

- -ETIMEDOUT
- -EINTR (interrupted explicitly or by signal)
- -EAGAIN (no data written in non-blocking mode)
- -EBADF (device has been closed while writing)

## 5.4.2 Define Documentation

### 5.4.2.1 #define RTSER\_RTIOC\_BREAK\_CTL\_IOR(RTIOC\_TYPE\_SERIAL, 0x06, int)

Set or clear break on UART output line.

#### Parameters:

← *arg* RTSER\_BREAK\_SET or RTSER\_BREAK\_CLR (int)

#### Returns:

0 on success, otherwise negative error code

Environments:

This service can be called from:

- Kernel module initialization/cleanup code



- Kernel-based task
- User-space task (RT, non-RT)

**Note:**

A set break condition may also be cleared on UART line reconfiguration.

Rescheduling: never.

**5.4.2.2 #define RTSER\_RTIOC\_GET\_CONFIG \_IOR(RTIOC\_TYPE\_SERIAL, 0x00, struct rtser\_config)**

Get serial device configuration.

**Parameters:**

→ *arg* Pointer to configuration buffer (struct [rtser\\_config](#))

**Returns:**

0 on success, otherwise negative error code

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

**5.4.2.3 #define RTSER\_RTIOC\_GET\_CONTROL \_IOR(RTIOC\_TYPE\_SERIAL, 0x03, int)**

Get serial device's modem control register.

**Parameters:**

→ *arg* Pointer to variable receiving the content (int, see [RTSER\\_MCR\\_xxx](#))

**Returns:**

0 on success, otherwise negative error code

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

#### 5.4.2.4 `#define RTSER_RTIOC_GET_STATUS _IOR(RTIOC_TYPE_SERIAL, 0x02, struct rtser_status)`

Get serial device status.

##### Parameters:

→ *arg* Pointer to status buffer (struct [rtser\\_status](#))

##### Returns:

0 on success, otherwise negative error code

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

##### Note:

The error states `RTSER_LSR_OVERRUN_ERR`, `RTSER_LSR_PARITY_ERR`, `RTSER_LSR_FRAMING_ERR`, and `RTSER_SOFT_OVERRUN_ERR` that may have occurred during previous read accesses to the device will be saved for being reported via this IOCTL. Upon return from `RTSER_RTIOC_GET_STATUS`, the saved state will be cleared.

Rescheduling: never.

#### 5.4.2.5 `#define RTSER_RTIOC_SET_CONFIG _IOW(RTIOC_TYPE_SERIAL, 0x01, struct rtser_config)`

Set serial device configuration.

##### Parameters:

← *arg* Pointer to configuration buffer (struct [rtser\\_config](#))

##### Returns:

0 on success, otherwise:

- `-EPERM` is returned if the caller's context is invalid, see note below.
- `-ENOMEM` is returned if a new history buffer for timestamps cannot be allocated.

Environments:

This service can be called from:

- Kernel module initialization/cleanup code

- Kernel-based task
- User-space task (RT, non-RT)

**Note:**

If [rtser\\_config](#) contains a valid timestamp\_history and the addressed device has been opened in non-real-time context, this IOCTL must be issued in non-real-time context as well. Otherwise, this command will fail.

Rescheduling: never.

**Examples:**

[cross-link.c](#).

**5.4.2.6 #define RTSER\_RTIOC\_SET\_CONTROL \_IOW(RTIOC\_TYPE\_SERIAL, 0x04, int)**

Set serial device's modem control register.

**Parameters:**

← *arg* New control register content (int, see [RTSER\\_MCR\\_xxx](#))

**Returns:**

0 on success, otherwise negative error code

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

**5.4.2.7 #define RTSER\_RTIOC\_WAIT\_EVENT \_IOR(RTIOC\_TYPE\_SERIAL, 0x05, struct rtser\_event)**

Wait on serial device events according to previously set mask.

**Parameters:**

→ *arg* Pointer to event information buffer (struct [rtser\\_event](#))

**Returns:**

0 on success, otherwise:

- -EBUSY is returned if another task is already waiting on events of this device.

- -EBADF is returned if the file descriptor is invalid or the device has just been closed.

Environments:

This service can be called from:

- Kernel-based task
- User-space task (RT)

Rescheduling: possible.

**Examples:**

[cross-link.c](#).

## 5.5 Testing Devices

Collaboration diagram for Testing Devices:



### Files

- file [rttesting.h](#)

*Real-Time Driver Model for Xenomai, testing device profile header.*

### Sub-Classes of RTDM\_CLASS\_TESTING

- `#define RTDM_SUBCLASS_TIMERBENCH 0`
- `#define RTDM_SUBCLASS_IRQBENCH 1`
- `#define RTDM_SUBCLASS_SWITCHTEST 2`

### IOCTLs

Testing device IOCTLs

- `#define RTTST_RTIOC_INTERM_BENCH_RES _IOW(RTIOC_TYPE_TESTING, 0x00, struct rttst_interm_bench_res)`
- `#define RTTST_RTIOC_TMBENCH_START _IOW(RTIOC_TYPE_TESTING, 0x10, struct rttst_tmbench_config)`
- `#define RTTST_RTIOC_TMBENCH_STOP _IOW(RTIOC_TYPE_TESTING, 0x11, struct rttst_overall_bench_res)`
- `#define RTTST_RTIOC_IRQBENCH_START _IOW(RTIOC_TYPE_TESTING, 0x20, struct rttst_irqbench_config)`
- `#define RTTST_RTIOC_IRQBENCH_STOP _IO(RTIOC_TYPE_TESTING, 0x21)`
- `#define RTTST_RTIOC_IRQBENCH_GET_STATS _IOR(RTIOC_TYPE_TESTING, 0x22, struct rttst_irqbench_stats)`
- `#define RTTST_RTIOC_IRQBENCH_WAIT_IRQ _IO(RTIOC_TYPE_TESTING, 0x23)`
- `#define RTTST_RTIOC_IRQBENCH_REPLY_IRQ _IO(RTIOC_TYPE_TESTING, 0x24)`
- `#define RTTST_RTIOC_SWTEST_SET_TASKS_COUNT _IOW(RTIOC_TYPE_TESTING, 0x30, unsigned long)`
- `#define RTTST_RTIOC_SWTEST_SET_CPU _IOW(RTIOC_TYPE_TESTING, 0x31, unsigned long)`
- `#define RTTST_RTIOC_SWTEST_REGISTER_UTASK _IOW(RTIOC_TYPE_TESTING, 0x32, struct rttst_swtest_task)`
- `#define RTTST_RTIOC_SWTEST_CREATE_KTASK _IOW(RTIOC_TYPE_TESTING, 0x33, struct rttst_swtest_task)`
- `#define RTTST_RTIOC_SWTEST_PEND _IOR(RTIOC_TYPE_TESTING, 0x34, struct rttst_swtest_task)`
- `#define RTTST_RTIOC_SWTEST_SWITCH_TO _IOR(RTIOC_TYPE_TESTING, 0x35, struct rttst_swtest_dir)`

- `#define RTTST_RTIOC_SWTEST_GET_SWITCHES_COUNT _IOR(RTIOC_TYPE_TESTING, 0x36, unsigned long)`
- `#define RTTST_RTIOC_SWTEST_GET_LAST_ERROR _IOR(RTIOC_TYPE_TESTING, 0x37, struct rttst_swtest_error)`
- `#define RTTST_RTIOC_SWTEST_SET_PAUSE _IOW(RTIOC_TYPE_TESTING, 0x38, unsigned long)`

### 5.5.1 Detailed Description

This group of devices is intended to provide in-kernel testing results. Feel free to comment on this profile via the Xenomai mailing list ([xenomai-core@gna.org](mailto:xenomai-core@gna.org)) or directly to the author ([jan.kiszka@web.de](mailto:jan.kiszka@web.de)).

**Profile Revision:** 1

#### Device Characteristics

**Device Flags:** RTDM\_NAMED\_DEVICE  
**Device Name:** "rtttest<N>", N >= 0  
**Device Class:** RTDM\_CLASS\_TESTING

#### Supported Operations

##### Open

Environments: non-RT (RT optional)

Specific return values: none

##### Close

Environments: non-RT (RT optional)

Specific return values: none

##### IOCTL

Mandatory Environments: see [TSTIOCTLs](#) below

Specific return values: see [TSTIOCTLs](#) below

## 5.6 Inter-Driver API

Collaboration diagram for Inter-Driver API:



### Functions

- struct `rt dm_dev_context` \* `rt dm_context_get` (int fd)  
*Resolve file descriptor to device context.*
- int `rt dm_select_bind` (int fd, `rt dm_selector_t` \*selector, enum `rt dm_selecttype` type, unsigned fd\_index)  
*Bind a selector to specified event types of a given file descriptor.*
- void `rt dm_context_lock` (struct `rt dm_dev_context` \*context)  
*Increment context reference counter.*
- void `rt dm_context_unlock` (struct `rt dm_dev_context` \*context)  
*Decrement context reference counter.*
- int `rt dm_open` (const char \*path, int oflag,...)  
*Open a device.*
- int `rt dm_socket` (int protocol\_family, int socket\_type, int protocol)  
*Create a socket.*
- int `rt dm_close` (int fd)  
*Close a device or socket.*
- int `rt dm_ioctl` (int fd, int request,...)  
*Issue an IOCTL.*
- ssize\_t `rt dm_read` (int fd, void \*buf, size\_t nbyte)  
*Read from device.*
- ssize\_t `rt dm_write` (int fd, const void \*buf, size\_t nbyte)  
*Write to device.*
- ssize\_t `rt dm_recvmmsg` (int fd, struct `msg_hdr` \*msg, int flags)  
*Receive message from socket.*
- ssize\_t `rt dm_recvfrom` (int fd, void \*buf, size\_t len, int flags, struct `sockaddr` \*from, `socklen_t` \*fromlen)  
*Receive message from socket.*
- ssize\_t `rt dm_recv` (int fd, void \*buf, size\_t len, int flags)  
*Receive message from socket.*

- `ssize_t rtdm_sendmsg` (int fd, const struct msghdr \*msg, int flags)  
*Transmit message to socket.*
- `ssize_t rtdm_sendto` (int fd, const void \*buf, size\_t len, int flags, const struct sockaddr \*to, socklen\_t tolen)  
*Transmit message to socket.*
- `ssize_t rtdm_send` (int fd, const void \*buf, size\_t len, int flags)  
*Transmit message to socket.*
- `int rtdm_bind` (int fd, const struct sockaddr \*my\_addr, socklen\_t addrlen)  
*Bind to local address.*
- `int rtdm_connect` (int fd, const struct sockaddr \*serv\_addr, socklen\_t addrlen)  
*Connect to remote address.*
- `int rtdm_listen` (int fd, int backlog)  
*Listen for incoming connection requests.*
- `int rtdm_accept` (int fd, struct sockaddr \*addr, socklen\_t \*addrlen)  
*Accept a connection requests.*
- `int rtdm_shutdown` (int fd, int how)  
*Shut down parts of a connection.*
- `int rtdm_getsockopt` (int fd, int level, int optname, void \*optval, socklen\_t \*optlen)  
*Get socket option.*
- `int rtdm_setsockopt` (int fd, int level, int optname, const void \*optval, socklen\_t optlen)  
*Set socket option.*
- `int rtdm_getsockname` (int fd, struct sockaddr \*name, socklen\_t \*namelen)  
*Get local socket address.*
- `int rtdm_getpeername` (int fd, struct sockaddr \*name, socklen\_t \*namelen)  
*Get socket destination address.*

## 5.6.1 Function Documentation

### 5.6.1.1 `int rtdm_accept` (int fd, struct sockaddr \* addr, socklen\_t \* addrlen)

Accept a connection requests.

Refer to `rt_dev_accept()` for parameters and return values

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.



**5.6.1.2 int rtdm\_bind (int *fd*, const struct sockaddr \* *my\_addr*, socklen\_t *addrlen*)**

Bind to local address.

Refer to [rt\\_dev\\_bind\(\)](#) for parameters and return values

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**5.6.1.3 int rtdm\_close (int *fd*)**

Close a device or socket.

Refer to [rt\\_dev\\_close\(\)](#) for parameters and return values

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**5.6.1.4 int rtdm\_connect (int *fd*, const struct sockaddr \* *serv\_addr*, socklen\_t *addrlen*)**

Connect to remote address.

Refer to [rt\\_dev\\_connect\(\)](#) for parameters and return values

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**5.6.1.5 struct rtdm\_dev\_context\* rtdm\_context\_get (int *fd*) [read]**

Resolve file descriptor to device context.

**Parameters:**

← *fd* File descriptor

**Returns:**

Pointer to associated device context, or NULL on error

**Note:**

The device context has to be unlocked using [rtdm\\_context\\_unlock\(\)](#) when it is no longer referenced.

Environments:

This service can be called from:

- Kernel module initialization/cleanup code

- Interrupt service routine
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

References `rtdm_dev_context::context_flags`, `RTDM_CLOSING`, and `rtdm_context_lock()`.

Referenced by `rtdm_select_bind()`.

#### 5.6.1.6 `void rtdm_context_lock (struct rtdm_dev_context * context)`

Increment context reference counter.

##### Parameters:

← *context* Device context

##### Note:

[rtdm\\_context\\_get\(\)](#) automatically increments the lock counter. You only need to call this function in special scenarios.

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

Referenced by `rtdm_context_get()`.

#### 5.6.1.7 `void rtdm_context_unlock (struct rtdm_dev_context * context)`

Decrement context reference counter.

##### Parameters:

← *context* Device context

##### Note:

Every successful call to [rtdm\\_context\\_get\(\)](#) must be matched by a [rtdm\\_context\\_unlock\(\)](#) invocation.

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

Referenced by `rtdm_select_bind()`.

#### 5.6.1.8 `int rtdm_getpeername (int fd, struct sockaddr * name, socklen_t * namelen)`

Get socket destination address.

Refer to `rt_dev_getpeername()` for parameters and return values

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

#### 5.6.1.9 `int rtdm_getsockname (int fd, struct sockaddr * name, socklen_t * namelen)`

Get local socket address.

Refer to `rt_dev_getsockname()` for parameters and return values

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

#### 5.6.1.10 `int rtdm_getsockopt (int fd, int level, int optname, void * optval, socklen_t * optlen)`

Get socket option.

Refer to `rt_dev_getsockopt()` for parameters and return values

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

#### 5.6.1.11 `int rtdm_ioctl (int fd, int request, ...)`

Issue an IOCTL.

Refer to `rt_dev_ioctl()` for parameters and return values

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

#### 5.6.1.12 `int rtdm_listen (int fd, int backlog)`

Listen for incoming connection requests.

Refer to `rt_dev_listen()` for parameters and return values

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

#### 5.6.1.13 `int rtdm_open (const char * path, int oflag, ...)`

Open a device.

Refer to `rt_dev_open()` for parameters and return values

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

#### 5.6.1.14 `ssize_t rtdm_read (int fd, void * buf, size_t nbyte)`

Read from device.

Refer to `rt_dev_read()` for parameters and return values

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

#### 5.6.1.15 `ssize_t rtdm_recv (int fd, void * buf, size_t len, int flags)`

Receive message from socket.

Refer to `rt_dev_recv()` for parameters and return values

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

#### 5.6.1.16 `ssize_t rtdm_recvfrom (int fd, void * buf, size_t len, int flags, struct sockaddr * from, socklen_t * fromlen)`

Receive message from socket.

Refer to `rt_dev_recvfrom()` for parameters and return values

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**5.6.1.17** `ssize_t rtdm_recvmmsg (int fd, struct msghdr * msg, int flags)`

Receive message from socket.

Refer to `rt_dev_recvmmsg()` for parameters and return values

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

**5.6.1.18** `int rtdm_select_bind (int fd, rtdm_selector_t * selector, enum rtdm_selecttype type, unsigned fd_index)`

Bind a selector to specified event types of a given file descriptor.

**For internal use only.**

This function is invoked by higher RTOS layers implementing select-like services. It shall not be called directly by RTDM drivers.

**Parameters:**

- ← *fd* File descriptor to bind to
- ↔ *selector* Selector object that shall be bound to the given event
- ← *type* Event type the caller is interested in
- ← *fd\_index* Index in the file descriptor set of the caller

**Returns:**

0 on success, otherwise:

- -EBADF is returned if the file descriptor *fd* cannot be resolved.
- -EINVAL is returned if *type* or *fd\_index* are invalid.

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

References `rtdm_dev_context::ops`, `rtdm_context_get()`, `rtdm_context_unlock()`, and `rtdm_operations::select_bind`.

**5.6.1.19** `ssize_t rtdm_send (int fd, const void * buf, size_t len, int flags)`

Transmit message to socket.

Refer to `rt_dev_send()` for parameters and return values

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

#### 5.6.1.20 `ssize_t rtdm_sendmsg (int fd, const struct msghdr * msg, int flags)`

Transmit message to socket.

Refer to `rt_dev_sendmsg()` for parameters and return values

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

#### 5.6.1.21 `ssize_t rtdm_sendto (int fd, const void * buf, size_t len, int flags, const struct sockaddr * to, socklen_t tolen)`

Transmit message to socket.

Refer to `rt_dev_sendto()` for parameters and return values

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

#### 5.6.1.22 `int rtdm_setsockopt (int fd, int level, int optname, const void * optval, socklen_t optlen)`

Set socket option.

Refer to `rt_dev_setsockopt()` for parameters and return values

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

#### 5.6.1.23 `int rtdm_shutdown (int fd, int how)`

Shut down parts of a connection.

Refer to `rt_dev_shutdown()` for parameters and return values

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

#### 5.6.1.24 `int rtdm_socket (int protocol_family, int socket_type, int protocol)`

Create a socket.

Refer to `rt_dev_socket()` for parameters and return values

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

#### 5.6.1.25 `ssize_t rtdm_write (int fd, const void * buf, size_t nbyte)`

Write to device.

Refer to `rt_dev_write()` for parameters and return values

Environments:

Depends on driver implementation, see [Device Profiles](#).

Rescheduling: possible.

## 5.7 Device Registration Services

Collaboration diagram for Device Registration Services:



### Data Structures

- struct [rt dm\\_operations](#)  
*Device operations.*
- struct [rt dm\\_dev\\_context](#)  
*Device context.*
- struct [rt dm\\_device](#)  
*RTDM device.*

### Modules

- [Synchronisation Services](#)

### Functions

- int [rt dm\\_dev\\_register](#) (struct [rt dm\\_device](#) \*device)  
*Register a RTDM device.*
- int [rt dm\\_dev\\_unregister](#) (struct [rt dm\\_device](#) \*device, unsigned int poll\_delay)  
*Unregisters a RTDM device.*

### Operation Handler Prototypes

- typedef int(\* [rt dm\\_open\\_handler\\_t](#) )(struct [rt dm\\_dev\\_context](#) \*context, [rt dm\\_user\\_info\\_t](#) \*user\_info, int oflag)  
*Named device open handler.*
- typedef int(\* [rt dm\\_socket\\_handler\\_t](#) )(struct [rt dm\\_dev\\_context](#) \*context, [rt dm\\_user\\_info\\_t](#) \*user\_info, int protocol)  
*Socket creation handler for protocol devices.*
- typedef int(\* [rt dm\\_close\\_handler\\_t](#) )(struct [rt dm\\_dev\\_context](#) \*context, [rt dm\\_user\\_info\\_t](#) \*user\_info)  
*Close handler.*
- typedef int(\* [rt dm\\_ioctl\\_handler\\_t](#) )(struct [rt dm\\_dev\\_context](#) \*context, [rt dm\\_user\\_info\\_t](#) \*user\_info, unsigned int request, void \_\_user \*arg)



*IOCTL handler.*

- typedef int(\* [rtm\\_select\\_bind\\_handler\\_t](#) )(struct [rtm\\_dev\\_context](#) \*context, [rtm\\_selector\\_t](#) \*selector, enum [rtm\\_selecttype](#) type, unsigned fd\_index)

*Select binding handler.*

- typedef ssize\_t(\* [rtm\\_read\\_handler\\_t](#) )(struct [rtm\\_dev\\_context](#) \*context, [rtm\\_user\\_info\\_t](#) \*user\_info, void \*buf, size\_t nbyte)

*Read handler.*

- typedef ssize\_t(\* [rtm\\_write\\_handler\\_t](#) )(struct [rtm\\_dev\\_context](#) \*context, [rtm\\_user\\_info\\_t](#) \*user\_info, const void \*buf, size\_t nbyte)

*Write handler.*

- typedef ssize\_t(\* [rtm\\_recvmmsg\\_handler\\_t](#) )(struct [rtm\\_dev\\_context](#) \*context, [rtm\\_user\\_info\\_t](#) \*user\_info, struct msghdr \*msg, int flags)

*Receive message handler.*

- typedef ssize\_t(\* [rtm\\_sendmsg\\_handler\\_t](#) )(struct [rtm\\_dev\\_context](#) \*context, [rtm\\_user\\_info\\_t](#) \*user\_info, const struct msghdr \*msg, int flags)

*Transmit message handler.*

## Device Flags

Static flags describing a RTDM device

- #define [RTDM\\_EXCLUSIVE](#) 0x0001  
*If set, only a single instance of the device can be requested by an application.*
- #define [RTDM\\_NAMED\\_DEVICE](#) 0x0010  
*If set, the device is addressed via a clear-text name.*
- #define [RTDM\\_PROTOCOL\\_DEVICE](#) 0x0020  
*If set, the device is addressed via a combination of protocol ID and socket type.*
- #define [RTDM\\_DEVICE\\_TYPE\\_MASK](#) 0x00F0  
*Mask selecting the device type.*

## Context Flags

Dynamic flags describing the state of an open RTDM device (bit numbers)

- #define [RTDM\\_CREATED\\_IN\\_NRT](#) 0  
*Set by RTDM if the device instance was created in non-real-time context.*
- #define [RTDM\\_CLOSING](#) 1  
*Set by RTDM when the device is being closed.*

- `#define RTDM_USER_CONTEXT_FLAG 8`  
*Lowest bit number the driver developer can use freely.*

## Driver Versioning

Current revisions of RTDM structures, encoding of driver versions. See [API Versioning](#) for the interface revision.

- `#define RTDM_DEVICE_STRUCT_VER 5`  
*Version of struct `rtdm_device`.*
- `#define RTDM_CONTEXT_STRUCT_VER 3`  
*Version of struct `rtdm_dev_context`.*
- `#define RTDM_SECURE_DEVICE 0x80000000`  
*Flag indicating a secure variant of RTDM (not supported here).*
- `#define RTDM_DRIVER_VER(major, minor, patch) (((major & 0xFF) << 16) | ((minor & 0xFF) << 8) | (patch & 0xFF))`  
*Version code constructor for driver revisions.*
- `#define RTDM_DRIVER_MAJOR_VER(ver) (((ver) >> 16) & 0xFF)`  
*Get major version number from driver revision code.*
- `#define RTDM_DRIVER_MINOR_VER(ver) (((ver) >> 8) & 0xFF)`  
*Get minor version number from driver revision code.*
- `#define RTDM_DRIVER_PATCH_VER(ver) ((ver) & 0xFF)`  
*Get patch version number from driver revision code.*

### 5.7.1 Define Documentation

#### 5.7.1.1 `#define RTDM_CLOSING 1`

Set by RTDM when the device is being closed.

Referenced by `rtdm_context_get()`.

#### 5.7.1.2 `#define RTDM_CREATED_IN_NRT 0`

Set by RTDM if the device instance was created in non-real-time context.

#### 5.7.1.3 `#define RTDM_DEVICE_TYPE_MASK 0x00F0`

Mask selecting the device type.

Referenced by `rtdm_dev_register()`, and `rtdm_dev_unregister()`.

#### 5.7.1.4 `#define RTDM_EXCLUSIVE 0x0001`

If set, only a single instance of the device can be requested by an application.

Referenced by `rtdm_dev_register()`.

#### 5.7.1.5 `#define RTDM_NAMED_DEVICE 0x0010`

If set, the device is addressed via a clear-text name.

Referenced by `rtdm_dev_register()`, and `rtdm_dev_unregister()`.

#### 5.7.1.6 `#define RTDM_PROTOCOL_DEVICE 0x0020`

If set, the device is addressed via a combination of protocol ID and socket type.

Referenced by `rtdm_dev_register()`.

### 5.7.2 Typedef Documentation

#### 5.7.2.1 `typedef int(* rtdm_close_handler_t)(struct rtdm_dev_context *context, rtdm_user_info_t *user_info)`

Close handler.

##### Parameters:

- ← *context* Context structure associated with opened device instance
- ← *user\_info* Opaque pointer to information about user mode caller, NULL if kernel mode call

##### Returns:

0 on success. On failure return either `-ENOSYS`, to request that this handler be called again from the opposite realtime/non-realtime context, or another negative error code.

##### See also:

`close()` in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

#### 5.7.2.2 `typedef int(* rtdm_ioctl_handler_t)(struct rtdm_dev_context *context, rtdm_user_info_t *user_info, unsigned int request, void __user *arg)`

IOCTL handler.

##### Parameters:

- ← *context* Context structure associated with opened device instance
- ← *user\_info* Opaque pointer to information about user mode caller, NULL if kernel mode call
- ← *request* Request number as passed by the user
- ↔ *arg* Request argument as passed by the user

**Returns:**

A positive value or 0 on success. On failure return either -ENOSYS, to request that the function be called again from the opposite realtime/non-realtime context, or another negative error code.

**See also:**

ioctl() in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

### 5.7.2.3 `typedef int(* rtdm_open_handler_t)(struct rtdm_dev_context *context, rtdm_user_info_t *user_info, int oflag)`

Named device open handler.

**Parameters:**

- ← *context* Context structure associated with opened device instance
- ← *user\_info* Opaque pointer to information about user mode caller, NULL if kernel mode call
- ← *oflag* Open flags as passed by the user

**Returns:**

0 on success. On failure return either -ENOSYS, to request that this handler be called again from the opposite realtime/non-realtime context, or another negative error code.

**See also:**

open() in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

### 5.7.2.4 `typedef ssize_t(* rtdm_read_handler_t)(struct rtdm_dev_context *context, rtdm_user_info_t *user_info, void *buf, size_t nbyte)`

Read handler.

**Parameters:**

- ← *context* Context structure associated with opened device instance
- ← *user\_info* Opaque pointer to information about user mode caller, NULL if kernel mode call
- *buf* Input buffer as passed by the user
- ← *nbyte* Number of bytes the user requests to read

**Returns:**

On success, the number of bytes read. On failure return either -ENOSYS, to request that this handler be called again from the opposite realtime/non-realtime context, or another negative error code.

**See also:**

read() in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

**5.7.2.5** `typedef ssize_t(* rtdm_recvmmsg_handler_t)(struct rtdm_dev_context *context, rtdm_user_info_t *user_info, struct msghdr *msg, int flags)`

Receive message handler.

**Parameters:**

- ← *context* Context structure associated with opened device instance
- ← *user\_info* Opaque pointer to information about user mode caller, NULL if kernel mode call
- ↔ *msg* Message descriptor as passed by the user, automatically mirrored to safe kernel memory in case of user mode call
- ← *flags* Message flags as passed by the user

**Returns:**

On success, the number of bytes received. On failure return either -ENOSYS, to request that this handler be called again from the opposite realtime/non-realtime context, or another negative error code.

**See also:**

recvmmsg() in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

**5.7.2.6** `typedef int(* rtdm_select_bind_handler_t)(struct rtdm_dev_context *context, rtdm_selector_t *selector, enum rtdm_selecttype type, unsigned fd_index)`

Select binding handler.

**Parameters:**

- ← *context* Context structure associated with opened device instance
- ↔ *selector* Object that shall be bound to the given event
- ← *type* Event type the selector is interested in
- ← *fd\_index* Opaque value, to be passed to rtdm\_event\_select\_bind or rtdm\_sem\_select\_bind unmodified

**Returns:**

0 on success. On failure return either -ENOSYS, to request that this handler be called again from the opposite realtime/non-realtime context, or another negative error code.

**5.7.2.7** `typedef ssize_t(* rtdm_sendmsg_handler_t)(struct rtdm_dev_context *context, rtdm_user_info_t *user_info, const struct msghdr *msg, int flags)`

Transmit message handler.

**Parameters:**

- ← *context* Context structure associated with opened device instance

- ← *user\_info* Opaque pointer to information about user mode caller, NULL if kernel mode call
- ← *msg* Message descriptor as passed by the user, automatically mirrored to safe kernel memory in case of user mode call
- ← *flags* Message flags as passed by the user

**Returns:**

On success, the number of bytes transmitted. On failure return either -ENOSYS, to request that this handler be called again from the opposite realtime/non-realtime context, or another negative error code.

**See also:**

sendmsg() in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

#### 5.7.2.8 **typedef int(\* rtdm\_socket\_handler\_t)(struct rtdm\_dev\_context \*context, rtdm\_user\_info\_t \*user\_info, int protocol)**

Socket creation handler for protocol devices.

**Parameters:**

- ← *context* Context structure associated with opened device instance
- ← *user\_info* Opaque pointer to information about user mode caller, NULL if kernel mode call
- ← *protocol* Protocol number as passed by the user

**Returns:**

0 on success. On failure return either -ENOSYS, to request that this handler be called again from the opposite realtime/non-realtime context, or another negative error code.

**See also:**

socket() in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

#### 5.7.2.9 **typedef ssize\_t(\* rtdm\_write\_handler\_t)(struct rtdm\_dev\_context \*context, rtdm\_user\_info\_t \*user\_info, const void \*buf, size\_t nbyte)**

Write handler.

**Parameters:**

- ← *context* Context structure associated with opened device instance
- ← *user\_info* Opaque pointer to information about user mode caller, NULL if kernel mode call
- ← *buf* Output buffer as passed by the user
- ← *nbyte* Number of bytes the user requests to write

**Returns:**

On success, the number of bytes written. On failure return either -ENOSYS, to request that this handler be called again from the opposite realtime/non-realtime context, or another negative error code.

**See also:**

write() in IEEE Std 1003.1, <http://www.opengroup.org/onlinepubs/009695399>

### 5.7.3 Function Documentation

#### 5.7.3.1 int rtdm\_dev\_register (struct rtdm\_device \* device)

Register a RTDM device.

**Parameters:**

← *device* Pointer to structure describing the new device.

**Returns:**

0 is returned upon success. Otherwise:

- -EINVAL is returned if the device structure contains invalid entries. Check kernel log in this case.
- -ENOMEM is returned if the context for an exclusive device cannot be allocated.
- -EEXIST is returned if the specified device name or protocol ID is already in use.
- -EAGAIN is returned if some /proc entry cannot be created.

**Environments:**

This service can be called from:

- Kernel module initialization/cleanup code

Rescheduling: never.

References rtdm\_operations::close\_nrt, rtdm\_operations::close\_rt, rtdm\_device::context\_size, rtdm\_device::device\_class, rtdm\_device::device\_flags, rtdm\_device::device\_name, rtdm\_device::device\_sub\_class, rtdm\_device::driver\_version, rtdm\_device::ops, rtdm\_device::proc\_name, rtdm\_device::profile\_version, rtdm\_device::protocol\_family, rtdm\_device::reserved, RTDM\_DEVICE\_STRUCT\_VER, RTDM\_DEVICE\_TYPE\_MASK, RTDM\_EXCLUSIVE, RTDM\_NAMED\_DEVICE, RTDM\_PROTOCOL\_DEVICE, rtdm\_operations::select\_bind, rtdm\_device::socket\_type, and rtdm\_device::struct\_version.

#### 5.7.3.2 int rtdm\_dev\_unregister (struct rtdm\_device \* device, unsigned int poll\_delay)

Unregisters a RTDM device.

**Parameters:**

- ← *device* Pointer to structure describing the device to be unregistered.
- ← *poll\_delay* Polling delay in milliseconds to check repeatedly for open instances of *device*, or 0 for non-blocking mode.

**Returns:**

0 is returned upon success. Otherwise:

- -ENODEV is returned if the device was not registered.
- -EAGAIN is returned if the device is busy with open instances and 0 has been passed for *poll\_delay*.

**Environments:**

This service can be called from:

- Kernel module initialization/cleanup code

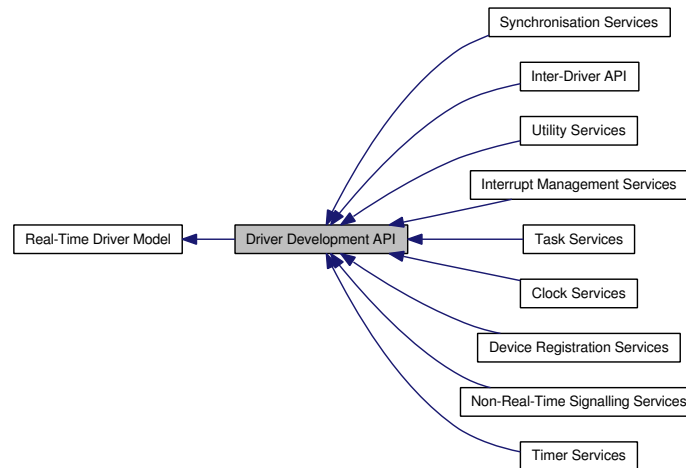
Rescheduling: never.

References `rtm_device::device_flags`, `rtm_device::device_name`, `rtm_device::proc_entry`, `rtm_device::proc_name`, `rtm_device::protocol_family`, `rtm_device::reserved`, `RTDM_DEVICE_TYPE_MASK`, `RTDM_NAMED_DEVICE`, and `rtm_device::socket_type`.



## 5.8 Driver Development API

Collaboration diagram for Driver Development API:



### Modules

- [Inter-Driver API](#)
- [Device Registration Services](#)
- [Clock Services](#)
- [Task Services](#)
- [Timer Services](#)
- [Synchronisation Services](#)
- [Interrupt Management Services](#)
- [Non-Real-Time Signalling Services](#)
- [Utility Services](#)

### Files

- file [rt dm\\_driver.h](#)  
*Real-Time Driver Model for Xenomai, driver API header.*

#### 5.8.1 Detailed Description

This is the lower interface of RTDM provided to device drivers, currently limited to kernel-space. Real-time drivers should only use functions of this interface in order to remain portable.

## 5.9 Clock Services

Collaboration diagram for Clock Services:



### Functions

- [nanosecs\\_abs\\_t rtdm\\_clock\\_read](#) (void)  
*Get system time.*
- [nanosecs\\_abs\\_t rtdm\\_clock\\_read\\_monotonic](#) (void)  
*Get monotonic time.*

### 5.9.1 Function Documentation

#### 5.9.1.1 [nanosecs\\_abs\\_t rtdm\\_clock\\_read](#) (void)

Get system time.

##### Returns:

The system time in nanoseconds is returned

##### Note:

The resolution of this service depends on the system timer. In particular, if the system timer is running in periodic mode, the return value will be limited to multiples of the timer tick period.

The system timer may have to be started to obtain valid results. Whether this happens automatically (as on Xenomai) or is controlled by the application depends on the RTDM host environment.

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

### 5.9.1.2 nanosecs\_abs\_t rtdm\_clock\_read\_monotonic (void)

Get monotonic time.

**Returns:**

The monotonic time in nanoseconds is returned

**Note:**

The resolution of this service depends on the system timer. In particular, if the system timer is running in periodic mode, the return value will be limited to multiples of the timer tick period.

The system timer may have to be started to obtain valid results. Whether this happens automatically (as on Xenomai) or is controlled by the application depends on the RTDM host environment.

**Environments:**

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

## 5.10 Task Services

Collaboration diagram for Task Services:



### Typedefs

- typedef void(\* [rtdm\\_task\\_proc\\_t](#))(void \*arg)  
*Real-time task procedure.*

### Functions

- int [rtdm\\_task\\_init](#) (rtdm\_task\_t \*task, const char \*name, [rtdm\\_task\\_proc\\_t](#) task\_proc, void \*arg, int priority, [nanosecs\\_rel\\_t](#) period)  
*Initialise and start a real-time task.*
- void [rtdm\\_task\\_destroy](#) (rtdm\_task\_t \*task)  
*Destroy a real-time task.*
- void [rtdm\\_task\\_set\\_priority](#) (rtdm\_task\_t \*task, int priority)  
*Adjust real-time task priority.*
- int [rtdm\\_task\\_set\\_period](#) (rtdm\_task\_t \*task, [nanosecs\\_rel\\_t](#) period)  
*Adjust real-time task period.*
- int [rtdm\\_task\\_wait\\_period](#) (void)  
*Wait on next real-time task period.*
- int [rtdm\\_task\\_unblock](#) (rtdm\_task\_t \*task)  
*Activate a blocked real-time task.*
- rtdm\_task\_t \* [rtdm\\_task\\_current](#) (void)  
*Get current real-time task.*
- int [rtdm\\_task\\_sleep](#) ([nanosecs\\_rel\\_t](#) delay)  
*Sleep a specified amount of time.*
- int [rtdm\\_task\\_sleep\\_until](#) ([nanosecs\\_abs\\_t](#) wakeup\_time)  
*Sleep until a specified absolute time.*
- int [rtdm\\_task\\_sleep\\_abs](#) ([nanosecs\\_abs\\_t](#) wakeup\_time, enum [rtdm\\_timer\\_mode](#) mode)  
*Sleep until a specified absolute time.*
- void [rtdm\\_task\\_join\\_nrt](#) (rtdm\_task\_t \*task, unsigned int poll\_delay)  
*Wait on a real-time task to terminate.*

- void `rtdm_task_busy_sleep` (`nanosecs_rel_t` delay)  
*Busy-wait a specified amount of time.*

## Task Priority Range

Maximum and minimum task priorities

- `#define RTDM_TASK_LOWEST_PRIORITY XNSCHED_LOW_PRIO`
- `#define RTDM_TASK_HIGHEST_PRIORITY XNSCHED_HIGH_PRIO`

## Task Priority Modification

Raise or lower task priorities by one level

- `#define RTDM_TASK_RAISE_PRIORITY (+1)`
- `#define RTDM_TASK_LOWER_PRIORITY (-1)`

### 5.10.1 Typedef Documentation

#### 5.10.1.1 typedef void(\* rtdm\_task\_proc\_t)(void \*arg)

Real-time task procedure.

**Parameters:**

↔ *arg* argument as passed to `rtdm_task_init()`

### 5.10.2 Function Documentation

#### 5.10.2.1 void rtdm\_task\_busy\_sleep (nanosecs\_rel\_t delay)

Busy-wait a specified amount of time.

**Parameters:**

← *delay* Delay in nanoseconds. Note that a zero delay does **not** have the meaning of `RTDM_TIMEOUT_INFINITE` here.

**Note:**

The caller must not be migratable to different CPUs while executing this service. Otherwise, the actual delay will be undefined.

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine (should be avoided or kept short)

- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never (except due to external interruptions).

#### 5.10.2.2 `rtdm_task_t* rtdm_task_current (void)`

Get current real-time task.

##### **Returns:**

Pointer to task handle

Environments:

This service can be called from:

- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

#### 5.10.2.3 `void rtdm_task_destroy (rtdm_task_t * task)`

Destroy a real-time task.

##### **Parameters:**

↔ *task* Task handle as returned by [rtdm\\_task\\_init\(\)](#)

##### **Note:**

Passing the same task handle to RTDM services after the completion of this function is not allowed.

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

#### 5.10.2.4 `int rtdm_task_init (rtdm_task_t * task, const char * name, rtdm_task_proc_t task_proc, void * arg, int priority, nanosecs_rel_t period)`

Initialise and start a real-time task.

After initialising a task, the task handle remains valid and can be passed to RTDM services until either `rtdm_task_destroy()` or `rtdm_task_join_nrt()` was invoked.

##### Parameters:

- ↔ *task* Task handle
- ← *name* Optional task name
- ← *task\_proc* Procedure to be executed by the task
- ← *arg* Custom argument passed to `task_proc()` on entry
- ← *priority* Priority of the task, see also [Task Priority Range](#)
- ← *period* Period in nanoseconds of a cyclic task, 0 for non-cyclic mode

##### Returns:

0 on success, otherwise negative error code

##### Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: possible.

#### 5.10.2.5 `void rtdm_task_join_nrt (rtdm_task_t * task, unsigned int poll_delay)`

Wait on a real-time task to terminate.

##### Parameters:

- ↔ *task* Task handle as returned by `rtdm_task_init()`
- ← *poll\_delay* Delay in milliseconds between periodic tests for the state of the real-time task.  
This parameter is ignored if the termination is internally realised without polling.

##### Note:

Passing the same task handle to RTDM services after the completion of this function is not allowed.

This service does not trigger the termination of the targeted task. The user has to take of this, otherwise `rtdm_task_join_nrt()` will never return.

##### Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- User-space task (non-RT)

Rescheduling: possible.

#### 5.10.2.6 `int rtdm_task_set_period (rtdm_task_t * task, nanosecs_rel_t period)`

Adjust real-time task period.

**Parameters:**

- ↔ *task* Task handle as returned by [rtdm\\_task\\_init\(\)](#)
- ← *period* New period in nanoseconds of a cyclic task, 0 for non-cyclic mode

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: possible.

#### 5.10.2.7 `void rtdm_task_set_priority (rtdm_task_t * task, int priority)`

Adjust real-time task priority.

**Parameters:**

- ↔ *task* Task handle as returned by [rtdm\\_task\\_init\(\)](#)
- ← *priority* New priority of the task, see also [Task Priority Range](#)

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: possible.

#### 5.10.2.8 `int rtdm_task_sleep (nanosecs_rel_t delay)`

Sleep a specified amount of time.

**Parameters:**

- ← *delay* Delay in nanoseconds, see [RTDM\\_TIMEOUT\\_XXX](#) for special values.



**Returns:**

0 on success, otherwise:

- -EINTR is returned if calling task has been unblock by a signal or explicitly via [rt dm\\_task\\_unblock\(\)](#).
- -EPERM *may* be returned if an illegal invocation environment is detected.

**Environments:**

This service can be called from:

- Kernel-based task
- User-space task (RT)

Rescheduling: always.

**5.10.2.9 int rtdm\_task\_sleep\_abs (nanosecs\_abs\_t *wakeup\_time*, enum rtdm\_timer\_mode *mode*)**

Sleep until a specified absolute time.

**Parameters:**

← *wakeup\_time* Absolute timeout in nanoseconds

← *mode* Selects the timer mode, see RTDM\_TIMERMODE\_XXX for details

**Returns:**

0 on success, otherwise:

- -EINTR is returned if calling task has been unblock by a signal or explicitly via [rt dm\\_task\\_unblock\(\)](#).
- -EPERM *may* be returned if an illegal invocation environment is detected.
- -EINVAL is returned if an invalid parameter was passed.

**Environments:**

This service can be called from:

- Kernel-based task
- User-space task (RT)

Rescheduling: always, unless the specified time already passed.

#### 5.10.2.10 `int rtdm_task_sleep_until (nanosecs_abs_t wakeup_time)`

Sleep until a specified absolute time.

##### Deprecated

Use `rtdm_task_sleep_abs` instead!

##### Parameters:

← *wakeup\_time* Absolute timeout in nanoseconds

##### Returns:

0 on success, otherwise:

- -EINTR is returned if calling task has been unblock by a signal or explicitly via [rtdm\\_task\\_unblock\(\)](#).
- -EPERM *may* be returned if an illegal invocation environment is detected.

Environments:

This service can be called from:

- Kernel-based task
- User-space task (RT)

Rescheduling: always, unless the specified time already passed.

#### 5.10.2.11 `int rtdm_task_unblock (rtdm_task_t * task)`

Activate a blocked real-time task.

##### Returns:

Non-zero is returned if the task was actually unblocked from a pending wait state, 0 otherwise.

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: possible.

#### 5.10.2.12 `int rtdm_task_wait_period (void)`

Wait on next real-time task period.

**Returns:**

0 on success, otherwise:

- -EINVAL is returned if calling task is not in periodic mode.
- -ETIMEDOUT is returned if a timer overrun occurred, which indicates that a previous release point has been missed by the calling task.

Environments:

This service can be called from:

- Kernel-based task
- User-space task (RT)

Rescheduling: always, unless a timer overrun occurred.

## 5.11 Timer Services

Collaboration diagram for Timer Services:



### Typedefs

- typedef void(\* [rtdm\\_timer\\_handler\\_t](#))(rtdm\_timer\_t \*timer)  
*Timer handler.*

### Functions

- int [rtdm\\_timer\\_init](#) (rtdm\_timer\_t \*timer, [rtdm\\_timer\\_handler\\_t](#) handler, const char \*name)  
*Initialise a timer.*
- void [rtdm\\_timer\\_destroy](#) (rtdm\_timer\_t \*timer)  
*Destroy a timer.*
- int [rtdm\\_timer\\_start](#) (rtdm\_timer\_t \*timer, [nanosecs\\_abs\\_t](#) expiry, [nanosecs\\_rel\\_t](#) interval, enum [rtdm\\_timer\\_mode](#) mode)  
*Start a timer.*
- void [rtdm\\_timer\\_stop](#) (rtdm\_timer\_t \*timer)  
*Stop a timer.*
- int [rtdm\\_timer\\_start\\_in\\_handler](#) (rtdm\_timer\_t \*timer, [nanosecs\\_abs\\_t](#) expiry, [nanosecs\\_rel\\_t](#) interval, enum [rtdm\\_timer\\_mode](#) mode)  
*Start a timer from inside a timer handler.*
- void [rtdm\\_timer\\_stop\\_in\\_handler](#) (rtdm\_timer\_t \*timer)  
*Stop a timer from inside a timer handler.*

### RTDM\_TIMERMODE\_XXX

Timer operation modes

- enum [rtdm\\_timer\\_mode](#) { [RTDM\\_TIMERMODE\\_RELATIVE](#) = XN\_RELATIVE, [RTDM\\_TIMERMODE\\_ABSOLUTE](#) = XN\_ABSOLUTE, [RTDM\\_TIMERMODE\\_REALTIME](#) = XN\_REALTIME }

## 5.11.1 Typedef Documentation

### 5.11.1.1 typedef void(\* rtdm\_timer\_handler\_t)(rtdm\_timer\_t \*timer)

Timer handler.

**Parameters:**

← *timer* Timer handle as returned by [rtdm\\_timer\\_init\(\)](#)

## 5.11.2 Enumeration Type Documentation

### 5.11.2.1 enum rtdm\_timer\_mode

**Enumerator:**

*RTDM\_TIMERMODE\_RELATIVE* Monotonic timer with relative timeout.

*RTDM\_TIMERMODE\_ABSOLUTE* Monotonic timer with absolute timeout.

*RTDM\_TIMERMODE\_REALTIME* Adjustable timer with absolute timeout.

## 5.11.3 Function Documentation

### 5.11.3.1 void rtdm\_timer\_destroy (rtdm\_timer\_t \* timer)

Destroy a timer.

**Parameters:**

↔ *timer* Timer handle as returned by [rtdm\\_timer\\_init\(\)](#)

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

### 5.11.3.2 int rtdm\_timer\_init (rtdm\_timer\_t \* timer, rtdm\_timer\_handler\_t handler, const char \* name)

Initialise a timer.

**Parameters:**

↔ *timer* Timer handle

← *handler* Handler to be called on timer expiry

← *name* Optional timer name

**Returns:**

0 on success, otherwise negative error code

**Environments:**

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

### 5.11.3.3 `int rtdm_timer_start(rtdm_timer_t * timer, nanosecs_abs_t expiry, nanosecs_rel_t interval, enum rtdm_timer_mode mode)`

Start a timer.

**Parameters:**

- ↔ *timer* Timer handle as returned by [rtdm\\_timer\\_init\(\)](#)
- ← *expiry* Firing time of the timer, *mode* defines if relative or absolute
- ← *interval* Relative reload value, > 0 if the timer shall work in periodic mode with the specific interval, 0 for one-shot timers
- ← *mode* Defines the operation mode, see [RTDM\\_TIMERMODE\\_XXX](#) for possible values

**Returns:**

0 on success, otherwise:

- -ETIMEDOUT is returned if *expiry* describes an absolute date in the past.

**Environments:**

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

#### 5.11.3.4 `int rtdm_timer_start_in_handler(rtdm_timer_t * timer, nanosecs_abs_t expiry, nanosecs_rel_t interval, enum rtdm_timer_mode mode)`

Start a timer from inside a timer handler.

**Parameters:**

- ↔ *timer* Timer handle as returned by [rtdm\\_timer\\_init\(\)](#)
- ← *expiry* Firing time of the timer, *mode* defines if relative or absolute
- ← *interval* Relative reload value, > 0 if the timer shall work in periodic mode with the specific interval, 0 for one-shot timers
- ← *mode* Defines the operation mode, see [RTDM\\_TIMERMODE\\_XXX](#) for possible values

**Returns:**

0 on success, otherwise:

- -ETIMEDOUT is returned if *expiry* describes an absolute date in the past.

Environments:

This service can be called from:

- Timer handler

Rescheduling: never.

#### 5.11.3.5 `void rtdm_timer_stop(rtdm_timer_t * timer)`

Stop a timer.

**Parameters:**

- ↔ *timer* Timer handle as returned by [rtdm\\_timer\\_init\(\)](#)

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

#### 5.11.3.6 void `rtdm_timer_stop_in_handler` (`rtdm_timer_t * timer`)

Stop a timer from inside a timer handler.

**Parameters:**

↔ *timer* Timer handle as returned by [rtdm\\_timer\\_init\(\)](#)

Environments:

This service can be called from:

- Timer handler

Rescheduling: never.



## 5.12 Synchronisation Services

Collaboration diagram for Synchronisation Services:



### Functions

- `int rtdm_select_bind(int fd, rtdm_selector_t *selector, enum rtdm_selecttype type, unsigned fd_index)`  
*Bind a selector to specified event types of a given file descriptor.*

### RTDM\_SELECTTYPE\_XXX

Event types select can bind to

- `enum rtdm_selecttype { RTDM_SELECTTYPE_READ = XNSELECT_READ, RTDM_SELECTTYPE_WRITE = XNSELECT_WRITE, RTDM_SELECTTYPE_EXCEPT = XNSELECT_EXCEPT }`

### Spinlock with Preemption Deactivation

- `typedef rthal_spinlock_t rtdm_lock_t`  
*Lock variable.*
- `typedef unsigned long rtdm_lockctx_t`  
*Variable to save the context while holding a lock.*
- `#define RTDM_LOCK_UNLOCKED RTHAL_SPIN_LOCK_UNLOCKED`  
*Static lock initialisation.*
- `#define rtdm_lock_init(lock) rthal_spin_lock_init(lock)`  
*Dynamic lock initialisation.*
- `#define rtdm_lock_get(lock) rthal_spin_lock(lock)`  
*Acquire lock from non-preemptible contexts.*
- `#define rtdm_lock_put(lock) rthal_spin_unlock(lock)`  
*Release lock without preemption restoration.*
- `#define rtdm_lock_get_irqsave(lock, context) rthal_spin_lock_irqsave(lock, context)`  
*Acquire lock and disable preemption.*
- `#define rtdm_lock_put_irqrestore(lock, context) rthal_spin_unlock_irqrestore(lock, context)`

*Release lock and restore preemption state.*

- #define `rt dm_lock_irqsave`(context) `rthal_local_irq_save`(context)  
*Disable preemption locally.*
- #define `rt dm_lock_irqrestore`(context) `rthal_local_irq_restore`(context)  
*Restore preemption state.*

## Timeout Sequence Management

- void `rt dm_toseq_init` (rt dm\_toseq\_t \*timeout\_seq, `nanosecs_rel_t` timeout)  
*Initialise a timeout sequence.*

## Event Services

- void `rt dm_event_init` (rt dm\_event\_t \*event, unsigned long pending)  
*Initialise an event.*
- void `rt dm_event_destroy` (rt dm\_event\_t \*event)  
*Destroy an event.*
- void `rt dm_event_pulse` (rt dm\_event\_t \*event)  
*Signal an event occurrence to currently listening waiters.*
- void `rt dm_event_signal` (rt dm\_event\_t \*event)  
*Signal an event occurrence.*
- int `rt dm_event_wait` (rt dm\_event\_t \*event)  
*Wait on event occurrence.*
- int `rt dm_event_timedwait` (rt dm\_event\_t \*event, `nanosecs_rel_t` timeout, rt dm\_toseq\_t \*timeout\_seq)  
*Wait on event occurrence with timeout.*
- void `rt dm_event_clear` (rt dm\_event\_t \*event)  
*Clear event state.*
- int `rt dm_event_select_bind` (rt dm\_event\_t \*event, rt dm\_selector\_t \*selector, enum `rt dm_selecttype` type, unsigned fd\_index)  
*Bind a selector to an event.*

## Semaphore Services

- void `rt dm_sem_init` (rt dm\_sem\_t \*sem, unsigned long value)  
*Initialise a semaphore.*

- void `rtm_sem_destroy` (`rtm_sem_t *sem`)  
*Destroy a semaphore.*
- int `rtm_sem_down` (`rtm_sem_t *sem`)  
*Decrement a semaphore.*
- int `rtm_sem_timeddown` (`rtm_sem_t *sem`, `nanosecs_rel_t` timeout, `rtm_toseq_t *timeout_seq`)  
*Decrement a semaphore with timeout.*
- void `rtm_sem_up` (`rtm_sem_t *sem`)  
*Increment a semaphore.*
- int `rtm_sem_select_bind` (`rtm_sem_t *sem`, `rtm_selector_t *selector`, enum `rtm_selecttype` type, unsigned `fd_index`)  
*Bind a selector to a semaphore.*

## Mutex Services

- void `rtm_mutex_init` (`rtm_mutex_t *mutex`)  
*Initialise a mutex.*
- void `rtm_mutex_destroy` (`rtm_mutex_t *mutex`)  
*Destroy a mutex.*
- void `rtm_mutex_unlock` (`rtm_mutex_t *mutex`)  
*Release a mutex.*
- int `rtm_mutex_lock` (`rtm_mutex_t *mutex`)  
*Request a mutex.*
- int `rtm_mutex_timedlock` (`rtm_mutex_t *mutex`, `nanosecs_rel_t` timeout, `rtm_toseq_t *timeout_seq`)  
*Request a mutex with timeout.*

## Global Lock across Scheduler Invocation

- #define `RTDM_EXECUTE_ATOMICALY`(code\_block)  
*Execute code block atomically.*

### 5.12.1 Define Documentation

#### 5.12.1.1 #define RTDM\_EXECUTE\_ATOMICALY(code\_block)

Value:

```

{
    <ENTER_ATOMIC_SECTION>      \
    code_block;                 \
    <LEAVE_ATOMIC_SECTION>     \
}

```

Execute code block atomically.

Generally, it is illegal to suspend the current task by calling `rtdm_task_sleep()`, `rtdm_event_wait()`, etc. while holding a spinlock. In contrast, this macro allows to combine several operations including a potentially rescheduling call to an atomic code block with respect to other `RTDM_EXECUTE_ATOMICALY()` blocks. The macro is a light-weight alternative for protecting code blocks via mutexes, and it can even be used to synchronise real-time and non-real-time contexts.

#### Parameters:

*code\_block* Commands to be executed atomically

#### Note:

It is not allowed to leave the code block explicitly by using `break`, `return`, `goto`, etc. This would leave the global lock held during the code block execution in an inconsistent state. Moreover, do not embed complex operations into the code block. Consider that they will be executed under preemption lock with interrupts switched-off. Also note that invocation of rescheduling calls may break the atomicity until the task gains the CPU again.

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: possible, depends on functions called within *code\_block*.

#### 5.12.1.2 #define rtdm\_lock\_get(lock) rthal\_spin\_lock(lock)

Acquire lock from non-preemptible contexts.

#### Parameters:

*lock* Address of lock variable

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

**5.12.1.3 #define rtdm\_lock\_get\_irqsave(lock, context) rthal\_spin\_lock\_irqsave(lock, context)**

Acquire lock and disable preemption.

**Parameters:**

*lock* Address of lock variable

*context* name of local variable to store the context in

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

**5.12.1.4 #define rtdm\_lock\_init(lock) rthal\_spin\_lock\_init(lock)**

Dynamic lock initialisation.

**Parameters:**

*lock* Address of lock variable

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

**5.12.1.5 #define rtdm\_lock\_irqrestore(context) rthal\_local\_irq\_restore(context)**

Restore preemption state.

**Parameters:**

*context* name of local variable which stored the context

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: possible.

#### 5.12.1.6 **#define rtdm\_lock\_irqsave(context) rthal\_local\_irq\_save(context)**

Disable preemption locally.

##### **Parameters:**

*context* name of local variable to store the context in

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

#### 5.12.1.7 **#define rtdm\_lock\_put(lock) rthal\_spin\_unlock(lock)**

Release lock without preemption restoration.

##### **Parameters:**

*lock* Address of lock variable

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

#### 5.12.1.8 `#define rtdm_lock_put_irqrestore(lock, context) rthal_spin_unlock_irqrestore(lock, context)`

Release lock and restore preemption state.

**Parameters:**

*lock* Address of lock variable

*context* name of local variable which stored the context

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: possible.

### 5.12.2 Enumeration Type Documentation

#### 5.12.2.1 `enum rtdm_selecttype`

**Enumerator:**

*RTDM\_SELECTTYPE\_READ* Select input data availability events.

*RTDM\_SELECTTYPE\_WRITE* Select output buffer availability events.

*RTDM\_SELECTTYPE\_EXCEPT* Select exceptional events.

### 5.12.3 Function Documentation

#### 5.12.3.1 `void rtdm_event_clear (rtdm_event_t * event)`

Clear event state.

**Parameters:**

↔ *event* Event handle as returned by [rtdm\\_event\\_init\(\)](#)

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

### 5.12.3.2 void rtdm\_event\_destroy (rtdm\_event\_t \* event)

Destroy an event.

**Parameters:**

↔ *event* Event handle as returned by [rtdm\\_event\\_init\(\)](#)

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: possible.

### 5.12.3.3 void rtdm\_event\_init (rtdm\_event\_t \* event, unsigned long pending)

Initialise an event.

**Parameters:**

↔ *event* Event handle

← *pending* Non-zero if event shall be initialised as set, 0 otherwise

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

### 5.12.3.4 void rtdm\_event\_pulse (rtdm\_event\_t \* event)

Signal an event occurrence to currently listening waiters.

This function wakes up all current waiters of the given event, but it does not change the event state. Subsequently callers of [rtdm\\_event\\_wait\(\)](#) or [rtdm\\_event\\_timedwait\(\)](#) will therefore be blocked first.

**Parameters:**

↔ *event* Event handle as returned by [rtdm\\_event\\_init\(\)](#)

Environments:

This service can be called from:



- Kernel module initialization/cleanup code
- Interrupt service routine
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: possible.

#### 5.12.3.5 `int rtdm_event_select_bind (rtdm_event_t * event, rtdm_selector_t * selector, enum rtdm_selecttype type, unsigned fd_index)`

Bind a selector to an event.

This functions binds the given selector to an event so that the former is notified when the event state changes. Typically the select binding handler will invoke this service.

##### Parameters:

- ↔ *event* Event handle as returned by `rtdm_event_init()`
- ↔ *selector* Selector as passed to the select binding handler
- ← *type* Type of the bound event as passed to the select binding handler
- ← *fd\_index* File descriptor index as passed to the select binding handler

##### Returns:

0 on success, otherwise:

- -EIDRM is returned if *event* has been destroyed.
- -ENOMEM is returned if there is insufficient memory to establish the dynamic binding.
- -EINVAL is returned if *type* or *fd\_index* are invalid.

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

#### 5.12.3.6 `void rtdm_event_signal (rtdm_event_t * event)`

Signal an event occurrence.

This function sets the given event and wakes up all current waiters. If no waiter is presently registered, the next call to `rtdm_event_wait()` or `rtdm_event_timedwait()` will return immediately.

**Parameters:**

↔ *event* Event handle as returned by [rt dm\\_event\\_init\(\)](#)

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: possible.

#### 5.12.3.7 `int rtdm_event_timedwait (rtdm_event_t * event, nanosecs_rel_t timeout, rtdm_toseq_t * timeout_seq)`

Wait on event occurrence with timeout.

This function waits or tests for the occurrence of the given event, taking the provided timeout into account. On successful return, the event is reset.

**Parameters:**

↔ *event* Event handle as returned by [rt dm\\_event\\_init\(\)](#)

← *timeout* Relative timeout in nanoseconds, see [RTDM\\_TIMEOUT\\_xxx](#) for special values

↔ *timeout\_seq* Handle of a timeout sequence as returned by [rt dm\\_toseq\\_init\(\)](#) or NULL

**Returns:**

0 on success, otherwise:

- -ETIMEDOUT is returned if the request has not been satisfied within the specified amount of time.
- -EINTR is returned if calling task has been unblock by a signal or explicitly via [rt dm\\_task\\_unblock\(\)](#).
- -EIDRM is returned if *event* has been destroyed.
- -EPERM *may* be returned if an illegal invocation environment is detected.

Environments:

This service can be called from:

- Kernel-based task
- User-space task (RT)

Rescheduling: possible.

Referenced by [rt dm\\_event\\_wait\(\)](#).

### 5.12.3.8 `int rtdm_event_wait (rtdm_event_t * event)`

Wait on event occurrence.

This is the light-weight version of [rtdm\\_event\\_timedwait\(\)](#), implying an infinite timeout.

**Parameters:**

↔ *event* Event handle as returned by [rtdm\\_event\\_init\(\)](#)

**Returns:**

0 on success, otherwise:

- -EINTR is returned if calling task has been unblock by a signal or explicitly via [rtdm\\_task\\_unblock\(\)](#).
- -EIDRM is returned if *event* has been destroyed.
- -EPERM *may* be returned if an illegal invocation environment is detected.

Environments:

This service can be called from:

- Kernel-based task
- User-space task (RT)

Rescheduling: possible.

References [rtdm\\_event\\_timedwait\(\)](#).

### 5.12.3.9 `void rtdm_mutex_destroy (rtdm_mutex_t * mutex)`

Destroy a mutex.

**Parameters:**

↔ *mutex* Mutex handle as returned by [rtdm\\_mutex\\_init\(\)](#)

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: possible.

### 5.12.3.10 void rtdm\_mutex\_init (rtdm\_mutex\_t \* mutex)

Initialise a mutex.

This function initialises a basic mutex with priority inversion protection. "Basic", as it does not allow a mutex owner to recursively lock the same mutex again.

#### Parameters:

↔ *mutex* Mutex handle

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

### 5.12.3.11 int rtdm\_mutex\_lock (rtdm\_mutex\_t \* mutex)

Request a mutex.

This is the light-weight version of [rtdm\\_mutex\\_timedlock\(\)](#), implying an infinite timeout.

#### Parameters:

↔ *mutex* Mutex handle as returned by [rtdm\\_mutex\\_init\(\)](#)

#### Returns:

0 on success, otherwise:

- -EIDRM is returned if *mutex* has been destroyed.
- -EPERM *may* be returned if an illegal invocation environment is detected.

Environments:

This service can be called from:

- Kernel-based task
- User-space task (RT)

Rescheduling: possible.

References [rtdm\\_mutex\\_timedlock\(\)](#).

### 5.12.3.12 `int rtdm_mutex_timedlock (rtdm_mutex_t * mutex, nanosecs_rel_t timeout, rtdm_toseq_t * timeout_seq)`

Request a mutex with timeout.

This function tries to acquire the given mutex. If it is not available, the caller is blocked unless non-blocking operation was selected.

#### Parameters:

- ↔ *mutex* Mutex handle as returned by [rtdm\\_mutex\\_init\(\)](#)
- ← *timeout* Relative timeout in nanoseconds, see [RTDM\\_TIMEOUT\\_xxx](#) for special values
- ↔ *timeout\_seq* Handle of a timeout sequence as returned by [rtdm\\_toseq\\_init\(\)](#) or NULL

#### Returns:

0 on success, otherwise:

- -ETIMEDOUT is returned if the request has not been satisfied within the specified amount of time.
- -EWOULDBLOCK is returned if *timeout* is negative and the semaphore value is currently not positive.
- -EIDRM is returned if *mutex* has been destroyed.
- -EPERM *may* be returned if an illegal invocation environment is detected.

Environments:

This service can be called from:

- Kernel-based task
- User-space task (RT)

Rescheduling: possible.

Referenced by [rtdm\\_mutex\\_lock\(\)](#).

### 5.12.3.13 `void rtdm_mutex_unlock (rtdm_mutex_t * mutex)`

Release a mutex.

This function releases the given mutex, waking up a potential waiter which was blocked upon [rtdm\\_mutex\\_lock\(\)](#) or [rtdm\\_mutex\\_timedlock\(\)](#).

#### Parameters:

- ↔ *mutex* Mutex handle as returned by [rtdm\\_mutex\\_init\(\)](#)

Environments:

This service can be called from:

- Kernel-based task
- User-space task (RT)

Rescheduling: possible.

#### 5.12.3.14 `int rtdm_select_bind (int fd, rtdm_selector_t * selector, enum rtdm_selecttype type, unsigned fd_index)`

Bind a selector to specified event types of a given file descriptor.

**For internal use only.**

This function is invoked by higher RTOS layers implementing select-like services. It shall not be called directly by RTDM drivers.

**Parameters:**

- ← *fd* File descriptor to bind to
- ↔ *selector* Selector object that shall be bound to the given event
- ← *type* Event type the caller is interested in
- ← *fd\_index* Index in the file descriptor set of the caller

**Returns:**

- 0 on success, otherwise:
- -EBADF is returned if the file descriptor *fd* cannot be resolved.
- -EINVAL is returned if *type* or *fd\_index* are invalid.

**Environments:**

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

References `rtdm_dev_context::ops`, `rtdm_context_get()`, `rtdm_context_unlock()`, and `rtdm_operations::select_bind`.

#### 5.12.3.15 `void rtdm_sem_destroy (rtdm_sem_t * sem)`

Destroy a semaphore.

**Parameters:**

- ↔ *sem* Semaphore handle as returned by [rtdm\\_sem\\_init\(\)](#)

**Environments:**

This service can be called from:

- Kernel module initialization/cleanup code

- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: possible.

#### 5.12.3.16 `int rtdm_sem_down (rtdm_sem_t * sem)`

Decrement a semaphore.

This is the light-weight version of `rtdm_sem_timeddown()`, implying an infinite timeout.

##### Parameters:

↔ *sem* Semaphore handle as returned by `rtdm_sem_init()`

##### Returns:

0 on success, otherwise:

- -EINTR is returned if calling task has been unblock by a signal or explicitly via `rtdm_task_unblock()`.
- -EIDRM is returned if *sem* has been destroyed.
- -EPERM *may* be returned if an illegal invocation environment is detected.

Environments:

This service can be called from:

- Kernel-based task
- User-space task (RT)

Rescheduling: possible.

References `rtdm_sem_timeddown()`.

#### 5.12.3.17 `void rtdm_sem_init (rtdm_sem_t * sem, unsigned long value)`

Initialise a semaphore.

##### Parameters:

↔ *sem* Semaphore handle

← *value* Initial value of the semaphore

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

### 5.12.3.18 `int rtdm_sem_select_bind (rtdm_sem_t * sem, rtdm_selector_t * selector, enum rtdm_selecttype type, unsigned fd_index)`

Bind a selector to a semaphore.

This functions binds the given selector to the semaphore so that the former is notified when the semaphore state changes. Typically the select binding handler will invoke this service.

#### Parameters:

- ↔ *sem* Semaphore handle as returned by [rtdm\\_sem\\_init\(\)](#)
- ↔ *selector* Selector as passed to the select binding handler
- ← *type* Type of the bound event as passed to the select binding handler
- ← *fd\_index* File descriptor index as passed to the select binding handler

#### Returns:

0 on success, otherwise:

- -EIDRM is returned if *sem* has been destroyed.
- -ENOMEM is returned if there is insufficient memory to establish the dynamic binding.
- -EINVAL is returned if *type* or *fd\_index* are invalid.

#### Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

### 5.12.3.19 `int rtdm_sem_timeddown (rtdm_sem_t * sem, nanosecs_rel_t timeout, rtdm_toseq_t * timeout_seq)`

Decrement a semaphore with timeout.

This function tries to decrement the given semaphore's value if it is positive on entry. If not, the caller is blocked unless non-blocking operation was selected.

#### Parameters:

- ↔ *sem* Semaphore handle as returned by [rtdm\\_sem\\_init\(\)](#)
- ← *timeout* Relative timeout in nanoseconds, see [RTDM\\_TIMEOUT\\_xxx](#) for special values
- ↔ *timeout\_seq* Handle of a timeout sequence as returned by [rtdm\\_toseq\\_init\(\)](#) or NULL

#### Returns:

0 on success, otherwise:



- -ETIMEDOUT is returned if the request has not been satisfied within the specified amount of time.
- -EWOULDBLOCK is returned if *timeout* is negative and the semaphore value is currently not positive.
- -EINTR is returned if calling task has been unblock by a signal or explicitly via [rt dm\\_task\\_unblock\(\)](#).
- -EIDRM is returned if *sem* has been destroyed.
- -EPERM *may* be returned if an illegal invocation environment is detected.

Environments:

This service can be called from:

- Kernel-based task
- User-space task (RT)

Rescheduling: possible.

Referenced by [rt dm\\_sem\\_down\(\)](#).

#### 5.12.3.20 void [rt dm\\_sem\\_up](#) ([rt dm\\_sem\\_t](#) \* *sem*)

Increment a semaphore.

This function increments the given semaphore's value, waking up a potential waiter which was blocked upon [rt dm\\_sem\\_down\(\)](#).

##### Parameters:

↔ *sem* Semaphore handle as returned by [rt dm\\_sem\\_init\(\)](#)

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: possible.

### 5.12.3.21 void rtdm\_toseq\_init (rtdm\_toseq\_t \* *timeout\_seq*, nanosecs\_rel\_t *timeout*)

Initialise a timeout sequence.

This service initialises a timeout sequence handle according to the given timeout value. Timeout sequences allow to maintain a continuous *timeout* across multiple calls of blocking synchronisation services. A typical application scenario is given below.

#### Parameters:

- ↔ *timeout\_seq* Timeout sequence handle
- ← *timeout* Relative timeout in nanoseconds, see [RTDM\\_TIMEOUT\\_xxx](#) for special values

#### Application Scenario:

```
int device_service_routine(...)
{
    rtdm_toseq_t timeout_seq;
    ...

    rtdm_toseq_init(&timeout_seq, timeout);
    ...
    while (received < requested) {
        ret = rtdm_event_timedwait(&data_available, timeout, &timeout_seq);
        if (ret < 0) // including -ETIMEDOUT
            break;

        // receive some data
        ...
    }
    ...
}
```

Using a timeout sequence in such a scenario avoids that the user-provided relative *timeout* is restarted on every call to [rtdm\\_event\\_timedwait\(\)](#), potentially causing an overall delay that is larger than specified by *timeout*. Moreover, all functions supporting timeout sequences also interpret special timeout values (infinite and non-blocking), disburdening the driver developer from handling them separately.

#### Environments:

This service can be called from:

- Kernel-based task
- User-space task (RT)

Rescheduling: never.

## 5.13 Interrupt Management Services

Collaboration diagram for Interrupt Management Services:



### Defines

- `#define rtdm\_irq\_get\_arg(irq_handle, type) ((type *)irq_handle → cookie)`  
Retrieve IRQ handler argument.

### Typedefs

- `typedef int(* rtdm\_irq\_handler\_t)(rtdm_irq_t *irq_handle)`  
Interrupt handler.

### Functions

- `int rtdm\_irq\_request(rtdm_irq_t *irq_handle, unsigned int irq_no, rtdm\_irq\_handler\_t handler, unsigned long flags, const char *device_name, void *arg)`  
Register an interrupt handler.
- `int rtdm\_irq\_free(rtdm_irq_t *irq_handle)`  
Release an interrupt handler.
- `int rtdm\_irq\_enable(rtdm_irq_t *irq_handle)`  
Enable interrupt line.
- `int rtdm\_irq\_disable(rtdm_irq_t *irq_handle)`  
Disable interrupt line.

### RTDM\_IRQTYPE\_XXX

Interrupt registrations flags

- `#define RTDM\_IRQTYPE\_SHARED XN_ISR_SHARED`  
Enable IRQ-sharing with other real-time drivers.
- `#define RTDM\_IRQTYPE\_EDGE XN_ISR_EDGE`  
Mark IRQ as edge-triggered, relevant for correct handling of shared edge-triggered IRQs.

## RTDM\_IRQ\_XXX

Return flags of interrupt handlers

- #define [RTDM\\_IRQ\\_NONE](#) XN\_ISR\_NONE  
*Unhandled interrupt.*
- #define [RTDM\\_IRQ\\_HANDLED](#) XN\_ISR\_HANDLED  
*Denote handled interrupt.*

### 5.13.1 Define Documentation

#### 5.13.1.1 #define `rtm_irq_get_arg(irq_handle, type) ((type *)irq_handle → cookie)`

Retrieve IRQ handler argument.

##### Parameters:

*irq\_handle* IRQ handle  
*type* Type of the pointer to return

##### Returns:

The argument pointer registered on [rtm\\_irq\\_request\(\)](#) is returned, type-casted to the specified *type*.

Environments:

This service can be called from:

- Interrupt service routine

Rescheduling: never.

### 5.13.2 Typedef Documentation

#### 5.13.2.1 typedef `int(* rtm_irq_handler_t)(rtm_irq_t *irq_handle)`

Interrupt handler.

##### Parameters:

← *irq\_handle* IRQ handle as returned by [rtm\\_irq\\_request\(\)](#)

##### Returns:

0 or a combination of [RTDM\\_IRQ\\_XXX](#) flags

### 5.13.3 Function Documentation

#### 5.13.3.1 `int rtdm_irq_disable (rtdm_irq_t * irq_handle)`

Disable interrupt line.

**Parameters:**

↔ *irq\_handle* IRQ handle as returned by [rtdm\\_irq\\_request\(\)](#)

**Returns:**

0 on success, otherwise negative error code

**Environments:**

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

#### 5.13.3.2 `int rtdm_irq_enable (rtdm_irq_t * irq_handle)`

Enable interrupt line.

**Parameters:**

↔ *irq\_handle* IRQ handle as returned by [rtdm\\_irq\\_request\(\)](#)

**Returns:**

0 on success, otherwise negative error code

**Environments:**

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: possible.

### 5.13.3.3 `int rtdm_irq_free (rtdm_irq_t * irq_handle)`

Release an interrupt handler.

**Parameters:**

↔ *irq\_handle* IRQ handle as returned by [rtdm\\_irq\\_request\(\)](#)

**Returns:**

0 on success, otherwise negative error code

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

### 5.13.3.4 `int rtdm_irq_request (rtdm_irq_t * irq_handle, unsigned int irq_no, rtdm_irq_handler_t handler, unsigned long flags, const char * device_name, void * arg)`

Register an interrupt handler.

This function registers the provided handler with an IRQ line and enables the line.

**Parameters:**

↔ *irq\_handle* IRQ handle  
 ← *irq\_no* Line number of the addressed IRQ  
 ← *handler* Interrupt handler  
 ← *flags* Registration flags, see [RTDM\\_IRQTYPE\\_xxx](#) for details  
 ← *device\_name* Device name to show up in real-time IRQ lists  
 ← *arg* Pointer to be passed to the interrupt handler on invocation

**Returns:**

0 on success, otherwise:

- -EINVAL is returned if an invalid parameter was passed.
- -EBUSY is returned if the specified IRQ line is already in use.

Environments:

This service can be called from:

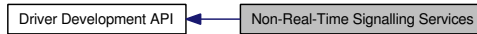
- Kernel module initialization/cleanup code

- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

## 5.14 Non-Real-Time Signalling Services

Collaboration diagram for Non-Real-Time Signalling Services:



### Typedefs

- typedef void(\* [rtdm\\_nrtsig\\_handler\\_t](#))(rtdm\_nrtsig\_t nrt\_sig, void \*arg)  
*Non-real-time signal handler.*

### Functions

- int [rtdm\\_nrtsig\\_init](#) (rtdm\_nrtsig\_t \*nrt\_sig, [rtdm\\_nrtsig\\_handler\\_t](#) handler, void \*arg)  
*Register a non-real-time signal handler.*
- void [rtdm\\_nrtsig\\_destroy](#) (rtdm\_nrtsig\_t \*nrt\_sig)  
*Release a non-realtime signal handler.*
- void [rtdm\\_nrtsig\\_pend](#) (rtdm\_nrtsig\_t \*nrt\_sig)  
*Trigger non-real-time signal.*

#### 5.14.1 Detailed Description

These services provide a mechanism to request the execution of a specified handler in non-real-time context. The triggering can safely be performed in real-time context without suffering from unknown delays. The handler execution will be deferred until the next time the real-time subsystem releases the CPU to the non-real-time part.

#### 5.14.2 Typedef Documentation

##### 5.14.2.1 typedef void(\* [rtdm\\_nrtsig\\_handler\\_t](#))(rtdm\_nrtsig\_t nrt\_sig, void \*arg)

Non-real-time signal handler.

##### Parameters:

- ← *nrt\_sig* Signal handle as returned by [rtdm\\_nrtsig\\_init\(\)](#)
- ← *arg* Argument as passed to [rtdm\\_nrtsig\\_init\(\)](#)

##### Note:

The signal handler will run in soft-IRQ context of the non-real-time subsystem. Note the implications of this context, e.g. no invocation of blocking operations.



### 5.14.3 Function Documentation

#### 5.14.3.1 `void rtdm_nrtsig_destroy (rtdm_nrtsig_t * nrt_sig)`

Release a non-realtime signal handler.

**Parameters:**

↔ *nrt\_sig* Signal handle

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

#### 5.14.3.2 `int rtdm_nrtsig_init (rtdm_nrtsig_t * nrt_sig, rtdm_nrtsig_handler_t handler, void * arg)`

Register a non-real-time signal handler.

**Parameters:**

↔ *nrt\_sig* Signal handle

← *handler* Non-real-time signal handler

← *arg* Custom argument passed to `handler()` on each invocation

**Returns:**

0 on success, otherwise:

- -EAGAIN is returned if no free signal slot is available.

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

#### 5.14.3.3 void rtdm\_nrtsig\_pend (rtdm\_nrtsig\_t \* *nrt\_sig*)

Trigger non-real-time signal.

**Parameters:**

↔ *nrt\_sig* Signal handle

**Environments:**

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never in real-time context, possible in non-real-time environments.

## 5.15 Utility Services

Collaboration diagram for Utility Services:



### Functions

- `int rtdm_mmap_to_user (rtdm_user_info_t *user_info, void *src_addr, size_t len, int prot, void **pptr, struct vm_operations_struct *vm_ops, void *vm_private_data)`  
*Map a kernel memory range into the address space of the user.*
- `int rtdm_iomap_to_user (rtdm_user_info_t *user_info, unsigned long src_addr, size_t len, int prot, void **pptr, struct vm_operations_struct *vm_ops, void *vm_private_data)`  
*Map an I/O memory range into the address space of the user.*
- `int rtdm_munmap (rtdm_user_info_t *user_info, void *ptr, size_t len)`  
*Unmap a user memory range.*
- `void rtdm_printk (const char *format,...)`  
*Real-time safe message printing on kernel console.*
- `void * rtdm_malloc (size_t size)`  
*Allocate memory block in real-time context.*
- `void rtdm_free (void *ptr)`  
*Release real-time memory block.*
- `int rtdm_read_user_ok (rtdm_user_info_t *user_info, const void __user *ptr, size_t size)`  
*Check if read access to user-space memory block is safe.*
- `int rtdm_rw_user_ok (rtdm_user_info_t *user_info, const void __user *ptr, size_t size)`  
*Check if read/write access to user-space memory block is safe.*
- `int rtdm_copy_from_user (rtdm_user_info_t *user_info, void *dst, const void __user *src, size_t size)`  
*Copy user-space memory block to specified buffer.*
- `int rtdm_safe_copy_from_user (rtdm_user_info_t *user_info, void *dst, const void __user *src, size_t size)`  
*Check if read access to user-space memory block and copy it to specified buffer.*
- `int rtdm_copy_to_user (rtdm_user_info_t *user_info, void __user *dst, const void *src, size_t size)`  
*Copy specified buffer to user-space memory block.*
- `int rtdm_safe_copy_to_user (rtdm_user_info_t *user_info, void __user *dst, const void *src, size_t size)`

*Check if read/write access to user-space memory block is safe and copy specified buffer to it.*

- `int rtdm_strncpy_from_user` (`rtdm_user_info_t *user_info`, `char *dst`, `const char __user *src`, `size_t count`)

*Copy user-space string to specified buffer.*

- `int rtdm_in_rt_context` (`void`)

*Test if running in a real-time task.*

## 5.15.1 Function Documentation

### 5.15.1.1 `int rtdm_copy_from_user` (`rtdm_user_info_t * user_info`, `void * dst`, `const void __user * src`, `size_t size`)

Copy user-space memory block to specified buffer.

#### Parameters:

- ← *user\_info* User information pointer as passed to the invoked device operation handler
- ← *dst* Destination buffer address
- ← *src* Address of the user-space memory block
- ← *size* Size of the memory block

#### Returns:

0 on success, otherwise:

- -EFAULT is returned if an invalid memory area was accessed.

#### Note:

Before invoking this service, verify via `rtdm_read_user_ok()` that the provided user-space address can securely be accessed.

#### Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

### 5.15.1.2 `int rtdm_copy_to_user` (`rtdm_user_info_t * user_info`, `void __user * dst`, `const void * src`, `size_t size`)

Copy specified buffer to user-space memory block.

**Parameters:**

- ← *user\_info* User information pointer as passed to the invoked device operation handler
- ← *dst* Address of the user-space memory block
- ← *src* Source buffer address
- ← *size* Size of the memory block

**Returns:**

0 on success, otherwise:

- -EFAULT is returned if an invalid memory area was accessed.

**Note:**

Before invoking this service, verify via [rt dm\\_rw\\_user\\_ok\(\)](#) that the provided user-space address can securely be accessed.

**Environments:**

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

**5.15.1.3 void rtdm\_free (void \* ptr)**

Release real-time memory block.

**Parameters:**

- ← *ptr* Pointer to memory block as returned by [rt dm\\_malloc\(\)](#)

**Environments:**

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine (consider the overhead!)
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

#### 5.15.1.4 `int rtdm_in_rt_context (void)`

Test if running in a real-time task.

##### Returns:

Non-zero is returned if the caller resides in real-time context, 0 otherwise.

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

#### 5.15.1.5 `int rtdm_iomap_to_user (rtdm_user_info_t * user_info, unsigned long src_addr, size_t len, int prot, void ** pptr, struct vm_operations_struct * vm_ops, void * vm_private_data)`

Map an I/O memory range into the address space of the user.

##### Parameters:

- ← *user\_info* User information pointer as passed to the invoked device operation handler
- ← *src\_addr* physical I/O address to be mapped
- ← *len* Length of the memory range
- ← *prot* Protection flags for the user's memory range, typically either PROT\_READ or PROT\_READ|PROT\_WRITE
- ↔ *pptr* Address of a pointer containing the desired user address or NULL on entry and the finally assigned address on return
- ← *vm\_ops* vm\_operations to be executed on the vma\_area of the user memory range or NULL
- ← *vm\_private\_data* Private data to be stored in the vma\_area, primarily useful for vm\_-operation handlers

##### Returns:

0 on success, otherwise (most common values):

- -EINVAL is returned if an invalid start address, size, or destination address was passed.
- -ENOMEM is returned if there is insufficient free memory or the limit of memory mapping for the user process was reached.
- -EAGAIN is returned if too much memory has been already locked by the user process.
- -EPERM *may* be returned if an illegal invocation environment is detected.

**Note:**

RTDM supports two models for unmapping the user memory range again. One is explicit unmapping via `rtdm_munmap()`, either performed when the user requests it via an IOCTL etc. or when the related device is closed. The other is automatic unmapping, triggered by the user invoking standard `munmap()` or by the termination of the related process. To track release of the mapping and therefore relinquishment of the referenced physical memory, the caller of `rtdm_iomap_to_user()` can pass a `vm_operations_struct` on invocation, defining a close handler for the `vm_area`. See Linux documentaion (e.g. Linux Device Drivers book) on virtual memory management for details.

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- User-space task (non-RT)

Rescheduling: possible.

**5.15.1.6 void\* rtdm\_malloc (size\_t size)**

Allocate memory block in real-time context.

**Parameters:**

← *size* Requested size of the memory block

**Returns:**

The pointer to the allocated block is returned on success, NULL otherwise.

Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine (consider the overhead!)
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

**5.15.1.7 int rtdm\_mmap\_to\_user (rtdm\_user\_info\_t \* user\_info, void \* src\_addr, size\_t len, int prot, void \*\* pptr, struct vm\_operations\_struct \* vm\_ops, void \* vm\_private\_data)**

Map a kernel memory range into the address space of the user.

**Parameters:**

← *user\_info* User information pointer as passed to the invoked device operation handler

- ← *src\_addr* Kernel virtual address to be mapped
- ← *len* Length of the memory range
- ← *prot* Protection flags for the user's memory range, typically either PROT\_READ or PROT\_READ|PROT\_WRITE
- ↔ *pptr* Address of a pointer containing the desired user address or NULL on entry and the finally assigned address on return
- ← *vm\_ops* vm\_operations to be executed on the vma\_area of the user memory range or NULL
- ← *vm\_private\_data* Private data to be stored in the vma\_area, primarily useful for vm\_-operation handlers

**Returns:**

0 on success, otherwise (most common values):

- -EINVAL is returned if an invalid start address, size, or destination address was passed.
- -ENOMEM is returned if there is insufficient free memory or the limit of memory mapping for the user process was reached.
- -EAGAIN is returned if too much memory has been already locked by the user process.
- -EPERM *may* be returned if an illegal invocation environment is detected.

**Note:**

This service only works on memory regions allocated via `kmalloc()` or `vmalloc()`. To map physical I/O memory to user-space use `rtdm_iomap_to_user()` instead.

RTDM supports two models for unmapping the user memory range again. One is explicit unmapping via `rtdm_munmap()`, either performed when the user requests it via an IOCTL etc. or when the related device is closed. The other is automatic unmapping, triggered by the user invoking standard `munmap()` or by the termination of the related process. To track release of the mapping and therefore relinquishment of the referenced physical memory, the caller of `rtdm_mmap_to_user()` can pass a `vm_operations_struct` on invocation, defining a close handler for the `vm_area`. See Linux documentaion (e.g. Linux Device Drivers book) on virtual memory management for details.

**Environments:**

This service can be called from:

- Kernel module initialization/cleanup code
- User-space task (non-RT)

Rescheduling: possible.

**5.15.1.8 int rtdm\_munmap (rt dm \_user \_info \_t \* user \_info, void \* ptr, size \_t len)**

Unmap a user memory range.



**Parameters:**

- ← *user\_info* User information pointer as passed to `rtdm_mmap_to_user()` when requesting to map the memory range
- ← *ptr* User address or the memory range
- ← *len* Length of the memory range

**Returns:**

0 on success, otherwise:

- -EINVAL is returned if an invalid address or size was passed.
- -EPERM *may* be returned if an illegal invocation environment is detected.

**Environments:**

This service can be called from:

- Kernel module initialization/cleanup code
- User-space task (non-RT)

Rescheduling: possible.

**5.15.1.9 void rtdm\_printk (const char \* *format*, ...)**

Real-time safe message printing on kernel console.

**Parameters:**

- ← *format* Format string (conforming standard `printf()`)
- ... Arguments referred by *format*

**Returns:**

On success, this service returns the number of characters printed. Otherwise, a negative error code is returned.

**Environments:**

This service can be called from:

- Kernel module initialization/cleanup code
- Interrupt service routine (consider the overhead!)
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never in real-time context, possible in non-real-time environments.

#### 5.15.1.10 `int rtdm_read_user_ok (rtdm_user_info_t * user_info, const void __user * ptr, size_t size)`

Check if read access to user-space memory block is safe.

##### Parameters:

- ← *user\_info* User information pointer as passed to the invoked device operation handler
- ← *ptr* Address of the user-provided memory block
- ← *size* Size of the memory block

##### Returns:

Non-zero is return when it is safe to read from the specified memory block, 0 otherwise.

##### Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

#### 5.15.1.11 `int rtdm_rw_user_ok (rtdm_user_info_t * user_info, const void __user * ptr, size_t size)`

Check if read/write access to user-space memory block is safe.

##### Parameters:

- ← *user\_info* User information pointer as passed to the invoked device operation handler
- ← *ptr* Address of the user-provided memory block
- ← *size* Size of the memory block

##### Returns:

Non-zero is return when it is safe to read from or write to the specified memory block, 0 otherwise.

##### Environments:

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

**5.15.1.12** `int rtdm_safe_copy_from_user (rtdm_user_info_t * user_info, void * dst, const void __user * src, size_t size)`

Check if read access to user-space memory block and copy it to specified buffer.

**Parameters:**

- ← *user\_info* User information pointer as passed to the invoked device operation handler
- ← *dst* Destination buffer address
- ← *src* Address of the user-space memory block
- ← *size* Size of the memory block

**Returns:**

0 on success, otherwise:

- -EFAULT is returned if an invalid memory area was accessed.

**Note:**

This service is a combination of `rtdm_read_user_ok` and `rtdm_copy_from_user`.

**Environments:**

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

**5.15.1.13** `int rtdm_safe_copy_to_user (rtdm_user_info_t * user_info, void __user * dst, const void * src, size_t size)`

Check if read/write access to user-space memory block is safe and copy specified buffer to it.

**Parameters:**

- ← *user\_info* User information pointer as passed to the invoked device operation handler
- ← *dst* Address of the user-space memory block
- ← *src* Source buffer address
- ← *size* Size of the memory block

**Returns:**

0 on success, otherwise:

- -EFAULT is returned if an invalid memory area was accessed.

**Note:**

This service is a combination of `rtdm_rw_user_ok` and `rtdm_copy_to_user`.

**Environments:**

This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

**5.15.1.14** `int rtdm_strncpy_from_user (rtdm_user_info_t * user_info, char * dst, const char __user * src, size_t count)`

Copy user-space string to specified buffer.

**Parameters:**

- ← *user\_info* User information pointer as passed to the invoked device operation handler
- ← *dst* Destination buffer address
- ← *src* Address of the user-space string
- ← *count* Maximum number of bytes to copy, including the trailing '0'

**Returns:**

Length of the string on success (not including the trailing '0'), otherwise:

- -EFAULT is returned if an invalid memory area was accessed.

**Note:**

This services already includes a check of the source address, calling `rt dm_read_user_ok()` for *src* explicitly is not required.

**Environments:**

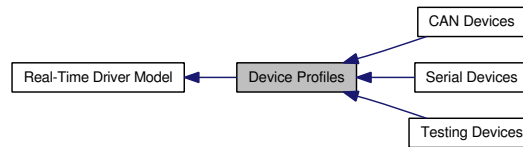
This service can be called from:

- Kernel module initialization/cleanup code
- Kernel-based task
- User-space task (RT, non-RT)

Rescheduling: never.

## 5.16 Device Profiles

Collaboration diagram for Device Profiles:



### Data Structures

- struct `rtdm_device_info`  
*Device information.*

### Modules

- [CAN Devices](#)
- [Serial Devices](#)
- [Testing Devices](#)

### Typedefs

- typedef struct `rtdm_device_info` `rtdm_device_info_t`  
*Device information.*

### RTDM\_CLASS\_XXX

Device classes

- `#define RTDM_CLASS_PARPORT 1`
- `#define RTDM_CLASS_SERIAL 2`
- `#define RTDM_CLASS_CAN 3`
- `#define RTDM_CLASS_NETWORK 4`
- `#define RTDM_CLASS_RTMAC 5`
- `#define RTDM_CLASS_TESTING 6`
- `#define RTDM_CLASS_EXPERIMENTAL 224`
- `#define RTDM_CLASS_MAX 255`

### Device Naming

Maximum length of device names (excluding the final null character)

- `#define RTDM_MAX_DEVNAME_LEN 31`

## RTDM\_PURGE\_XXX\_BUFFER

Flags selecting buffers to be purged

- `#define RTDM_PURGE_RX_BUFFER 0x0001`
- `#define RTDM_PURGE_TX_BUFFER 0x0002`

## Common IOCTLs

The following IOCTLs are common to all device profiles.

- `#define RTIOC_DEVICE_INFO _IOR(RTIOC_TYPE_COMMON, 0x00, struct rtdm_device_info)`  
*Retrieve information about a device or socket.*
- `#define RTIOC_PURGE _IOW(RTIOC_TYPE_COMMON, 0x10, int)`  
*Purge internal device or socket buffers.*

### 5.16.1 Detailed Description

Device profiles define which operation handlers a driver of a certain class has to implement, which name or protocol it has to register, which IOCTLs it has to provide, and further details. Sub-classes can be defined in order to extend a device profile with more hardware-specific functions.

### 5.16.2 Define Documentation

#### 5.16.2.1 `#define RTIOC_DEVICE_INFO _IOR(RTIOC_TYPE_COMMON, 0x00, struct rtdm_device_info)`

Retrieve information about a device or socket.

**Parameters:**

→ *arg* Pointer to information buffer (struct `rtdm_device_info`)

#### 5.16.2.2 `#define RTIOC_PURGE _IOW(RTIOC_TYPE_COMMON, 0x10, int)`

Purge internal device or socket buffers.

**Parameters:**

← *arg* Purge mask, see `RTDM_PURGE_XXX_BUFFER`

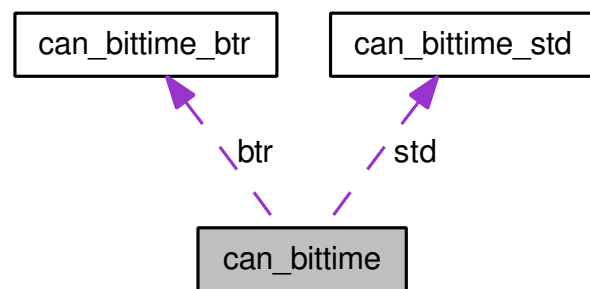
## Chapter 6

# Data Structure Documentation

### 6.1 `can_bittime` Struct Reference

Custom CAN bit-time definition.

Collaboration diagram for `can_bittime`:



#### Data Fields

- `can_bittime_type_t` type  
*Type of bit-time definition.*
- struct `can_bittime_std` `std`  
*Standard bit-time.*
- struct `can_bittime_btr` `btr`  
*Hardware-specific BTR bit-time.*

#### 6.1.1 Detailed Description

Custom CAN bit-time definition.

**Examples:**

[rtcanconfig.c](#).

The documentation for this struct was generated from the following file:

- [include/rtdm/rtcan.h](#)



## 6.2 can\_bittime\_btr Struct Reference

Hardware-specific BTR bit-times.

### Data Fields

- `uint8_t btr0`  
*Bus timing register 0.*
- `uint8_t btr1`  
*Bus timing register 1.*

### 6.2.1 Detailed Description

Hardware-specific BTR bit-times.

The documentation for this struct was generated from the following file:

- `include/rtdm/rtcan.h`

## 6.3 can\_bittime\_std Struct Reference

Standard bit-time parameters according to Bosch.

### Data Fields

- uint32\_t [brp](#)  
*Baud rate prescaler.*
- uint8\_t [prop\\_seg](#)  
*from 1 to 8*
- uint8\_t [phase\\_seg1](#)  
*from 1 to 8*
- uint8\_t [phase\\_seg2](#)  
*from 1 to 8*
- uint8\_t [sjw](#):7  
*from 1 to 4*
- uint8\_t [sam](#):1  
*1 - enable triple sampling*

### 6.3.1 Detailed Description

Standard bit-time parameters according to Bosch.

The documentation for this struct was generated from the following file:

- [include/rtdm/rtdmcan.h](#)

## 6.4 can\_filter Struct Reference

Filter for reception of CAN messages.

### Data Fields

- `uint32_t can_id`  
*CAN ID which must match with incoming IDs after passing the mask.*
- `uint32_t can_mask`  
*Mask which is applied to incoming IDs.*

### 6.4.1 Detailed Description

Filter for reception of CAN messages.

This filter works as follows: A received CAN ID is AND'ed bitwise with `can_mask` and then compared to `can_id`. This also includes the `CAN_EFF_FLAG` and `CAN_RTR_FLAG` of `CAN_XXX_FLAG`. If this comparison is true, the message will be received by the socket. The logic can be inverted with the `can_id` flag `CAN_INV_FILTER`:

```
if (can_id & CAN_INV_FILTER) {
    if ((received_can_id & can_mask) != (can_id & ~CAN_INV_FILTER))
        accept-message;
} else {
    if ((received_can_id & can_mask) == can_id)
        accept-message;
}
```

Multiple filters can be arranged in a filter list and set with `Sockopts`. If one of these filters matches a CAN ID upon reception of a CAN frame, this frame is accepted.

**Examples:**

`rtcan_rtt.c`, and `rtcanrecv.c`.

### 6.4.2 Field Documentation

#### 6.4.2.1 `uint32_t can_filter::can_id`

CAN ID which must match with incoming IDs after passing the mask.

The filter logic can be inverted with the flag `CAN_INV_FILTER`.

#### 6.4.2.2 `uint32_t can_filter::can_mask`

Mask which is applied to incoming IDs.

See [CAN ID masks](#) if exactly one CAN ID should come through.

The documentation for this struct was generated from the following file:

- `include/rtdm/rtcan.h`

## 6.5 can\_frame Struct Reference

Raw CAN frame.

### Public Member Functions

- `uint8_t data[8] \_\_attribute\_\_\(\(aligned\(8\)\)\)`  
*Payload data bytes.*

### Data Fields

- `can\_id\_t can_id`  
*CAN ID of the frame.*
- `uint8_t can\_dlc`  
*Size of the payload in bytes.*

### 6.5.1 Detailed Description

Raw CAN frame.

Central structure for receiving and sending CAN frames.

Examples:

[rtcan\\_rtt.c](#), [rtcanrecv.c](#), and [rtcansend.c](#).

### 6.5.2 Field Documentation

#### 6.5.2.1 `can_id_t can_frame::can_id`

CAN ID of the frame.

See [CAN ID flags](#) for special bits.

Examples:

[rtcan\\_rtt.c](#).

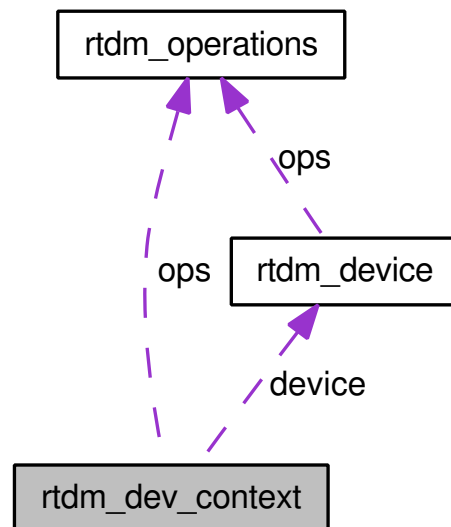
The documentation for this struct was generated from the following file:

- `include/rtdm/rtcan.h`

## 6.6 rtdm\_dev\_context Struct Reference

Device context.

Collaboration diagram for rtdm\_dev\_context:



### Data Fields

- unsigned long `context_flags`  
*Context flags, see [Context Flags](#) for details.*
- int `fd`  
*Associated file descriptor.*
- atomic\_t `close_lock_count`  
*Lock counter of context, held while structure is referenced by an operation handler.*
- struct `rtdm_operations` \* `ops`  
*Set of active device operation handlers.*
- struct `rtdm_device` \* `device`  
*Reference to owning device.*
- struct `rtdm_devctx_reserved` `reserved`  
*Data stored by RTDM inside a device context (internal use only).*
- char `dev_private` [0]  
*Begin of driver defined context data structure.*

### 6.6.1 Detailed Description

Device context.

A device context structure is associated with every open device instance. RTDM takes care of its creation and destruction and passes it to the operation handlers when being invoked.

Drivers can attach arbitrary data immediately after the official structure. The size of this data is provided via [rtdm\\_device.context\\_size](#) during device registration.

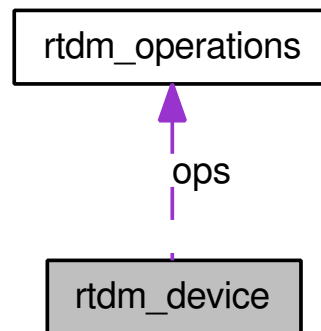
The documentation for this struct was generated from the following file:

- [include/rtdm/rtdm\\_driver.h](#)

## 6.7 rtdm\_device Struct Reference

RTDM device.

Collaboration diagram for rtdm\_device:



### Data Fields

- `int` [struct\\_version](#)  
Revision number of this structure, see [Driver Versioning](#) defines.
- `int` [device\\_flags](#)  
Device flags, see [Device Flags](#) for details.
- `size_t` [context\\_size](#)  
Size of driver defined appendix to struct [rtdm\\_dev\\_context](#).
- `char` [device\\_name](#) [RTDM\_MAX\_DEVNAME\_LEN+1]  
Named device identification (orthogonal to Linux device name space).
- `int` [protocol\\_family](#)  
Protocol device identification: protocol family (PF\_XXX).
- `int` [socket\\_type](#)  
Protocol device identification: socket type (SOCK\_XXX).
- [rtdm\\_open\\_handler\\_t](#) `open_rt`  
Named device instance creation for real-time contexts, optional if `open_nrt` is non-NULL, ignored for protocol devices.
- [rtdm\\_open\\_handler\\_t](#) `open_nrt`  
Named device instance creation for non-real-time contexts, optional if `open_rt` is non-NULL, ignored for protocol devices.
- [rtdm\\_socket\\_handler\\_t](#) `socket_rt`  
Protocol socket creation for real-time contexts, optional if `socket_nrt` is non-NULL, ignored for named devices.

- [rtm\\_socket\\_handler\\_t](#) [socket\\_nrt](#)  
*Protocol socket creation for non-real-time contexts, optional if [socket\\_rt](#) is non-NULL, ignored for named devices.*
- struct [rtm\\_operations](#) [ops](#)  
*Default operations on newly opened device instance.*
- int [device\\_class](#)  
*Device class ID, see [RTDM\\_CLASS\\_xxx](#).*
- int [device\\_sub\\_class](#)  
*Device sub-class, see [RTDM\\_SUBCLASS\\_xxx](#) definition in the [Device Profiles](#).*
- int [profile\\_version](#)  
*Supported device profile version.*
- const char \* [driver\\_name](#)  
*Informational driver name (reported via [/proc](#)).*
- int [driver\\_version](#)  
*Driver version, see [Driver Versioning](#) defines.*
- const char \* [peripheral\\_name](#)  
*Informational peripheral name the device is attached to (reported via [/proc](#)).*
- const char \* [provider\\_name](#)  
*Informational driver provider name (reported via [/proc](#)).*
- const char \* [proc\\_name](#)  
*Name of [/proc](#) entry for the device, must not be NULL.*
- struct [proc\\_dir\\_entry](#) \* [proc\\_entry](#)  
*Set to device's [/proc](#) root entry after registration, do not modify.*
- int [device\\_id](#)  
*Driver definable device ID.*
- void \* [device\\_data](#)  
*Driver definable device data.*
- struct [rtm\\_dev\\_reserved](#) [reserved](#)  
*Data stored by RTDM inside a registered device (internal use only).*

## 6.7.1 Detailed Description

RTDM device.

This structure specifies a RTDM device. As some fields, especially the reserved area, will be modified by RTDM during runtime, the structure must not reside in write-protected memory.

The documentation for this struct was generated from the following file:



- `include/rtdm/rtdm\_driver.h`

## 6.8 rtdm\_device\_info Struct Reference

Device information.

### Data Fields

- int [device\\_flags](#)  
*Device flags, see [Device Flags](#) for details.*
- int [device\\_class](#)  
*Device class ID, see [RTDM\\_CLASS\\_xxx](#).*
- int [device\\_sub\\_class](#)  
*Device sub-class, either [RTDM\\_SUBCLASS\\_GENERIC](#) or a [RTDM\\_SUBCLASS\\_xxx](#) definition of the related [Device Profile](#).*
- int [profile\\_version](#)  
*Supported device profile version.*

### 6.8.1 Detailed Description

Device information.

The documentation for this struct was generated from the following file:

- [include/rtdm/rtdm.h](#)

## 6.9 rtdm\_operations Struct Reference

Device operations.

### Data Fields

#### Common Operations

- [rtdm\\_close\\_handler\\_t close\\_rt](#)  
*Close handler for real-time contexts (optional).*
- [rtdm\\_close\\_handler\\_t close\\_nrt](#)  
*Close handler for non-real-time contexts (required).*
- [rtdm\\_ioctl\\_handler\\_t ioctl\\_rt](#)  
*IOCTL from real-time context (optional).*
- [rtdm\\_ioctl\\_handler\\_t ioctl\\_nrt](#)  
*IOCTL from non-real-time context (optional).*
- [rtdm\\_select\\_bind\\_handler\\_t select\\_bind](#)  
*Select binding handler for any context (optional).*

#### Stream-Oriented Device Operations

- [rtdm\\_read\\_handler\\_t read\\_rt](#)  
*Read handler for real-time context (optional).*
- [rtdm\\_read\\_handler\\_t read\\_nrt](#)  
*Read handler for non-real-time context (optional).*
- [rtdm\\_write\\_handler\\_t write\\_rt](#)  
*Write handler for real-time context (optional).*
- [rtdm\\_write\\_handler\\_t write\\_nrt](#)  
*Write handler for non-real-time context (optional).*

#### Message-Oriented Device Operations

- [rtdm\\_recvmsg\\_handler\\_t recvmsg\\_rt](#)  
*Receive message handler for real-time context (optional).*
- [rtdm\\_recvmsg\\_handler\\_t recvmsg\\_nrt](#)  
*Receive message handler for non-real-time context (optional).*
- [rtdm\\_sendmsg\\_handler\\_t sendmsg\\_rt](#)  
*Transmit message handler for real-time context (optional).*
- [rtdm\\_sendmsg\\_handler\\_t sendmsg\\_nrt](#)  
*Transmit message handler for non-real-time context (optional).*

### 6.9.1 Detailed Description

Device operations.

The documentation for this struct was generated from the following file:

- [include/rtdm/rtdm\\_driver.h](#)

## 6.10 rtser\_config Struct Reference

Serial device configuration.

### Data Fields

- int [config\\_mask](#)  
*mask specifying valid fields, see [RTSER\\_SET\\_xxx](#)*
- int [baud\\_rate](#)  
*baud rate, default [RTSER\\_DEF\\_BAUD](#)*
- int [parity](#)  
*number of parity bits, see [RTSER\\_xxx\\_PARITY](#)*
- int [data\\_bits](#)  
*number of data bits, see [RTSER\\_xxx\\_BITS](#)*
- int [stop\\_bits](#)  
*number of stop bits, see [RTSER\\_xxx\\_STOPB](#)*
- int [handshake](#)  
*handshake mechanisms, see [RTSER\\_xxx\\_HAND](#)*
- int [fifo\\_depth](#)  
*reception FIFO interrupt threshold, see [RTSER\\_FIFO\\_xxx](#)*
- [nanosecs\\_rel\\_t rx\\_timeout](#)  
*reception timeout, see [RTSER\\_TIMEOUT\\_xxx](#) for special values*
- [nanosecs\\_rel\\_t tx\\_timeout](#)  
*transmission timeout, see [RTSER\\_TIMEOUT\\_xxx](#) for special values*
- [nanosecs\\_rel\\_t event\\_timeout](#)  
*event timeout, see [RTSER\\_TIMEOUT\\_xxx](#) for special values*
- int [timestamp\\_history](#)  
*enable timestamp history, see [RTSER\\_xxx\\_TIMESTAMP\\_HISTORY](#)*
- int [event\\_mask](#)  
*event mask to be used with [RTSER\\_RTIOC\\_WAIT\\_EVENT](#), see [RTSER\\_EVENT\\_xxx](#)*

### 6.10.1 Detailed Description

Serial device configuration.

Examples:

[cross-link.c](#).

The documentation for this struct was generated from the following file:

- `include/rtdm/rtserial.h`

## 6.11 rtser\_event Struct Reference

Additional information about serial device events.

### Data Fields

- `int events`  
*signalled events, see [RTSER\\_EVENT\\_XXX](#)*
- `int rx_pending`  
*number of pending input characters*
- `nanosecs_abs_t last_timestamp`  
*last interrupt timestamp*
- `nanosecs_abs_t rxpend_timestamp`  
*reception timestamp of oldest character in input queue*

### 6.11.1 Detailed Description

Additional information about serial device events.

Examples:

[cross-link.c](#).

The documentation for this struct was generated from the following file:

- `include/rtdm/rtserial.h`

## 6.12 rtser\_status Struct Reference

Serial device status.

### Data Fields

- int [line\\_status](#)  
*line status register, see [RTSER\\_LSR\\_xxx](#)*
- int [modem\\_status](#)  
*modem status register, see [RTSER\\_MSR\\_xxx](#)*

### 6.12.1 Detailed Description

Serial device status.

The documentation for this struct was generated from the following file:

- [include/rtdm/rtserial.h](#)



## 6.13 sockaddr\_can Struct Reference

Socket address structure for the CAN address family.

### Data Fields

- `sa_family_t can_family`  
*CAN address family, must be AF\_CAN.*
- `int can_ifindex`  
*Interface index of CAN controller.*

### 6.13.1 Detailed Description

Socket address structure for the CAN address family.

#### Examples:

`rtcan_rtt.c`, `rtcanrecv.c`, and `rtcansend.c`.

### 6.13.2 Field Documentation

#### 6.13.2.1 `int sockaddr_can::can_ifindex`

Interface index of CAN controller.

See [SIOCGIFINDEX](#).

The documentation for this struct was generated from the following file:

- `include/rtdm/rtcan.h`



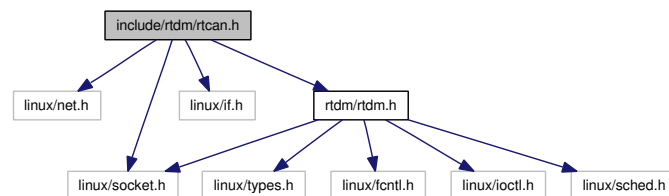
# Chapter 7

## File Documentation

### 7.1 include/rtdm/rtdm.h File Reference

Real-Time Driver Model for RT-Socket-CAN, CAN device profile header.

Include dependency graph for rtdm.h:



### Data Structures

- struct [can\\_bittime\\_std](#)  
*Standard bit-time parameters according to Bosch.*
- struct [can\\_bittime\\_btr](#)  
*Hardware-specific BTR bit-times.*
- struct [can\\_bittime](#)  
*Custom CAN bit-time definition.*
- struct [can\\_filter](#)  
*Filter for reception of CAN messages.*
- struct [sockaddr\\_can](#)  
*Socket address structure for the CAN address family.*
- struct [can\\_frame](#)  
*Raw CAN frame.*

## Defines

- #define [AF\\_CAN](#) 29  
*CAN address family.*
- #define [PF\\_CAN](#) [AF\\_CAN](#)  
*CAN protocol family.*
- #define [SOL\\_CAN\\_RAW](#) 103  
*CAN socket levels.*

### CAN ID masks

*Bit masks for masking CAN IDs*

- #define [CAN\\_EFF\\_MASK](#) 0x1FFFFFFF  
*Bit mask for extended CAN IDs.*
- #define [CAN\\_SFF\\_MASK](#) 0x000007FF  
*Bit mask for standard CAN IDs.*

### CAN ID flags

*Flags within a CAN ID indicating special CAN frame attributes*

- #define [CAN\\_EFF\\_FLAG](#) 0x80000000  
*Extended frame.*
- #define [CAN\\_RTR\\_FLAG](#) 0x40000000  
*Remote transmission frame.*
- #define [CAN\\_ERR\\_FLAG](#) 0x20000000  
*Error frame (see [Errors](#)), not valid in struct [can\\_filter](#).*
- #define [CAN\\_INV\\_FILTER](#) [CAN\\_ERR\\_FLAG](#)  
*Invert CAN filter definition, only valid in struct [can\\_filter](#).*

### Particular CAN protocols

*Possible protocols for the [PF\\_CAN](#) protocol family*

*Currently only the RAW protocol is supported.*

- #define [CAN\\_RAW](#) 1  
*Raw protocol of [PF\\_CAN](#), applicable to socket type [SOCK\\_RAW](#).*

### CAN controller modes

*Special CAN controllers modes, which can be or'ed together.*

#### **Note:**

*These modes are hardware-dependent. Please consult the hardware manual of the CAN controller for more detailed information.*

- #define `CAN_CTRLMODE_LISTENONLY` 0x1
- #define `CAN_CTRLMODE_LOOPBACK` 0x2

### Timestamp switches

Arguments to pass to `RTCAN_RTIOC_TAKE_TIMESTAMP`

- #define `RTCAN_TAKE_NO_TIMESTAMPS` 0  
*Switch off taking timestamps.*
- #define `RTCAN_TAKE_TIMESTAMPS` 1  
*Do take timestamps.*

### RAW socket options

Setting and getting CAN RAW socket options.

- #define `CAN_RAW_FILTER` 0x1  
*CAN filter definition.*
- #define `CAN_RAW_ERR_FILTER` 0x2  
*CAN error mask.*
- #define `CAN_RAW_LOOPBACK` 0x3  
*CAN TX loopback.*
- #define `CAN_RAW_RECV_OWN_MSGS` 0x4  
*CAN receive own messages.*

### IOCTLs

CAN device IOCTLs

- #define `SIOCGIFINDEX` `defined_by_kernel_header_file`  
*Get CAN interface index by name.*
- #define `SIOCSCANBAUDRATE` `_IOW(RTIOC_TYPE_CAN, 0x01, struct ifreq)`  
*Set baud rate.*
- #define `SIOCGCANBAUDRATE` `_IOWR(RTIOC_TYPE_CAN, 0x02, struct ifreq)`  
*Get baud rate.*
- #define `SIOCSCANCUSTOMBITTIME` `_IOW(RTIOC_TYPE_CAN, 0x03, struct ifreq)`  
*Set custom bit time parameter.*
- #define `SIOCGCANCUSTOMBITTIME` `_IOWR(RTIOC_TYPE_CAN, 0x04, struct ifreq)`  
*Get custom bit-time parameters.*
- #define `SIOCSCANMODE` `_IOW(RTIOC_TYPE_CAN, 0x05, struct ifreq)`  
*Set operation mode of CAN controller.*
- #define `SIOCGCANSTATE` `_IOWR(RTIOC_TYPE_CAN, 0x06, struct ifreq)`  
*Get current state of CAN controller.*
- #define `SIOCSCANCTRLMODE` `_IOW(RTIOC_TYPE_CAN, 0x07, struct ifreq)`

*Set special controller modes.*

- #define [SIOCGCANCTRLMODE](#) \_IOW(RTIOC\_TYPE\_CAN, 0x08, struct ifreq)  
*Get special controller modes.*
- #define [RTCAN\\_RTIOC\\_TAKE\\_TIMESTAMP](#) \_IOW(RTIOC\_TYPE\_CAN, 0x09, int)  
*Enable or disable storing a high precision timestamp upon reception of a CAN frame.*
- #define [RTCAN\\_RTIOC\\_RCV\\_TIMEOUT](#) \_IOW(RTIOC\_TYPE\_CAN, 0x0A, nanosecs\_rel\_t)  
*Specify a reception timeout for a socket.*
- #define [RTCAN\\_RTIOC\\_SND\\_TIMEOUT](#) \_IOW(RTIOC\_TYPE\_CAN, 0x0B, nanosecs\_rel\_t)  
*Specify a transmission timeout for a socket.*

### Error mask

Error class (mask) in `can_id` field of struct `can_frame` to be used with [CAN\\_RAW\\_ERR\\_FILTER](#).

**Note:** Error reporting is hardware dependent and most CAN controllers report less detailed error conditions than the SJA1000.

**Note:** In case of a bus-off error condition ([CAN\\_ERR\\_BUSOFF](#)), the CAN controller is **not** restarted automatically. It is the application's responsibility to react appropriately, e.g. calling [CAN\\_MODE\\_START](#).

**Note:** Bus error interrupts ([CAN\\_ERR\\_BUSERROR](#)) are enabled when an application is calling a [Recv](#) function on a socket listening on bus errors (using [CAN\\_RAW\\_ERR\\_FILTER](#)). After one bus error has occurred, the interrupt will be disabled to allow the application time for error processing and to efficiently avoid bus error interrupt flooding.

- #define [CAN\\_ERR\\_TX\\_TIMEOUT](#) 0x00000001U  
*TX timeout (netdevice driver).*
- #define [CAN\\_ERR\\_LOSTARB](#) 0x00000002U  
*Lost arbitration (see [data\[0\]](#)).*
- #define [CAN\\_ERR\\_CRTL](#) 0x00000004U  
*Controller problems (see [data\[1\]](#)).*
- #define [CAN\\_ERR\\_PROT](#) 0x00000008U  
*Protocol violations (see [data\[2\]](#), [data\[3\]](#)).*
- #define [CAN\\_ERR\\_TRX](#) 0x00000010U  
*Transceiver status (see [data\[4\]](#)).*
- #define [CAN\\_ERR\\_ACK](#) 0x00000020U  
*Received no ACK on transmission.*
- #define [CAN\\_ERR\\_BUSOFF](#) 0x00000040U  
*Bus off.*
- #define [CAN\\_ERR\\_BUSERROR](#) 0x00000080U  
*Bus error (may flood!).*

- #define [CAN\\_ERR\\_RESTARTED](#) 0x00000100U  
*Controller restarted.*
- #define [CAN\\_ERR\\_MASK](#) 0x1FFFFFFFU  
*Omit EFF, RTR, ERR flags.*

#### Arbitration lost error

Error in the data[0] field of struct [can\\_frame](#).

- #define [CAN\\_ERR\\_LOSTARB\\_UNSPEC](#) 0x00  
*unspecified*

#### Controller problems

Error in the data[1] field of struct [can\\_frame](#).

- #define [CAN\\_ERR\\_CTRL\\_UNSPEC](#) 0x00  
*unspecified*
- #define [CAN\\_ERR\\_CTRL\\_RX\\_OVERFLOW](#) 0x01  
*RX buffer overflow.*
- #define [CAN\\_ERR\\_CTRL\\_TX\\_OVERFLOW](#) 0x02  
*TX buffer overflow.*
- #define [CAN\\_ERR\\_CTRL\\_RX\\_WARNING](#) 0x04  
*reached warning level for RX errors*
- #define [CAN\\_ERR\\_CTRL\\_TX\\_WARNING](#) 0x08  
*reached warning level for TX errors*
- #define [CAN\\_ERR\\_CTRL\\_RX\\_PASSIVE](#) 0x10  
*reached passive level for RX errors*
- #define [CAN\\_ERR\\_CTRL\\_TX\\_PASSIVE](#) 0x20  
*reached passive level for TX errors*

#### Protocol error type

Error in the data[2] field of struct [can\\_frame](#).

- #define [CAN\\_ERR\\_PROT\\_UNSPEC](#) 0x00  
*unspecified*
- #define [CAN\\_ERR\\_PROT\\_BIT](#) 0x01  
*single bit error*
- #define [CAN\\_ERR\\_PROT\\_FORM](#) 0x02  
*frame format error*
- #define [CAN\\_ERR\\_PROT\\_STUFF](#) 0x04  
*bit stuffing error*

- #define `CAN_ERR_PROT_BIT0` 0x08  
*unable to send dominant bit*
- #define `CAN_ERR_PROT_BIT1` 0x10  
*unable to send recessive bit*
- #define `CAN_ERR_PROT_OVERLOAD` 0x20  
*bus overload*
- #define `CAN_ERR_PROT_ACTIVE` 0x40  
*active error announcement*
- #define `CAN_ERR_PROT_TX` 0x80  
*error occurred on transmission*

### Protocol error location

Error in the `data[3]` field of struct `can_frame`.

- #define `CAN_ERR_PROT_LOC_UNSPEC` 0x00  
*unspecified*
- #define `CAN_ERR_PROT_LOC_SOF` 0x03  
*start of frame*
- #define `CAN_ERR_PROT_LOC_ID28_21` 0x02  
*ID bits 28 - 21 (SFF: 10 - 3).*
- #define `CAN_ERR_PROT_LOC_ID20_18` 0x06  
*ID bits 20 - 18 (SFF: 2 - 0).*
- #define `CAN_ERR_PROT_LOC_SRTR` 0x04  
*substitute RTR (SFF: RTR)*
- #define `CAN_ERR_PROT_LOC_IDE` 0x05  
*identifier extension*
- #define `CAN_ERR_PROT_LOC_ID17_13` 0x07  
*ID bits 17-13.*
- #define `CAN_ERR_PROT_LOC_ID12_05` 0x0F  
*ID bits 12-5.*
- #define `CAN_ERR_PROT_LOC_ID04_00` 0x0E  
*ID bits 4-0.*
- #define `CAN_ERR_PROT_LOC_RTR` 0x0C  
*RTR.*
- #define `CAN_ERR_PROT_LOC_RES1` 0x0D  
*reserved bit 1*



- #define [CAN\\_ERR\\_PROT\\_LOC\\_RES0](#) 0x09  
*reserved bit 0*
- #define [CAN\\_ERR\\_PROT\\_LOC\\_DLC](#) 0x0B  
*data length code*
- #define [CAN\\_ERR\\_PROT\\_LOC\\_DATA](#) 0x0A  
*data section*
- #define [CAN\\_ERR\\_PROT\\_LOC\\_CRC\\_SEQ](#) 0x08  
*CRC sequence.*
- #define [CAN\\_ERR\\_PROT\\_LOC\\_CRC\\_DEL](#) 0x18  
*CRC delimiter.*
- #define [CAN\\_ERR\\_PROT\\_LOC\\_ACK](#) 0x19  
*ACK slot.*
- #define [CAN\\_ERR\\_PROT\\_LOC\\_ACK\\_DEL](#) 0x1B  
*ACK delimiter.*
- #define [CAN\\_ERR\\_PROT\\_LOC\\_EOF](#) 0x1A  
*end of frame*
- #define [CAN\\_ERR\\_PROT\\_LOC\\_INTERM](#) 0x12  
*intermission*

### Protocol error location

Error in the `data[4]` field of struct `can_frame`.

- #define [CAN\\_ERR\\_TRX\\_UNSPEC](#) 0x00  
*0000 0000*
- #define [CAN\\_ERR\\_TRX\\_CANH\\_NO\\_WIRE](#) 0x04  
*0000 0100*
- #define [CAN\\_ERR\\_TRX\\_CANH\\_SHORT\\_TO\\_BAT](#) 0x05  
*0000 0101*
- #define [CAN\\_ERR\\_TRX\\_CANH\\_SHORT\\_TO\\_VCC](#) 0x06  
*0000 0110*
- #define [CAN\\_ERR\\_TRX\\_CANH\\_SHORT\\_TO\\_GND](#) 0x07  
*0000 0111*
- #define [CAN\\_ERR\\_TRX\\_CANL\\_NO\\_WIRE](#) 0x40  
*0100 0000*
- #define [CAN\\_ERR\\_TRX\\_CANL\\_SHORT\\_TO\\_BAT](#) 0x50  
*0101 0000*
- #define [CAN\\_ERR\\_TRX\\_CANL\\_SHORT\\_TO\\_VCC](#) 0x60

0110 0000

- `#define CAN_ERR_TRX_CANL_SHORT_TO_GND 0x70`  
0111 0000
- `#define CAN_ERR_TRX_CANL_SHORT_TO_CANH 0x80`  
1000 0000

## Typedefs

- `typedef uint32_t can_id_t`  
*Type of CAN id (see [CAN\\_xxx\\_MASK](#) and [CAN\\_xxx\\_FLAG](#)).*
- `typedef can_id_t can_err_mask_t`  
*Type of CAN error mask.*
- `typedef uint32_t can_baudrate_t`  
*Baudrate definition in bits per second.*
- `typedef enum CAN_BITTIME_TYPE can_bittime_type_t`  
*See [CAN\\_BITTIME\\_TYPE](#).*
- `typedef enum CAN_MODE can_mode_t`  
*See [CAN\\_MODE](#).*
- `typedef int can_ctrlmode_t`  
*See [CAN\\_CTRLMODE](#).*
- `typedef enum CAN_STATE can_state_t`  
*See [CAN\\_STATE](#).*
- `typedef struct can_filter can_filter_t`  
*Filter for reception of CAN messages.*
- `typedef struct can_frame can_frame_t`  
*Raw CAN frame.*

## Enumerations

- `enum CAN_BITTIME_TYPE { CAN_BITTIME_STD, CAN_BITTIME_BTR }`  
*Supported CAN bit-time types.*

### CAN operation modes

*Modes into which CAN controllers can be set*

- `enum CAN_MODE { CAN_MODE_STOP = 0, CAN_MODE_START, CAN_MODE_SLEEP }`

### CAN controller states

*States a CAN controller can be in.*

- enum `CAN_STATE` {  
    `CAN_STATE_ACTIVE` = 0, `CAN_STATE_BUS_WARNING`, `CAN_STATE_BUS_-`  
    `PASSIVE`, `CAN_STATE_BUS_OFF`,  
    `CAN_STATE_SCANNING_BAUDRATE`, `CAN_STATE_STOPPED`, `CAN_STATE_-`  
    `SLEEPING` }

#### 7.1.1 Detailed Description

Real-Time Driver Model for RT-Socket-CAN, CAN device profile header.

##### Note:

Copyright (C) 2006 Wolfgang Grandegger <[wg@grandegger.com](mailto:wg@grandegger.com)>

Copyright (C) 2005, 2006 Sebastian Smolorz <[Sebastian.Smolorz@stud.uni-hannover.de](mailto:Sebastian.Smolorz@stud.uni-hannover.de)>

This RTDM CAN device profile header is based on:

include/linux/can.h, include/linux/socket.h, net/can/pf\_can.h in linux-can.patch, a CAN socket framework for Linux

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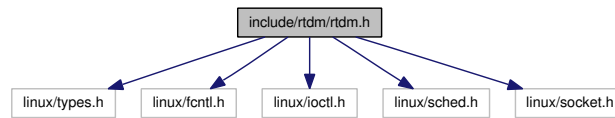
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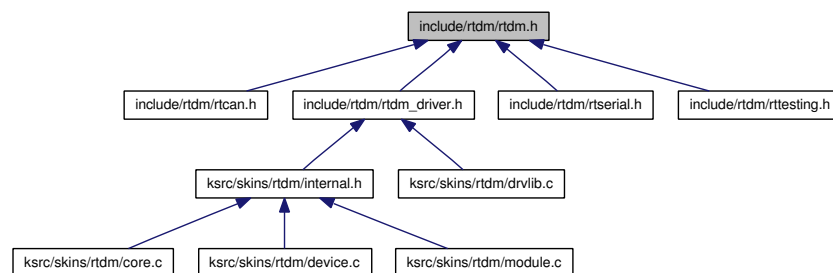
## 7.2 include/rtdm/rtdm.h File Reference

Real-Time Driver Model for Xenomai, user API header.

Include dependency graph for rtdm.h:



This graph shows which files directly or indirectly include this file:



## Data Structures

- struct [rtdm\\_device\\_info](#)

*Device information.*

## Defines

### API Versioning

- #define [RTDM\\_API\\_VER](#) 7  
*Common user and driver API version.*
- #define [RTDM\\_API\\_MIN\\_COMPAT\\_VER](#) 6  
*Minimum API revision compatible with the current release.*

### RTDM\_TIMEOUT\_xxx

*Special timeout values*

- #define [RTDM\\_TIMEOUT\\_INFINITE](#) 0  
*Block forever.*
- #define [RTDM\\_TIMEOUT\\_NONE](#) (-1)  
*Any negative timeout means non-blocking.*

**RTDM\_CLASS\_xxx***Device classes*

- `#define RTDM_CLASS_PARPORT 1`
- `#define RTDM_CLASS_SERIAL 2`
- `#define RTDM_CLASS_CAN 3`
- `#define RTDM_CLASS_NETWORK 4`
- `#define RTDM_CLASS_RTMAC 5`
- `#define RTDM_CLASS_TESTING 6`
- `#define RTDM_CLASS_EXPERIMENTAL 224`
- `#define RTDM_CLASS_MAX 255`

**Device Naming***Maximum length of device names (excluding the final null character)*

- `#define RTDM_MAX_DEVNAME_LEN 31`

**RTDM\_PURGE\_xxx\_BUFFER***Flags selecting buffers to be purged*

- `#define RTDM_PURGE_RX_BUFFER 0x0001`
- `#define RTDM_PURGE_TX_BUFFER 0x0002`

**Common IOCTLs***The following IOCTLs are common to all device profiles.*

- `#define RTIOC_DEVICE_INFO _IOR(RTIOC_TYPE_COMMON, 0x00, struct rtdm_device_info)`  
*Retrieve information about a device or socket.*
- `#define RTIOC_PURGE _IOW(RTIOC_TYPE_COMMON, 0x10, int)`  
*Purge internal device or socket buffers.*

**Typedefs**

- `typedef uint64_t nanosecs_abs_t`  
*RTDM type for representing absolute dates.*
- `typedef int64_t nanosecs_rel_t`  
*RTDM type for representing relative intervals.*
- `typedef struct rtdm_device_info rtdm_device_info_t`  
*Device information.*

**7.2.1 Detailed Description**

Real-Time Driver Model for Xenomai, user API header.

**Note:**

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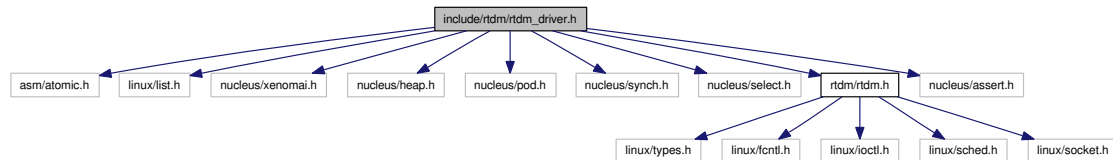
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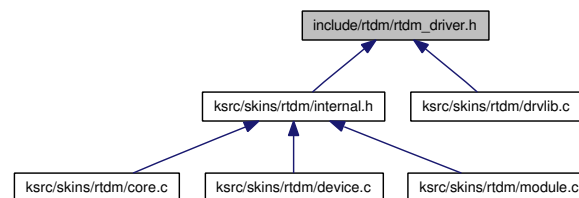
## 7.3 include/rtdm/rtdm\_driver.h File Reference

Real-Time Driver Model for Xenomai, driver API header.

Include dependency graph for rtdm\_driver.h:



This graph shows which files directly or indirectly include this file:



## Data Structures

- struct [rtdm\\_operations](#)  
*Device operations.*
- struct [rtdm\\_dev\\_context](#)  
*Device context.*
- struct [rtdm\\_device](#)  
*RTDM device.*

## Defines

- #define [rtdm\\_irq\\_get\\_arg](#)(irq\_handle, type) ((type \*)irq\_handle → cookie)  
*Retrieve IRQ handler argument.*

## Device Flags

*Static flags describing a RTDM device*

- #define [RTDM\\_EXCLUSIVE](#) 0x0001  
*If set, only a single instance of the device can be requested by an application.*
- #define [RTDM\\_NAMED\\_DEVICE](#) 0x0010  
*If set, the device is addressed via a clear-text name.*

- #define [RTDM\\_PROTOCOL\\_DEVICE](#) 0x0020  
*If set, the device is addressed via a combination of protocol ID and socket type.*
- #define [RTDM\\_DEVICE\\_TYPE\\_MASK](#) 0x00F0  
*Mask selecting the device type.*

### Context Flags

*Dynamic flags describing the state of an open RTDM device (bit numbers)*

- #define [RTDM\\_CREATED\\_IN\\_NRT](#) 0  
*Set by RTDM if the device instance was created in non-real-time context.*
- #define [RTDM\\_CLOSING](#) 1  
*Set by RTDM when the device is being closed.*
- #define [RTDM\\_USER\\_CONTEXT\\_FLAG](#) 8  
*Lowest bit number the driver developer can use freely.*

### Driver Versioning

*Current revisions of RTDM structures, encoding of driver versions. See [API Versioning](#) for the interface revision.*

- #define [RTDM\\_DEVICE\\_STRUCT\\_VER](#) 5  
*Version of struct [rtdm\\_device](#).*
- #define [RTDM\\_CONTEXT\\_STRUCT\\_VER](#) 3  
*Version of struct [rtdm\\_dev\\_context](#).*
- #define [RTDM\\_SECURE\\_DEVICE](#) 0x80000000  
*Flag indicating a secure variant of RTDM (not supported here).*
- #define [RTDM\\_DRIVER\\_VER](#)(major, minor, patch) (((major & 0xFF) << 16) | ((minor & 0xFF) << 8) | (patch & 0xFF))  
*Version code constructor for driver revisions.*
- #define [RTDM\\_DRIVER\\_MAJOR\\_VER](#)(ver) (((ver) >> 16) & 0xFF)  
*Get major version number from driver revision code.*
- #define [RTDM\\_DRIVER\\_MINOR\\_VER](#)(ver) (((ver) >> 8) & 0xFF)  
*Get minor version number from driver revision code.*
- #define [RTDM\\_DRIVER\\_PATCH\\_VER](#)(ver) ((ver) & 0xFF)  
*Get patch version number from driver revision code.*

### Global Lock across Scheduler Invocation

- #define [RTDM\\_EXECUTE\\_ATOMICALY](#)(code\_block)  
*Execute code block atomically.*



**RTDM\_IRQTYPE\_xxx***Interrupt registrations flags*

- #define [RTDM\\_IRQTYPE\\_SHARED](#) XN\_ISR\_SHARED  
*Enable IRQ-sharing with other real-time drivers.*
- #define [RTDM\\_IRQTYPE\\_EDGE](#) XN\_ISR\_EDGE  
*Mark IRQ as edge-triggered, relevant for correct handling of shared edge-triggered IRQs.*

**RTDM\_IRQ\_xxx***Return flags of interrupt handlers*

- #define [RTDM\\_IRQ\\_NONE](#) XN\_ISR\_NONE  
*Unhandled interrupt.*
- #define [RTDM\\_IRQ\\_HANDLED](#) XN\_ISR\_HANDLED  
*Denote handled interrupt.*

**Task Priority Range***Maximum and minimum task priorities*

- #define [RTDM\\_TASK\\_LOWEST\\_PRIORITY](#) XNSCHED\_LOW\_Prio
- #define [RTDM\\_TASK\\_HIGHEST\\_PRIORITY](#) XNSCHED\_HIGH\_Prio

**Task Priority Modification***Raise or lower task priorities by one level*

- #define [RTDM\\_TASK\\_RAISE\\_PRIORITY](#) (+1)
- #define [RTDM\\_TASK\\_LOWER\\_PRIORITY](#) (-1)

**Typedefs**

- typedef int(\* [rtdm\\_irq\\_handler\\_t](#))(rtdm\_irq\_t \*irq\_handle)  
*Interrupt handler.*
- typedef void(\* [rtdm\\_nrtsig\\_handler\\_t](#))(rtdm\_nrtsig\_t nrt\_sig, void \*arg)  
*Non-real-time signal handler.*
- typedef void(\* [rtdm\\_timer\\_handler\\_t](#))(rtdm\_timer\_t \*timer)  
*Timer handler.*
- typedef void(\* [rtdm\\_task\\_proc\\_t](#))(void \*arg)  
*Real-time task procedure.*

**Operation Handler Prototypes**

- typedef int(\* [rtdm\\_open\\_handler\\_t](#))(struct [rtdm\\_dev\\_context](#) \*context, rtdm\_user\_info\_t \*user\_info, int oflag)

*Named device open handler.*

- typedef int(\* [rtdm\\_socket\\_handler\\_t](#) )(struct [rtdm\\_dev\\_context](#) \*context, [rtdm\\_user\\_info\\_t](#) \*user\_info, int protocol)  
*Socket creation handler for protocol devices.*
- typedef int(\* [rtdm\\_close\\_handler\\_t](#) )(struct [rtdm\\_dev\\_context](#) \*context, [rtdm\\_user\\_info\\_t](#) \*user\_info)  
*Close handler.*
- typedef int(\* [rtdm\\_ioctl\\_handler\\_t](#) )(struct [rtdm\\_dev\\_context](#) \*context, [rtdm\\_user\\_info\\_t](#) \*user\_info, unsigned int request, void \_\_user \*arg)  
*IOCTL handler.*
- typedef int(\* [rtdm\\_select\\_bind\\_handler\\_t](#) )(struct [rtdm\\_dev\\_context](#) \*context, [rtdm\\_selector\\_t](#) \*selector, enum [rtdm\\_selecttype](#) type, unsigned fd\_index)  
*Select binding handler.*
- typedef ssize\_t(\* [rtdm\\_read\\_handler\\_t](#) )(struct [rtdm\\_dev\\_context](#) \*context, [rtdm\\_user\\_info\\_t](#) \*user\_info, void \*buf, size\_t nbyte)  
*Read handler.*
- typedef ssize\_t(\* [rtdm\\_write\\_handler\\_t](#) )(struct [rtdm\\_dev\\_context](#) \*context, [rtdm\\_user\\_info\\_t](#) \*user\_info, const void \*buf, size\_t nbyte)  
*Write handler.*
- typedef ssize\_t(\* [rtdm\\_recvmmsg\\_handler\\_t](#) )(struct [rtdm\\_dev\\_context](#) \*context, [rtdm\\_user\\_info\\_t](#) \*user\_info, struct msghdr \*msg, int flags)  
*Receive message handler.*
- typedef ssize\_t(\* [rtdm\\_sendmmsg\\_handler\\_t](#) )(struct [rtdm\\_dev\\_context](#) \*context, [rtdm\\_user\\_info\\_t](#) \*user\_info, const struct msghdr \*msg, int flags)  
*Transmit message handler.*

## Enumerations

### RTDM\_SELECTTYPE\_XXX

*Event types select can bind to*

- enum [rtdm\\_selecttype](#) { [RTDM\\_SELECTTYPE\\_READ](#) = XNSELECT\_READ, [RTDM\\_SELECTTYPE\\_WRITE](#) = XNSELECT\_WRITE, [RTDM\\_SELECTTYPE\\_EXCEPT](#) = XNSELECT\_EXCEPT }

### RTDM\_TIMERMODE\_XXX

*Timer operation modes*

- enum [rtdm\\_timer\\_mode](#) { [RTDM\\_TIMERMODE\\_RELATIVE](#) = XN\_RELATIVE, [RTDM\\_TIMERMODE\\_ABSOLUTE](#) = XN\_ABSOLUTE, [RTDM\\_TIMERMODE\\_REALTIME](#) = XN\_REALTIME }

## Functions

- int [rtdm\\_dev\\_register](#) (struct [rtdm\\_device](#) \*device)  
*Register a RTDM device.*
- int [rtdm\\_dev\\_unregister](#) (struct [rtdm\\_device](#) \*device, unsigned int poll\_delay)  
*Unregisters a RTDM device.*
- struct [rtdm\\_dev\\_context](#) \* [rtdm\\_context\\_get](#) (int fd)  
*Resolve file descriptor to device context.*
- int [rtdm\\_select\\_bind](#) (int fd, rtdm\_selector\_t \*selector, enum [rtdm\\_selecttype](#) type, unsigned fd\_index)  
*Bind a selector to specified event types of a given file descriptor.*
- int [rtdm\\_irq\\_request](#) (rtdm\_irq\_t \*irq\_handle, unsigned int irq\_no, [rtdm\\_irq\\_handler\\_t](#) handler, unsigned long flags, const char \*device\_name, void \*arg)  
*Register an interrupt handler.*
- void [rtdm\\_timer\\_destroy](#) (rtdm\_timer\_t \*timer)  
*Destroy a timer.*
- int [rtdm\\_timer\\_start](#) (rtdm\_timer\_t \*timer, [nanosecs\\_abs\\_t](#) expiry, [nanosecs\\_rel\\_t](#) interval, enum [rtdm\\_timer\\_mode](#) mode)  
*Start a timer.*
- void [rtdm\\_timer\\_stop](#) (rtdm\_timer\_t \*timer)  
*Stop a timer.*
- int [rtdm\\_task\\_init](#) (rtdm\_task\_t \*task, const char \*name, [rtdm\\_task\\_proc\\_t](#) task\_proc, void \*arg, int priority, [nanosecs\\_rel\\_t](#) period)  
*Intialise and start a real-time task.*
- void [rtdm\\_task\\_busy\\_sleep](#) ([nanosecs\\_rel\\_t](#) delay)  
*Busy-wait a specified amount of time.*
- void [rtdm\\_toseq\\_init](#) (rtdm\_toseq\_t \*timeout\_seq, [nanosecs\\_rel\\_t](#) timeout)  
*Initialise a timeout sequence.*
- void [rtdm\\_event\\_init](#) (rtdm\_event\_t \*event, unsigned long pending)  
*Initialise an event.*
- int [rtdm\\_event\\_select\\_bind](#) (rtdm\_event\_t \*event, rtdm\_selector\_t \*selector, enum [rtdm\\_selecttype](#) type, unsigned fd\_index)  
*Bind a selector to an event.*
- int [rtdm\\_event\\_wait](#) (rtdm\_event\_t \*event)  
*Wait on event occurrence.*
- int [rtdm\\_event\\_timedwait](#) (rtdm\_event\_t \*event, [nanosecs\\_rel\\_t](#) timeout, rtdm\_toseq\_t \*timeout\_seq)

*Wait on event occurrence with timeout.*

- void [rt dm\\_event\\_signal](#) (rt dm\_event\_t \*event)  
*Signal an event occurrence.*
- void [rt dm\\_event\\_clear](#) (rt dm\_event\_t \*event)  
*Clear event state.*
- void [rt dm\\_sem\\_init](#) (rt dm\_sem\_t \*sem, unsigned long value)  
*Initialise a semaphore.*
- int [rt dm\\_sem\\_select\\_bind](#) (rt dm\_sem\_t \*sem, rt dm\_selector\_t \*selector, enum [rt dm\\_selecttype](#) type, unsigned fd\_index)  
*Bind a selector to a semaphore.*
- int [rt dm\\_sem\\_down](#) (rt dm\_sem\_t \*sem)  
*Decrement a semaphore.*
- int [rt dm\\_sem\\_timeddown](#) (rt dm\_sem\_t \*sem, [nanosecs\\_rel\\_t](#) timeout, rt dm\_toseq\_t \*timeout\_seq)  
*Decrement a semaphore with timeout.*
- void [rt dm\\_sem\\_up](#) (rt dm\_sem\_t \*sem)  
*Increment a semaphore.*
- void [rt dm\\_mutex\\_init](#) (rt dm\_mutex\_t \*mutex)  
*Initialise a mutex.*
- int [rt dm\\_mutex\\_lock](#) (rt dm\_mutex\_t \*mutex)  
*Request a mutex.*
- int [rt dm\\_mutex\\_timedlock](#) (rt dm\_mutex\_t \*mutex, [nanosecs\\_rel\\_t](#) timeout, rt dm\_toseq\_t \*timeout\_seq)  
*Request a mutex with timeout.*

## Spinlock with Preemption Deactivation

- #define [RTDM\\_LOCK\\_UNLOCKED](#) RTHAL\_SPIN\_LOCK\_UNLOCKED  
*Static lock initialisation.*
- #define [rt dm\\_lock\\_init](#)(lock) rthal\_spin\_lock\_init(lock)  
*Dynamic lock initialisation.*
- #define [rt dm\\_lock\\_get](#)(lock) rthal\_spin\_lock(lock)  
*Acquire lock from non-preemptible contexts.*
- #define [rt dm\\_lock\\_put](#)(lock) rthal\_spin\_unlock(lock)  
*Release lock without preemption restoration.*

- #define `rtdm_lock_get_irqsave`(lock, context) `rthal_spin_lock_irqsave`(lock, context)  
*Acquire lock and disable preemption.*
- #define `rtdm_lock_put_irqrestore`(lock, context) `rthal_spin_unlock_irqrestore`(lock, context)  
*Release lock and restore preemption state.*
- #define `rtdm_lock_irqsave`(context) `rthal_local_irq_save`(context)  
*Disable preemption locally.*
- #define `rtdm_lock_irqrestore`(context) `rthal_local_irq_restore`(context)  
*Restore preemption state.*
- typedef `rthal_spinlock_t` `rtdm_lock_t`  
*Lock variable.*
- typedef unsigned long `rtdm_lockctx_t`  
*Variable to save the context while holding a lock.*

### 7.3.1 Detailed Description

Real-Time Driver Model for Xenomai, driver API header.

**Note:**

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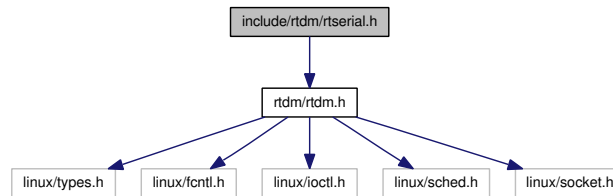
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## 7.4 include/rtdm/rtserial.h File Reference

Real-Time Driver Model for Xenomai, serial device profile header.

Include dependency graph for rtserial.h:



### Data Structures

- struct [rtser\\_config](#)  
*Serial device configuration.*
- struct [rtser\\_status](#)  
*Serial device status.*
- struct [rtser\\_event](#)  
*Additional information about serial device events.*

### Defines

- #define [RTSER\\_RTIOC\\_BREAK\\_CTL](#) \_IOR(RTIOC\_TYPE\_SERIAL, 0x06, int)  
*Set or clear break on UART output line.*

#### RTSER\_DEF\_BAUD

*Default baud rate*

- #define **RTSER\_DEF\_BAUD** 9600

#### RTSER\_xxx\_PARITY

*Number of parity bits*

- #define **RTSER\_NO\_PARITY** 0x00
- #define **RTSER\_ODD\_PARITY** 0x01
- #define **RTSER\_EVEN\_PARITY** 0x03
- #define **RTSER\_DEF\_PARITY** RTSER\_NO\_PARITY

#### RTSER\_xxx\_BITS

*Number of data bits*

- #define **RTSER\_5\_BITS** 0x00
- #define **RTSER\_6\_BITS** 0x01
- #define **RTSER\_7\_BITS** 0x02

- #define **RTSER\_8\_BITS** 0x03
- #define **RTSER\_DEF\_BITS** RTSER\_8\_BITS

### **RTSER\_xxx\_STOPB**

*Number of stop bits*

- #define **RTSER\_1\_STOPB** 0x00  
*valid only in combination with 5 data bits*
- #define **RTSER\_1\_5\_STOPB** 0x01  
*valid only in combination with 5 data bits*
- #define **RTSER\_2\_STOPB** 0x01  
*valid only in combination with 5 data bits*
- #define **RTSER\_DEF\_STOPB** RTSER\_1\_STOPB  
*valid only in combination with 5 data bits*

### **RTSER\_xxx\_HAND**

*Handshake mechanisms*

- #define **RTSER\_NO\_HAND** 0x00
- #define **RTSER\_RTSCTS\_HAND** 0x01
- #define **RTSER\_DEF\_HAND** RTSER\_NO\_HAND

### **RTSER\_FIFO\_xxx**

*Reception FIFO interrupt threshold*

- #define **RTSER\_FIFO\_DEPTH\_1** 0x00
- #define **RTSER\_FIFO\_DEPTH\_4** 0x40
- #define **RTSER\_FIFO\_DEPTH\_8** 0x80
- #define **RTSER\_FIFO\_DEPTH\_14** 0xC0
- #define **RTSER\_DEF\_FIFO\_DEPTH** RTSER\_FIFO\_DEPTH\_1

### **RTSER\_TIMEOUT\_xxx**

*Special timeout values, see also [RTDM\\_TIMEOUT\\_xxx](#)*

- #define **RTSER\_TIMEOUT\_INFINITE** RTDM\_TIMEOUT\_INFINITE
- #define **RTSER\_TIMEOUT\_NONE** RTDM\_TIMEOUT\_NONE
- #define **RTSER\_DEF\_TIMEOUT** RTDM\_TIMEOUT\_INFINITE

### **RTSER\_xxx\_TIMESTAMP\_HISTORY**

*Timestamp history control*

- #define **RTSER\_RX\_TIMESTAMP\_HISTORY** 0x01
- #define **RTSER\_DEF\_TIMESTAMP\_HISTORY** 0x00

### **RTSER\_EVENT\_xxx**

*Events bits*

- #define **RTSER\_EVENT\_RXPEND** 0x01
- #define **RTSER\_EVENT\_ERRPEND** 0x02

- #define **RTSER\_EVENT\_MODEMHI** 0x04
- #define **RTSER\_EVENT\_MODEMLO** 0x08
- #define **RTSER\_DEF\_EVENT\_MASK** 0x00

### **RTSER\_SET\_xxx**

*Configuration mask bits*

- #define **RTSER\_SET\_BAUD** 0x0001
- #define **RTSER\_SET\_PARITY** 0x0002
- #define **RTSER\_SET\_DATA\_BITS** 0x0004
- #define **RTSER\_SET\_STOP\_BITS** 0x0008
- #define **RTSER\_SET\_HANDSHAKE** 0x0010
- #define **RTSER\_SET\_FIFO\_DEPTH** 0x0020
- #define **RTSER\_SET\_TIMEOUT\_RX** 0x0100
- #define **RTSER\_SET\_TIMEOUT\_TX** 0x0200
- #define **RTSER\_SET\_TIMEOUT\_EVENT** 0x0400
- #define **RTSER\_SET\_TIMESTAMP\_HISTORY** 0x0800
- #define **RTSER\_SET\_EVENT\_MASK** 0x1000

### **RTSER\_LSR\_xxx**

*Line status bits*

- #define **RTSER\_LSR\_DATA** 0x01
- #define **RTSER\_LSR\_OVERRUN\_ERR** 0x02
- #define **RTSER\_LSR\_PARITY\_ERR** 0x04
- #define **RTSER\_LSR\_FRAMING\_ERR** 0x08
- #define **RTSER\_LSR\_BREAK\_IND** 0x10
- #define **RTSER\_LSR\_THR\_EMPTY** 0x20
- #define **RTSER\_LSR\_TRANSM\_EMPTY** 0x40
- #define **RTSER\_LSR\_FIFO\_ERR** 0x80
- #define **RTSER\_SOFT\_OVERRUN\_ERR** 0x0100

### **RTSER\_MSR\_xxx**

*Modem status bits*

- #define **RTSER\_MSR\_DCTS** 0x01
- #define **RTSER\_MSR\_DDSD** 0x02
- #define **RTSER\_MSR\_TERI** 0x04
- #define **RTSER\_MSR\_DDSD** 0x08
- #define **RTSER\_MSR\_CTS** 0x10
- #define **RTSER\_MSR\_DSR** 0x20
- #define **RTSER\_MSR\_RI** 0x40
- #define **RTSER\_MSR\_DCD** 0x80

### **RTSER\_MCR\_xxx**

*Modem control bits*

- #define **RTSER\_MCR\_DTR** 0x01
- #define **RTSER\_MCR\_RTS** 0x02
- #define **RTSER\_MCR\_OUT1** 0x04
- #define **RTSER\_MCR\_OUT2** 0x08
- #define **RTSER\_MCR\_LOOP** 0x10

### **Sub-Classes of RTDM\_CLASS\_SERIAL**

- #define **RTDM\_SUBCLASS\_16550A** 0



## IOCTLs

### Serial device IOCTLs

- #define [RTSER\\_RTIOC\\_GET\\_CONFIG](#) \_IOR(RTIOC\_TYPE\_SERIAL, 0x00, struct rtser\_config)  
*Get serial device configuration.*
- #define [RTSER\\_RTIOC\\_SET\\_CONFIG](#) \_IOW(RTIOC\_TYPE\_SERIAL, 0x01, struct rtser\_config)  
*Set serial device configuration.*
- #define [RTSER\\_RTIOC\\_GET\\_STATUS](#) \_IOR(RTIOC\_TYPE\_SERIAL, 0x02, struct rtser\_status)  
*Get serial device status.*
- #define [RTSER\\_RTIOC\\_GET\\_CONTROL](#) \_IOR(RTIOC\_TYPE\_SERIAL, 0x03, int)  
*Get serial device's modem control register.*
- #define [RTSER\\_RTIOC\\_SET\\_CONTROL](#) \_IOW(RTIOC\_TYPE\_SERIAL, 0x04, int)  
*Set serial device's modem control register.*
- #define [RTSER\\_RTIOC\\_WAIT\\_EVENT](#) \_IOR(RTIOC\_TYPE\_SERIAL, 0x05, struct rtser\_event)  
*Wait on serial device events according to previously set mask.*

## RTSER\_BREAK\_xxx

### Break control

- #define [RTSER\\_BREAK\\_CLR](#) 0x00  
*Serial device configuration.*
- #define [RTSER\\_BREAK\\_SET](#) 0x01  
*Serial device configuration.*
- #define [RTIOC\\_TYPE\\_SERIAL](#) RTDM\_CLASS\_SERIAL  
*Serial device configuration.*
- typedef struct [rtser\\_config](#) [rtser\\_config\\_t](#)  
*Serial device configuration.*
- typedef struct [rtser\\_status](#) [rtser\\_status\\_t](#)  
*Serial device status.*
- typedef struct [rtser\\_event](#) [rtser\\_event\\_t](#)  
*Additional information about serial device events.*

### 7.4.1 Detailed Description

Real-Time Driver Model for Xenomai, serial device profile header.

**Note:**

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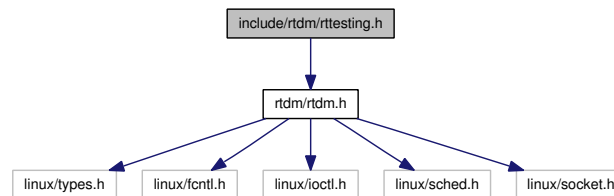
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## 7.5 include/rtdm/rttesting.h File Reference

Real-Time Driver Model for Xenomai, testing device profile header.

Include dependency graph for rttesting.h:



### Defines

#### Sub-Classes of RTDM\_CLASS\_TESTING

- #define **RTDM\_SUBCLASS\_TIMERBENCH** 0
- #define **RTDM\_SUBCLASS\_IRQBENCH** 1
- #define **RTDM\_SUBCLASS\_SWITCHTEST** 2

#### IOCTLs

Testing device IOCTLs

- #define **RTTST\_RTIOC\_INTERM\_BENCH\_RES** \_IOWR(RTIOC\_TYPE\_TESTING, 0x00, struct rttst\_interm\_bench\_res)
- #define **RTTST\_RTIOC\_TMBENCH\_START** \_IOW(RTIOC\_TYPE\_TESTING, 0x10, struct rttst\_tmbench\_config)
- #define **RTTST\_RTIOC\_TMBENCH\_STOP** \_IOWR(RTIOC\_TYPE\_TESTING, 0x11, struct rttst\_overall\_bench\_res)
- #define **RTTST\_RTIOC\_IRQBENCH\_START** \_IOW(RTIOC\_TYPE\_TESTING, 0x20, struct rttst\_irqbench\_config)
- #define **RTTST\_RTIOC\_IRQBENCH\_STOP** \_IO(RTIOC\_TYPE\_TESTING, 0x21)
- #define **RTTST\_RTIOC\_IRQBENCH\_GET\_STATS** \_IOR(RTIOC\_TYPE\_TESTING, 0x22, struct rttst\_irqbench\_stats)
- #define **RTTST\_RTIOC\_IRQBENCH\_WAIT\_IRQ** \_IO(RTIOC\_TYPE\_TESTING, 0x23)
- #define **RTTST\_RTIOC\_IRQBENCH\_REPLY\_IRQ** \_IO(RTIOC\_TYPE\_TESTING, 0x24)
- #define **RTTST\_RTIOC\_SWTEST\_SET\_TASKS\_COUNT** \_IOW(RTIOC\_TYPE\_TESTING, 0x30, unsigned long)
- #define **RTTST\_RTIOC\_SWTEST\_SET\_CPU** \_IOW(RTIOC\_TYPE\_TESTING, 0x31, unsigned long)
- #define **RTTST\_RTIOC\_SWTEST\_REGISTER\_UTASK** \_IOW(RTIOC\_TYPE\_TESTING, 0x32, struct rttst\_swtest\_task)
- #define **RTTST\_RTIOC\_SWTEST\_CREATE\_KTASK** \_IOWR(RTIOC\_TYPE\_TESTING, 0x33, struct rttst\_swtest\_task)
- #define **RTTST\_RTIOC\_SWTEST\_PEND** \_IOR(RTIOC\_TYPE\_TESTING, 0x34, struct rttst\_swtest\_task)
- #define **RTTST\_RTIOC\_SWTEST\_SWITCH\_TO** \_IOR(RTIOC\_TYPE\_TESTING, 0x35, struct rttst\_swtest\_dir)
- #define **RTTST\_RTIOC\_SWTEST\_GET\_SWITCHES\_COUNT** \_IOR(RTIOC\_TYPE\_TESTING, 0x36, unsigned long)
- #define **RTTST\_RTIOC\_SWTEST\_GET\_LAST\_ERROR** \_IOR(RTIOC\_TYPE\_TESTING, 0x37, struct rttst\_swtest\_error)
- #define **RTTST\_RTIOC\_SWTEST\_SET\_PAUSE** \_IOW(RTIOC\_TYPE\_TESTING, 0x38, unsigned long)

### 7.5.1 Detailed Description

Real-Time Driver Model for Xenomai, testing device profile header.

**Note:**

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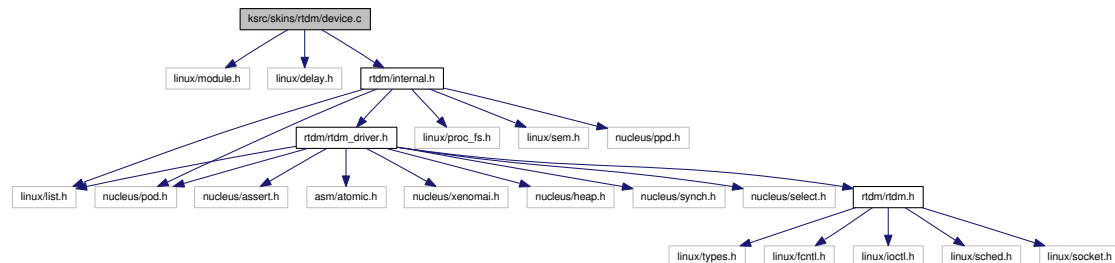
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## 7.6 ksrc/skins/rtdm/device.c File Reference

Real-Time Driver Model for Xenomai, device management.

Include dependency graph for device.c:



### Functions

- `int rtdm_dev_register` (struct `rtdm_device` \*device)  
Register a RTDM device.
- `int rtdm_dev_unregister` (struct `rtdm_device` \*device, unsigned int poll\_delay)  
Unregisters a RTDM device.

### 7.6.1 Detailed Description

Real-Time Driver Model for Xenomai, device management.

#### Note:

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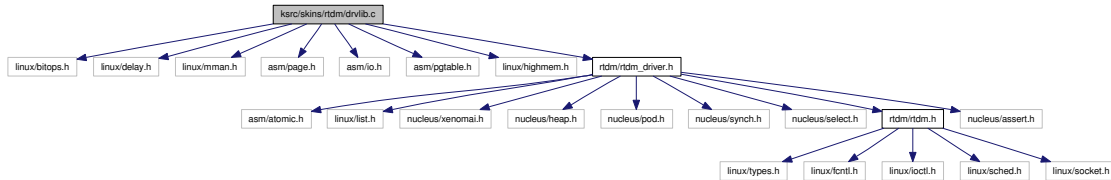
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## 7.7 ksrc/skins/rtdm/drvlib.c File Reference

Real-Time Driver Model for Xenomai, driver library.

Include dependency graph for drvlib.c:



### Functions

- [nanosecs\\_abs\\_t rtdm\\_clock\\_read](#) (void)  
*Get system time.*
- [nanosecs\\_abs\\_t rtdm\\_clock\\_read\\_monotonic](#) (void)  
*Get monotonic time.*
- [int rtdm\\_task\\_init](#) (rtdm\_task\_t \*task, const char \*name, [rtdm\\_task\\_proc\\_t](#) task\_proc, void \*arg, int priority, [nanosecs\\_rel\\_t](#) period)  
*Initialise and start a real-time task.*
- [void rtdm\\_task\\_destroy](#) (rtdm\_task\_t \*task)  
*Destroy a real-time task.*
- [void rtdm\\_task\\_set\\_priority](#) (rtdm\_task\_t \*task, int priority)  
*Adjust real-time task priority.*
- [int rtdm\\_task\\_set\\_period](#) (rtdm\_task\_t \*task, [nanosecs\\_rel\\_t](#) period)  
*Adjust real-time task period.*
- [int rtdm\\_task\\_wait\\_period](#) (void)  
*Wait on next real-time task period.*
- [int rtdm\\_task\\_unblock](#) (rtdm\_task\_t \*task)  
*Activate a blocked real-time task.*
- [rtdm\\_task\\_t \\* rtdm\\_task\\_current](#) (void)  
*Get current real-time task.*
- [int rtdm\\_task\\_sleep](#) ([nanosecs\\_rel\\_t](#) delay)  
*Sleep a specified amount of time.*
- [int rtdm\\_task\\_sleep\\_until](#) ([nanosecs\\_abs\\_t](#) wakeup\_time)  
*Sleep until a specified absolute time.*
- [int rtdm\\_task\\_sleep\\_abs](#) ([nanosecs\\_abs\\_t](#) wakeup\_time, enum [rtdm\\_timer\\_mode](#) mode)

*Sleep until a specified absolute time.*

- void `rtdm_task_join_nrt` (rtdm\_task\_t \*task, unsigned int poll\_delay)  
*Wait on a real-time task to terminate.*
- void `rtdm_task_busy_sleep` (nanosecs\_rel\_t delay)  
*Busy-wait a specified amount of time.*
- int `rtdm_timer_init` (rtdm\_timer\_t \*timer, rtdm\_timer\_handler\_t handler, const char \*name)  
*Initialise a timer.*
- void `rtdm_timer_destroy` (rtdm\_timer\_t \*timer)  
*Destroy a timer.*
- int `rtdm_timer_start` (rtdm\_timer\_t \*timer, nanosecs\_abs\_t expiry, nanosecs\_rel\_t interval, enum rtdm\_timer\_mode mode)  
*Start a timer.*
- void `rtdm_timer_stop` (rtdm\_timer\_t \*timer)  
*Stop a timer.*
- int `rtdm_timer_start_in_handler` (rtdm\_timer\_t \*timer, nanosecs\_abs\_t expiry, nanosecs\_rel\_t interval, enum rtdm\_timer\_mode mode)  
*Start a timer from inside a timer handler.*
- void `rtdm_timer_stop_in_handler` (rtdm\_timer\_t \*timer)  
*Stop a timer from inside a timer handler.*
- int `rtdm_irq_request` (rtdm\_irq\_t \*irq\_handle, unsigned int irq\_no, rtdm\_irq\_handler\_t handler, unsigned long flags, const char \*device\_name, void \*arg)  
*Register an interrupt handler.*
- int `rtdm_irq_free` (rtdm\_irq\_t \*irq\_handle)  
*Release an interrupt handler.*
- int `rtdm_irq_enable` (rtdm\_irq\_t \*irq\_handle)  
*Enable interrupt line.*
- int `rtdm_irq_disable` (rtdm\_irq\_t \*irq\_handle)  
*Disable interrupt line.*
- int `rtdm_nrtsig_init` (rtdm\_nrtsig\_t \*nrt\_sig, rtdm\_nrtsig\_handler\_t handler, void \*arg)  
*Register a non-real-time signal handler.*
- void `rtdm_nrtsig_destroy` (rtdm\_nrtsig\_t \*nrt\_sig)  
*Release a non-realtime signal handler.*
- void `rtdm_nrtsig_pend` (rtdm\_nrtsig\_t \*nrt\_sig)  
*Trigger non-real-time signal.*

- `int rtdm_mmap_to_user` (`rtdm_user_info_t *user_info`, `void *src_addr`, `size_t len`, `int prot`, `void **pptr`, `struct vm_operations_struct *vm_ops`, `void *vm_private_data`)  
*Map a kernel memory range into the address space of the user.*
- `int rtdm_iomap_to_user` (`rtdm_user_info_t *user_info`, `unsigned long src_addr`, `size_t len`, `int prot`, `void **pptr`, `struct vm_operations_struct *vm_ops`, `void *vm_private_data`)  
*Map an I/O memory range into the address space of the user.*
- `int rtdm_munmap` (`rtdm_user_info_t *user_info`, `void *ptr`, `size_t len`)  
*Unmap a user memory range.*
- `void rtdm_printk` (`const char *format`,...)  
*Real-time safe message printing on kernel console.*
- `void * rtdm_malloc` (`size_t size`)  
*Allocate memory block in real-time context.*
- `void rtdm_free` (`void *ptr`)  
*Release real-time memory block.*
- `int rtdm_read_user_ok` (`rtdm_user_info_t *user_info`, `const void __user *ptr`, `size_t size`)  
*Check if read access to user-space memory block is safe.*
- `int rtdm_rw_user_ok` (`rtdm_user_info_t *user_info`, `const void __user *ptr`, `size_t size`)  
*Check if read/write access to user-space memory block is safe.*
- `int rtdm_copy_from_user` (`rtdm_user_info_t *user_info`, `void *dst`, `const void __user *src`, `size_t size`)  
*Copy user-space memory block to specified buffer.*
- `int rtdm_safe_copy_from_user` (`rtdm_user_info_t *user_info`, `void *dst`, `const void __user *src`, `size_t size`)  
*Check if read access to user-space memory block and copy it to specified buffer.*
- `int rtdm_copy_to_user` (`rtdm_user_info_t *user_info`, `void __user *dst`, `const void *src`, `size_t size`)  
*Copy specified buffer to user-space memory block.*
- `int rtdm_safe_copy_to_user` (`rtdm_user_info_t *user_info`, `void __user *dst`, `const void *src`, `size_t size`)  
*Check if read/write access to user-space memory block is safe and copy specified buffer to it.*
- `int rtdm_strncpy_from_user` (`rtdm_user_info_t *user_info`, `char *dst`, `const char __user *src`, `size_t count`)  
*Copy user-space string to specified buffer.*
- `int rtdm_in_rt_context` (`void`)  
*Test if running in a real-time task.*



## Timeout Sequence Management

- void `rtdm_toseq_init` (rtdm\_toseq\_t \*timeout\_seq, nanosecs\_rel\_t timeout)  
*Initialise a timeout sequence.*

## Event Services

- void `rtdm_event_init` (rtdm\_event\_t \*event, unsigned long pending)  
*Initialise an event.*
- void `rtdm_event_destroy` (rtdm\_event\_t \*event)  
*Destroy an event.*
- void `rtdm_event_pulse` (rtdm\_event\_t \*event)  
*Signal an event occurrence to currently listening waiters.*
- void `rtdm_event_signal` (rtdm\_event\_t \*event)  
*Signal an event occurrence.*
- int `rtdm_event_wait` (rtdm\_event\_t \*event)  
*Wait on event occurrence.*
- int `rtdm_event_timedwait` (rtdm\_event\_t \*event, nanosecs\_rel\_t timeout, rtdm\_toseq\_t \*timeout\_seq)  
*Wait on event occurrence with timeout.*
- void `rtdm_event_clear` (rtdm\_event\_t \*event)  
*Clear event state.*
- int `rtdm_event_select_bind` (rtdm\_event\_t \*event, rtdm\_selector\_t \*selector, enum rtdm\_selecttype type, unsigned fd\_index)  
*Bind a selector to an event.*

## Semaphore Services

- void `rtdm_sem_init` (rtdm\_sem\_t \*sem, unsigned long value)  
*Initialise a semaphore.*
- void `rtdm_sem_destroy` (rtdm\_sem\_t \*sem)  
*Destroy a semaphore.*
- int `rtdm_sem_down` (rtdm\_sem\_t \*sem)  
*Decrement a semaphore.*
- int `rtdm_sem_timeddown` (rtdm\_sem\_t \*sem, nanosecs\_rel\_t timeout, rtdm\_toseq\_t \*timeout\_seq)  
*Decrement a semaphore with timeout.*
- void `rtdm_sem_up` (rtdm\_sem\_t \*sem)  
*Increment a semaphore.*
- int `rtdm_sem_select_bind` (rtdm\_sem\_t \*sem, rtdm\_selector\_t \*selector, enum rtdm\_selecttype type, unsigned fd\_index)

*Bind a selector to a semaphore.*

### Mutex Services

- void [rtdm\\_mutex\\_init](#) (rtdm\_mutex\_t \*mutex)  
*Initialise a mutex.*
- void [rtdm\\_mutex\\_destroy](#) (rtdm\_mutex\_t \*mutex)  
*Destroy a mutex.*
- void [rtdm\\_mutex\\_unlock](#) (rtdm\_mutex\_t \*mutex)  
*Release a mutex.*
- int [rtdm\\_mutex\\_lock](#) (rtdm\_mutex\_t \*mutex)  
*Request a mutex.*
- int [rtdm\\_mutex\\_timedlock](#) (rtdm\_mutex\_t \*mutex, [nanosecs\\_rel\\_t](#) timeout, rtdm\_toseq\_t \*timeout\_seq)  
*Request a mutex with timeout.*

## 7.7.1 Detailed Description

Real-Time Driver Model for Xenomai, driver library.

### Note:

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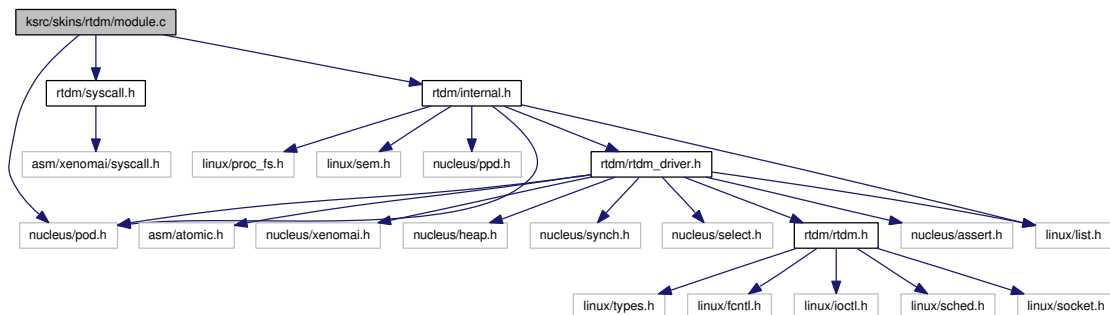
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## 7.8 ksrc/skins/rtdm/module.c File Reference

Real-Time Driver Model for Xenomai.

Include dependency graph for module.c:



### 7.8.1 Detailed Description

Real-Time Driver Model for Xenomai.

#### Note:

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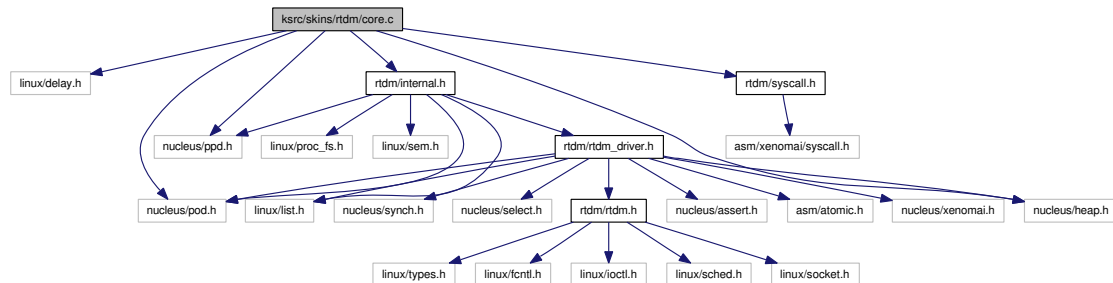
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## 7.9 ksrc/skins/rtdm/core.c File Reference

Real-Time Driver Model for Xenomai, device operation multiplexing.

Include dependency graph for core.c:



### Functions

- struct [rtdm\\_dev\\_context](#) \* [rtdm\\_context\\_get](#) (int fd)  
*Resolve file descriptor to device context.*
- int [rtdm\\_select\\_bind](#) (int fd, rtdm\_selector\_t \*selector, enum [rtdm\\_selecttype](#) type, unsigned fd\_index)  
*Bind a selector to specified event types of a given file descriptor.*
- void [rtdm\\_context\\_lock](#) (struct [rtdm\\_dev\\_context](#) \*context)  
*Increment context reference counter.*
- void [rtdm\\_context\\_unlock](#) (struct [rtdm\\_dev\\_context](#) \*context)  
*Decrement context reference counter.*
- int [rtdm\\_open](#) (const char \*path, int oflag,...)  
*Open a device.*
- int [rtdm\\_socket](#) (int protocol\_family, int socket\_type, int protocol)  
*Create a socket.*
- int [rtdm\\_close](#) (int fd)  
*Close a device or socket.*
- int [rtdm\\_ioctl](#) (int fd, int request,...)  
*Issue an IOCTL.*
- ssize\_t [rtdm\\_read](#) (int fd, void \*buf, size\_t nbyte)  
*Read from device.*
- ssize\_t [rtdm\\_write](#) (int fd, const void \*buf, size\_t nbyte)  
*Write to device.*
- ssize\_t [rtdm\\_recvmmsg](#) (int fd, struct msghdr \*msg, int flags)

*Receive message from socket.*

- `ssize_t rtdm_recvfrom` (int fd, void \*buf, size\_t len, int flags, struct sockaddr \*from, socklen\_t \*fromlen)

*Receive message from socket.*

- `ssize_t rtdm_recv` (int fd, void \*buf, size\_t len, int flags)

*Receive message from socket.*

- `ssize_t rtdm_sendmsg` (int fd, const struct msghdr \*msg, int flags)

*Transmit message to socket.*

- `ssize_t rtdm_sendto` (int fd, const void \*buf, size\_t len, int flags, const struct sockaddr \*to, socklen\_t tolen)

*Transmit message to socket.*

- `ssize_t rtdm_send` (int fd, const void \*buf, size\_t len, int flags)

*Transmit message to socket.*

- `int rtdm_bind` (int fd, const struct sockaddr \*my\_addr, socklen\_t addrlen)

*Bind to local address.*

- `int rtdm_connect` (int fd, const struct sockaddr \*serv\_addr, socklen\_t addrlen)

*Connect to remote address.*

- `int rtdm_listen` (int fd, int backlog)

*Listen for incoming connection requests.*

- `int rtdm_accept` (int fd, struct sockaddr \*addr, socklen\_t \*addrlen)

*Accept a connection requests.*

- `int rtdm_shutdown` (int fd, int how)

*Shut down parts of a connection.*

- `int rtdm_getsockopt` (int fd, int level, int optname, void \*optval, socklen\_t \*optlen)

*Get socket option.*

- `int rtdm_setsockopt` (int fd, int level, int optname, const void \*optval, socklen\_t optlen)

*Set socket option.*

- `int rtdm_getsockname` (int fd, struct sockaddr \*name, socklen\_t \*namelen)

*Get local socket address.*

- `int rtdm_getpeername` (int fd, struct sockaddr \*name, socklen\_t \*namelen)

*Get socket destination address.*

- `int rt_dev_open` (const char \*path, int oflag,...)

*Open a device.*

- `int rt_dev_socket` (int protocol\_family, int socket\_type, int protocol)

*Create a socket.*

- `int rt_dev_close (int fd)`  
*Close a device or socket.*
- `int rt_dev_ioctl (int fd, int request,...)`  
*Issue an IOCTL.*
- `ssize_t rt_dev_read (int fd, void *buf, size_t nbyte)`  
*Read from device.*
- `ssize_t rt_dev_write (int fd, const void *buf, size_t nbyte)`  
*Write to device.*
- `ssize_t rt_dev_recvmsg (int fd, struct msghdr *msg, int flags)`  
*Receive message from socket.*
- `ssize_t rt_dev_recvfrom (int fd, void *buf, size_t len, int flags, struct sockaddr *from, socklen_t *fromlen)`  
*Receive message from socket.*
- `ssize_t rt_dev_recv (int fd, void *buf, size_t len, int flags)`  
*Receive message from socket.*
- `ssize_t rt_dev_sendmsg (int fd, const struct msghdr *msg, int flags)`  
*Transmit message to socket.*
- `ssize_t rt_dev_sendto (int fd, const void *buf, size_t len, int flags, const struct sockaddr *to, socklen_t tolen)`  
*Transmit message to socket.*
- `ssize_t rt_dev_send (int fd, const void *buf, size_t len, int flags)`  
*Transmit message to socket.*
- `int rt_dev_bind (int fd, const struct sockaddr *my_addr, socklen_t addrlen)`  
*Bind to local address.*
- `int rt_dev_connect (int fd, const struct sockaddr *serv_addr, socklen_t addrlen)`  
*Connect to remote address.*
- `int rt_dev_listen (int fd, int backlog)`  
*Listen for incoming connection requests.*
- `int rt_dev_accept (int fd, struct sockaddr *addr, socklen_t *addrlen)`  
*Accept a connection requests.*
- `int rt_dev_shutdown (int fd, int how)`  
*Shut down parts of a connection.*
- `int rt_dev_getsockopt (int fd, int level, int optname, void *optval, socklen_t *optlen)`

*Get socket option.*

- int [rt\\_dev\\_setsockopt](#) (int fd, int level, int optname, const void \*optval, socklen\_t optlen)

*Set socket option.*

- int [rt\\_dev\\_getsockname](#) (int fd, struct sockaddr \*name, socklen\_t \*namelen)

*Get local socket address.*

- int [rt\\_dev\\_getpeername](#) (int fd, struct sockaddr \*name, socklen\_t \*namelen)

*Get socket destination address.*

### 7.9.1 Detailed Description

Real-Time Driver Model for Xenomai, device operation multiplexing.

**Note:**

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# Chapter 8

## Example Documentation

### 8.1 cross-link.c

```
/*
 * cross-link.c
 *
 * Userspace test program (Xenomai native skin) for RTDM-based UART drivers
 * Copyright 2005 by Joerg Langenberg <joergel75@gmx.net>
 *
 * Updates by Jan Kiszka <jan.kiszka@web.de>
 *
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 * along with this program; if not, write to the Free Software
 * Foundation, Inc., 675 Mass Ave, Cambridge, MA 02139, USA.
 */
#include <stdio.h>
#include <signal.h>
#include <unistd.h>
#include <sys/mman.h>

#include <native/task.h>
#include <native/timer.h>

#include <rtdm/rtserial.h>

#define MAIN_PREFIX    "main : "
#define WTASK_PREFIX   "write_task: "
#define RTASK_PREFIX   "read_task: "

#define WRITE_FILE      "rtser0"
#define READ_FILE       "rtser1"

int read_fd  = -1;
int write_fd = -1;

#define STATE_FILE_OPENED      1
#define STATE_TASK_CREATED    2
```

```

unsigned int read_state = 0;
unsigned int write_state = 0;

/*          --s-ms-us-ns */
RTIME write_task_period_ns = 100000000llu;
RT_TASK write_task;
RT_TASK read_task;

static const struct rtser_config read_config = {
    .config_mask      = 0xFFFF,
    .baud_rate        = 115200,
    .parity            = RTSER_DEF_PARITY,
    .data_bits         = RTSER_DEF_BITS,
    .stop_bits         = RTSER_DEF_STOPB,
    .handshake         = RTSER_DEF_HAND,
    .fifo_depth        = RTSER_DEF_FIFO_DEPTH,
    .rx_timeout        = RTSER_DEF_TIMEOUT,
    .tx_timeout        = RTSER_DEF_TIMEOUT,
    .event_timeout     = 1000000000, /* 1 s */
    .timestamp_history = RTSER_RX_TIMESTAMP_HISTORY,
    .event_mask        = RTSER_EVENT_RXPEND,
};

static const struct rtser_config write_config = {
    .config_mask      = RTSER_SET_BAUD | RTSER_SET_TIMESTAMP_HISTORY,
    .baud_rate        = 115200,
    .timestamp_history = RTSER_DEF_TIMESTAMP_HISTORY,
    /* the rest implicitly remains default */
};

static int close_file( int fd, char *name)
{
    int err, i=0;

    do {
        i++;
        err = rt_dev_close(fd);
        switch (err) {
            case -EAGAIN:
                printf(MAIN_PREFIX "%s -> EAGAIN (%d times)\n",
                    name, i);
                rt_task_sleep(50000); /* wait 50us */
                break;
            case 0:
                printf(MAIN_PREFIX "%s -> closed\n", name);
                break;
            default:
                printf(MAIN_PREFIX "%s -> %s\n", name,
                    strerror(-err));
                break;
        }
    } while (err == -EAGAIN && i < 10);

    return err;
}

void cleanup_all(void)
{
    if (read_state & STATE_FILE_OPENED) {
        close_file(read_fd, READ_FILE " (read)");
        read_state &= ~STATE_FILE_OPENED;
    }

    if (write_state & STATE_FILE_OPENED) {
        close_file(write_fd, WRITE_FILE " (write)");
        write_state &= ~STATE_FILE_OPENED;
    }
}

```

```

    }

    if (write_state & STATE_TASK_CREATED) {
        printf(MAIN_PREFIX "delete write_task\n");
        rt_task_delete(&write_task);
        write_state &= ~STATE_TASK_CREATED;
    }

    if (read_state & STATE_TASK_CREATED) {
        printf(MAIN_PREFIX "delete read_task\n");
        rt_task_delete(&read_task);
        read_state &= ~STATE_TASK_CREATED;
    }
}

void catch_signal(int sig)
{
    cleanup_all();
    printf(MAIN_PREFIX "exit\n");
    return;
}

void write_task_proc(void *arg)
{
    int err;
    RTIME write_time;
    ssize_t sz = sizeof(RTIME);
    ssize_t written = 0;

    err = rt_task_set_periodic(NULL, TM_NOW,
                               rt_timer_ns2ticks(write_task_period_ns));
    if (err) {
        printf(WTASK_PREFIX "error on set periodic, %s\n",
               strerror(-err));
        goto exit_write_task;
    }

    while (1) {
        err = rt_task_wait_period(NULL);
        if (err) {
            printf(WTASK_PREFIX
                   "error on rt_task_wait_period, %s\n",
                   strerror(-err));
            break;
        }

        write_time = rt_timer_read();

        written = rt_dev_write(write_fd, &write_time, sz);
        if (written < 0) {
            printf(WTASK_PREFIX "error on rt_dev_write, %s\n",
                   strerror(-err));
            break;
        } else if (written != sz) {
            printf(WTASK_PREFIX "only %d / %d byte transmitted\n",
                   written, sz);
            break;
        }
    }

    exit_write_task:
    if ((write_state & STATE_FILE_OPENED) &&
        close_file(write_fd, WRITE_FILE " (write)") == 0)
        write_state &= ~STATE_FILE_OPENED;

    printf(WTASK_PREFIX "exit\n");
}

```

```

void read_task_proc(void *arg)
{
    int err;
    int nr = 0;
    RTIME read_time = 0;
    RTIME write_time = 0;
    RTIME irq_time = 0;
    ssize_t sz = sizeof(RTIME);
    ssize_t read = 0;
    struct rtser_event rx_event;

    printf(" Nr |   write->irq   |   irq->read   |   write->read   |\n");
    printf("-----\n");

    /*
     * We are in secondary mode now due to printf, the next
     * blocking Xenomai or driver call will switch us back
     * (here: RTSER_RTIOC_WAIT_EVENT).
     */

    while (1) {
        /* waiting for event */
        err = rt_dev_ioctl(read_fd, RTSER_RTIOC_WAIT_EVENT, &rx_event);
        if (err) {
            printf(RTASK_PREFIX
                   "error on RTSER_RTIOC_WAIT_EVENT, %s\n",
                   strerror(-err));
            if (err == -ETIMEDOUT)
                continue;
            break;
        }

        irq_time = rx_event.rxspond_timestamp;
        read = rt_dev_read(read_fd, &write_time, sz);
        if (read == sz) {
            read_time = rt_timer_read();
            printf("%3d |%16llu |%16llu |%16llu\n", nr,
                   irq_time - write_time,
                   read_time - irq_time,
                   read_time - write_time);
            nr++;
        } else if (read < 0) {
            printf(RTASK_PREFIX "error on rt_dev_read, code %s\n",
                   strerror(-err));
            break;
        } else {
            printf(RTASK_PREFIX "only %d / %d byte received \n",
                   read, sz);
            break;
        }
    }

    if ((read_state & STATE_FILE_OPENED) &&
        close_file(read_fd, READ_FILE " (read)") == 0)
        read_state &= ~STATE_FILE_OPENED;

    printf(RTASK_PREFIX "exit\n");
}

int main(int argc, char* argv[])
{
    int err = 0;

    signal(SIGTERM, catch_signal);
    signal(SIGINT, catch_signal);

```

```

/* no memory-swapping for this program */
mlockall(MCL_CURRENT | MCL_FUTURE);

/* open rtser0 */
write_fd = rt_dev_open( WRITE_FILE, 0);
if (write_fd < 0) {
    printf(MAIN_PREFIX "can't open %s (write), %s\n", WRITE_FILE,
           strerror(-write_fd));
    goto error;
}
write_state |= STATE_FILE_OPENED;
printf(MAIN_PREFIX "write-file opened\n");

/* writing write-config */
err = rt_dev_ioctl(write_fd, RTSER_RTIOC_SET_CONFIG, &write_config);
if (err) {
    printf(MAIN_PREFIX "error while RTSER_RTIOC_SET_CONFIG, %s\n",
           strerror(-err));
    goto error;
}
printf(MAIN_PREFIX "write-config written\n");

/* open rtser1 */
read_fd = rt_dev_open( READ_FILE, 0 );
if (read_fd < 0) {
    printf(MAIN_PREFIX "can't open %s (read), %s\n", READ_FILE,
           strerror(-read_fd));
    goto error;
}
read_state |= STATE_FILE_OPENED;
printf(MAIN_PREFIX "read-file opened\n");

/* writing read-config */
err = rt_dev_ioctl(read_fd, RTSER_RTIOC_SET_CONFIG, &read_config);
if (err) {
    printf(MAIN_PREFIX "error while rt_dev_ioctl, %s\n",
           strerror(-err));
    goto error;
}
printf(MAIN_PREFIX "read-config written\n");

/* create write_task */
err = rt_task_create(&write_task, "write_task", 0, 50, 0);
if (err) {
    printf(MAIN_PREFIX "failed to create write_task, %s\n",
           strerror(-err));
    goto error;
}
write_state |= STATE_TASK_CREATED;
printf(MAIN_PREFIX "write-task created\n");

/* create read_task */
err = rt_task_create(&read_task, "read_task", 0, 51, 0);
if (err) {
    printf(MAIN_PREFIX "failed to create read_task, %s\n",
           strerror(-err));
    goto error;
}
read_state |= STATE_TASK_CREATED;
printf(MAIN_PREFIX "read-task created\n");

/* start write_task */
printf(MAIN_PREFIX "starting write-task\n");
err = rt_task_start(&write_task, &write_task_proc, NULL);
if (err) {
    printf(MAIN_PREFIX "failed to start write_task, %s\n",
           strerror(-err));
}

```

```
        goto error;
    }

    /* start read_task */
    printf(MAIN_PREFIX "starting read-task\n");
    err = rt_task_start(&read_task,&read_task_proc,NULL);
    if (err) {
        printf(MAIN_PREFIX "failed to start read_task, %s\n",
               strerror(-err));
        goto error;
    }

    pause();
    return 0;

error:
    cleanup_all();
    return err;
}
```

## 8.2 rtcan\_rtt.c

```

/*
 * Round-Trip-Time Test - sends and receives messages and measures the
 *                        time in between.
 *
 * Copyright (C) 2006 Wolfgang Grandegger <wg@grandegger.com>
 *
 * Based on RTnet's examples/xenomai/posix/rtt-sender.c.
 *
 * Copyright (C) 2002 Ulrich Marx <marx@kammer.uni-hannover.de>
 *                2002 Marc Kleine-Budde <kleine-budde@gmx.de>
 *                2006 Jan Kiszka <jan.kiszka@web.de>
 *
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 * Foundation, Inc., 675 Mass Ave, Cambridge, MA 02139, USA.
 *
 * The program sends out CAN messages periodically and copies the current
 * time-stamp to the payload. At reception, that time-stamp is compared
 * with the current time to determine the round-trip time. The jitter
 * values are printed out regularly. Concurrent tests can be carried out
 * by starting the program with different message identifiers. It is also
 * possible to use this program on a remote system as simple repeater to
 * loopback messages.
 */

#include <errno.h>
#include <mqueue.h>
#include <signal.h>
#include <pthread.h>
#include <stdio.h>
#include <stdlib.h>
#include <string.h>
#include <unistd.h>
#include <limits.h>
#include <getopt.h>
#include <netinet/in.h>
#include <sys/mman.h>

#include <rtcm/rtdm.h>

#define NSEC_PER_SEC 1000000000

static unsigned int cycle = 10000; /* 10 ms */
static can_id_t can_id = 0x1;

static pthread_t txthread, rxthread;
static int txsock, rxsock;
static mqd_t mq;
static int txcount, rxcount;
static int overruns;
static int repeater;

struct rtt_stat {
    long long rtt;

```

```

    long long rtt_min;
    long long rtt_max;
    long long rtt_sum;
    long long rtt_sum_last;
    int counts_per_sec;
};

static void print_usage(char *prg)
{
    fprintf(stderr,
        "Usage: %s [Options] <tx-can-interface> <rx-can-interface>\n"
        "Options:\n"
        "  -h, --help      This help\n"
        "  -r, --repeater Repeater, send back received messages\n"
        "  -i, --id=ID     CAN Identifier (default = 0x1)\n"
        "  -c, --cycle     Cycle time in us (default = 10000us)\n",
        prg);
}

void *transmitter(void *arg)
{
    struct sched_param param = { .sched_priority = 80 };
    struct timespec next_period;
    struct timespec time;
    struct can_frame frame;
    long long *rtt_time = (long long *)&frame.data;

    /* Pre-fill CAN frame */
    frame.can_id = can_id;
    frame.can_dlc = sizeof(*rtt_time);

    pthread_setschedparam(pthread_self(), SCHED_FIFO, &param);

    clock_gettime(CLOCK_MONOTONIC, &next_period);

    while(1) {
        next_period.tv_nsec += cycle * 1000;
        while (next_period.tv_nsec >= NSEC_PER_SEC) {
            next_period.tv_nsec -= NSEC_PER_SEC;
            next_period.tv_sec++;
        }

        clock_nanosleep(CLOCK_MONOTONIC, TIMER_ABSTIME, &next_period, NULL);

        if (rxcount != txcount) {
            overruns++;
            continue;
        }

        clock_gettime(CLOCK_MONOTONIC, &time);
        *rtt_time = time.tv_sec * NSEC_PER_SEC + time.tv_nsec;

        /* Transmit the message containing the local time */
        if (send(txsock, (void *)&frame, sizeof(can_frame_t), 0) < 0) {
            if (errno == EBADF)
                printf("terminating transmitter thread\n");
            else
                perror("send failed");
            return NULL;
        }
        txcount++;
    }
}

void *receiver(void *arg)
{

```



```

struct sched_param param = { .sched_priority = 82 };
struct timespec time;
struct can_frame frame;
long long *rtt_time = (long long *)frame.data;
struct rtt_stat rtt_stat = {0, 1000000000000000LL, -1000000000000000LL,
                          0, 0, 0};
pthread_setschedparam(pthread_self(), SCHED_FIFO, &param);

rtt_stat.counts_per_sec = 1000000 / cycle;

while (1) {
    if (recv(rxsock, (void *)&frame, sizeof(can_frame_t), 0) < 0) {
        if (errno == EBADF)
            printf("terminating receiver thread\n");
        else
            perror("recv failed");
        return NULL;
    }
    if (repeater) {
        /* Transmit the message back as is */
        if (send(txsock, (void *)&frame, sizeof(can_frame_t), 0) < 0) {
            if (errno == EBADF)
                printf("terminating transmitter thread\n");
            else
                perror("send failed");
            return NULL;
        }
        txcount++;
    } else {
        clock_gettime(CLOCK_MONOTONIC, &time);
        if (rxcount > 0) {
            rtt_stat.rtt = (time.tv_sec * 1000000000LL +
                          time.tv_nsec - *rtt_time);
            rtt_stat.rtt_sum += rtt_stat.rtt;
            if (rtt_stat.rtt < rtt_stat.rtt_min)
                rtt_stat.rtt_min = rtt_stat.rtt;
            if (rtt_stat.rtt > rtt_stat.rtt_max)
                rtt_stat.rtt_max = rtt_stat.rtt;
        }
        rxcount++;

        if ((rxcount % rtt_stat.counts_per_sec) == 0) {
            mq_send(mq, (char *)&rtt_stat, sizeof(rtt_stat), 0);
            rtt_stat.rtt_sum_last = rtt_stat.rtt_sum;
        }
    }
}

void catch_signal(int sig)
{
    mq_close(mq);
}

int main(int argc, char *argv[])
{
    struct sched_param param = { .sched_priority = 1 };
    pthread_attr_t thattr;
    struct mq_attr mqattr;
    struct sockaddr_can rxaddr, txaddr;
    struct can_filter rxfilter[1];
    struct rtt_stat rtt_stat;
    char mqname[32];
    char *txdev, *rxdev;
    struct ifreq ifr;
    int ret, opt;

```

```

struct option long_options[] = {
    { "id", required_argument, 0, 'i'},
    { "cycle", required_argument, 0, 'c'},
    { "repeater", required_argument, 0, 'r'},
    { "help", no_argument, 0, 'h'},
    { 0, 0, 0, 0},
};

while ((opt = getopt_long(argc, argv, "hri:c:",
                          long_options, NULL)) != -1) {
    switch (opt) {
    case 'c':
        cycle = atoi(optarg);
        break;

    case 'i':
        can_id = strtoul(optarg, NULL, 0);
        break;

    case 'r':
        repeater = 1;
        break;

    default:
        fprintf(stderr, "Unknown option %c\n", opt);
    case 'h':
        print_usage(argv[0]);
        exit(-1);
    }
}

printf("%d %d\n", optind, argc);
if (optind + 2 != argc) {
    print_usage(argv[0]);
    exit(0);
}

txdev = argv[optind];
rxdev = argv[optind + 1];

/* Create and configure RX socket */
if ((rxsock = socket(PF_CAN, SOCK_RAW, CAN_RAW)) < 0) {
    perror("RX socket failed");
    return -1;
}

strncpy(ifr.ifr_name, rxdev, IFNAMSIZ);
printf("RX rxsock=%d, ifr_name=%s\n", rxsock, ifr.ifr_name);

if (ioctl(rxsock, SIOCGIFINDEX, &ifr) < 0) {
    perror("RX ioctl SIOCGIFINDEX failed");
    goto failure1;
}

/* We only want to receive our own messages */
rxfilter[0].can_id = can_id;
rxfilter[0].can_mask = 0x3ff;
if (setsockopt(rxsock, SOL_CAN_RAW, CAN_RAW_FILTER,
              &rxfilter, sizeof(struct can_filter)) < 0) {
    perror("RX setsockopt CAN_RAW_FILTER failed");
    goto failure1;
}
memset(&rxaddr, 0, sizeof(rxaddr));
rxaddr.can_ifindex = ifr.ifr_ifindex;
rxaddr.can_family = AF_CAN;
if (bind(rxsock, (struct sockaddr *)&rxaddr, sizeof(rxaddr)) < 0) {

```

```

        perror("RX bind failed\n");
        goto failure1;
    }

    /* Create and configure TX socket */

    if (strcmp(rxdev, txdev) == 0) {
        txsock = rxsock;
    } else {
        if ((txsock = socket(PF_CAN, SOCK_RAW, 0)) < 0) {
            perror("TX socket failed");
            goto failure1;
        }

        strncpy(ifr.ifr_name, txdev, IFNAMSIZ);
        printf("TX txsock=%d, ifr_name=%s\n", txsock, ifr.ifr_name);

        if (ioctl(txsock, SIOCGIFINDEX, &ifr) < 0) {
            perror("TX ioctl SIOCGIFINDEX failed");
            goto failure2;
        }

        /* Suppress definition of a default receive filter list */
        if (setsockopt(txsock, SOL_CAN_RAW, CAN_RAW_FILTER, NULL, 0) < 0) {
            perror("TX setsockopt CAN_RAW_FILTER failed");
            goto failure2;
        }

        memset(&txaddr, 0, sizeof(txaddr));
        txaddr.can_ifindex = ifr.ifr_ifindex;
        txaddr.can_family = AF_CAN;

        if (bind(txsock, (struct sockaddr *)&txaddr, sizeof(txaddr)) < 0) {
            perror("TX bind failed\n");
            goto failure2;
        }
    }

    signal(SIGTERM, catch_signal);
    signal(SIGINT, catch_signal);
    signal(SIGHUP, catch_signal);
    mlockall(MCL_CURRENT|MCL_FUTURE);

    printf("Round-Trip-Time test %s -> %s with CAN ID 0x%x\n",
           argv[optind], argv[optind + 1], can_id);
    printf("Cycle time: %d us\n", cycle);
    printf("All RTT timing figures are in us.\n");

    /* Create statistics message queue */
    snprintf(mqname, sizeof(mqname), "/rtcan_rtt-%d", getpid());
    mqattr.mq_flags = 0;
    mqattr.mq_maxmsg = 100;
    mqattr.mq_msgsize = sizeof(struct rtt_stat);
    mq = mq_open(mqname, O_RDWR | O_CREAT | O_EXCL, 0600, &mqattr);
    if (mq == (mqd_t)-1) {
        perror("opening mqueue failed");
        goto failure2;
    }

    /* Create receiver RT-thread */
    pthread_attr_init(&thattr);
    pthread_attr_setdetachstate(&thattr, PTHREAD_CREATE_JOINABLE);
    pthread_attr_setstacksize(&thattr, PTHREAD_STACK_MIN);
    ret = pthread_create(&rxthread, &thattr, &receiver, NULL);
    if (ret) {
        fprintf(stderr, "%s: pthread_create(receiver) failed\n",
                strerror(-ret));
    }

```

```

    goto failure3;
}

if (!repeater) {
    /* Create transitter RT-thread */
    ret = pthread_create(&txthread, &thattr, &transmitter, NULL);
    if (ret) {
        fprintf(stderr, "%s: pthread_create(transmitter) failed\n",
                strerror(-ret));
        goto failure4;
    }
}

pthread_setschedparam(pthread_self(), SCHED_FIFO, &param);

if (repeater)
    printf("Messages\n");
else
    printf("Messages RTTlast RTT_avg RTT_min RTT_max Overruns\n");

while (1) {
    long long rtt_avg;

    ret = mq_receive(mq, (char *)&rtt_stat, sizeof(rtt_stat), NULL);
    if (ret != sizeof(rtt_stat)) {
        if (ret < 0) {
            if (errno == EBADF)
                printf("terminating mq_receive\n");
            else
                perror("mq_receive failed");
        } else
            fprintf(stderr,
                    "mq_receive returned invalid length %d\n", ret);
        break;
    }

    if (repeater) {
        printf("%8d\n", rxcount);
    } else {
        rtt_avg = ((rtt_stat.rtt_sum - rtt_stat.rtt_sum_last) /
                  rtt_stat.counts_per_sec);
        printf("%8d %7ld %7ld %7ld %7ld %8d\n", rxcount,
              (long)(rtt_stat.rtt / 1000), (long)(rtt_avg / 1000),
              (long)(rtt_stat.rtt_min / 1000),
              (long)(rtt_stat.rtt_max / 1000),
              overruns);
    }
}

/* This call also leaves primary mode, required for socket cleanup. */
printf("shutting down\n");

/* Important: First close the sockets! */
while ((close(rxsock) < 0) && (errno == EAGAIN)) {
    printf("RX socket busy - waiting...\n");
    sleep(1);
}
while ((close(txsock) < 0) && (errno == EAGAIN)) {
    printf("TX socket busy - waiting...\n");
    sleep(1);
}

pthread_join(txthread, NULL);
pthread_kill(rxthread, SIGHUP);
pthread_join(rxthread, NULL);

return 0;

```

```
failure4:
    pthread_kill(rxthread, SIGHUP);
    pthread_join(rxthread, NULL);
failure3:
    mq_close(mq);
failure2:
    close(txsock);
failure1:
    close(rxsock);

    return 1;
}
```

## 8.3 rtcanconfig.c

```

/*
 * Program to configuring the CAN controller
 *
 * Copyright (C) 2006 Wolfgang Grandegger <wg@grandegger.com>
 *
 * Copyright (C) 2005, 2006 Sebastian Smolorz
 *                               <Sebastian.Smolorz@stud.uni-hannover.de>
 *
 *
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 * Foundation, Inc., 675 Mass Ave, Cambridge, MA 02139, USA.
 */

#include <stdio.h>
#include <stdlib.h>
#include <signal.h>
#include <unistd.h>
#include <string.h>
#include <time.h>
#include <errno.h>
#include <getopt.h>
#include <sys/mman.h>

#include <rtcm/rctan.h>

static void print_usage(char *prg)
{
    fprintf(stderr,
        "Usage: %s <can-interface> [Options] [up|down|start|stop|sleep]\n"
        "Options:\n"
        "  -v, --verbose           be verbose\n"
        "  -h, --help             this help\n"
        "  -c, --ctrlmode=CTRLMODE listenonly, loopback or none\n"
        "  -b, --baudrate=BPS     baudrate in bits/sec\n"
        "  -B, --bittime=BTR0:BTR1 BTR or standard bit-time\n"
        "  -B, --bittime=BRP:PROP_SEG:PHASE_SEG1:PHASE_SEG2:SJW:SAM\n",
        prg);
}

can_baudrate_t string_to_baudrate(char *str)
{
    can_baudrate_t baudrate;
    if (sscanf(str, "%i", &baudrate) != 1)
        return -1;
    return baudrate;
}

int string_to_mode(char *str)
{
    if ( !strcmp(str, "up") || !strcmp(str, "start") )
        return CAN_MODE_START;
    else if ( !strcmp(str, "down") || !strcmp(str, "stop") )
        return CAN_MODE_STOP;
    else if ( !strcmp(str, "sleep") )

```

```

        return CAN_MODE_SLEEP;
    return -EINVAL;
}

int string_to_ctrlmode(char *str)
{
    if ( !strcmp(str, "listenonly") )
        return CAN_CTRLMODE_LISTENONLY;
    else if ( !strcmp(str, "loopback") )
        return CAN_CTRLMODE_LOOPBACK;
    else if ( !strcmp(str, "none") )
        return 0;

    return -1;
}

int main(int argc, char *argv[])
{
    char    ifname[16];
    int     can_fd = -1;
    int     new_baudrate = -1;
    int     new_mode = -1;
    int     new_ctrlmode = 0, set_ctrlmode = 0;
    int     verbose = 0;
    int     bittime_count = 0, bittime_data[6];
    struct ifreq ifr;
    can_baudrate_t *baudrate;
    can_ctrlmode_t *ctrlmode;
    can_mode_t *mode;
    struct can_bittime *bittime;
    int opt, ret;
    char* ptr;

    struct option long_options[] = {
        { "help", no_argument, 0, 'h' },
        { "verbose", no_argument, 0, 'v' },
        { "baudrate", required_argument, 0, 'b' },
        { "bittime", required_argument, 0, 'B' },
        { "ctrlmode", required_argument, 0, 'c' },
        { 0, 0, 0, 0 },
    };

    while ((opt = getopt_long(argc, argv, "hvb:B:c:",
                             long_options, NULL)) != -1) {
        switch (opt) {
            case 'h':
                print_usage(argv[0]);
                exit(0);

            case 'v':
                verbose = 1;
                break;

            case 'b':
                new_baudrate = string_to_baudrate(optarg);
                if (new_baudrate == -1) {
                    print_usage(argv[0]);
                    exit(0);
                }
                break;

            case 'B':
                ptr = optarg;
                while (1) {
                    bittime_data[bittime_count++] = strtoul(ptr, NULL, 0);
                    if (!(ptr = strchr(ptr, ':')))
                        break;
                }
                break;
        }
    }

```

```

        ptr++;
    }
    if (bittime_count != 2 && bittime_count != 6) {
        print_usage(argv[0]);
        exit(0);
    }
    break;

case 'c':
    ret = string_to_ctrlmode(optarg);
    if (ret == -1) {
        print_usage(argv[0]);
        exit(0);
    }
    new_ctrlmode |= ret;
    set_ctrlmode = 1;
    break;

    break;

default:
    fprintf(stderr, "Unknown option %c\n", opt);
    break;
}
}

/* Get CAN interface name */
if (optind != argc - 1 && optind != argc - 2) {
    print_usage(argv[0]);
    return 0;
}

strncpy(iframe, argv[optind], IFNAMSIZ);
strncpy(ifr.ifr_name, iframe, IFNAMSIZ);

if (optind == argc - 2) { /* Get mode setting */
    new_mode = string_to_mode(argv[optind + 1]);
    if (verbose)
        printf("mode: %s (%#x)\n", argv[optind + 1], new_mode);
    if (new_mode < 0) {
        print_usage(argv[0]);
        return 0;
    }
}

can_fd = rt_dev_socket(PF_CAN, SOCK_RAW, CAN_RAW);
if (can_fd < 0) {
    fprintf(stderr, "Cannot open RTDM CAN socket. Maybe driver not loaded? \n");
    return can_fd;
}

ret = rt_dev_ioctl(can_fd, SIOCGIFINDEX, &ifr);
if (ret) {
    fprintf(stderr, "Can't get interface index for %s, code = %d\n", iframe, ret);
    return ret;
}

if (new_baudrate != -1) {
    if (verbose)
        printf("baudrate: %d\n", new_baudrate);
    baudrate = (can_baudrate_t *)&ifr.ifr_ifru;
    *baudrate = new_baudrate;
    ret = rt_dev_ioctl(can_fd, SIOCSCANBAUDRATE, &ifr);
    if (ret) {
        goto abort;
    }
}

```



```

    }

    if (bittime_count) {
        bittime = (struct can_bittime *)&ifr.ifr_ifru;
        if (bittime_count == 2) {
            bittime->type = CAN_BITTIME_BTR;
            bittime->btr.btr0 = bittime_data[0];
            bittime->btr.btr1 = bittime_data[1];
            if (verbose)
                printf("bit-time: btr0=0x%02x btr1=0x%02x\n",
                       bittime->btr.btr0, bittime->btr.btr1);
        } else {
            bittime->type = CAN_BITTIME_STD;
            bittime->std.brp = bittime_data[0];
            bittime->std.prop_seg = bittime_data[1];
            bittime->std.phase_seg1 = bittime_data[2];
            bittime->std.phase_seg2 = bittime_data[3];
            bittime->std.sjw = bittime_data[4];
            bittime->std.sam = bittime_data[5];
            if (verbose)
                printf("bit-time: brp=%d prop_seg=%d phase_seg1=%d "
                       "phase_seg2=%d sjw=%d sam=%d\n",
                       bittime->std.brp,
                       bittime->std.prop_seg,
                       bittime->std.phase_seg1,
                       bittime->std.phase_seg2,
                       bittime->std.sjw,
                       bittime->std.sam);
        }

        ret = rt_dev_ioctl(can_fd, SIOCSCANCUSTOMBITTIME, &ifr);
        if (ret) {
            goto abort;
        }
    }

    if (set_ctrlmode != 0) {
        ctrlmode = (can_ctrlmode_t *)&ifr.ifr_ifru;
        *ctrlmode = new_ctrlmode;
        if (verbose)
            printf("ctrlmode: %#x\n", new_ctrlmode);
        ret = rt_dev_ioctl(can_fd, SIOCSCANCTRLMODE, &ifr);
        if (ret) {
            goto abort;
        }
    }

    if (new_mode != -1) {
        mode = (can_mode_t *)&ifr.ifr_ifru;
        *mode = new_mode;
        ret = rt_dev_ioctl(can_fd, SIOCSCANMODE, &ifr);
        if (ret) {
            goto abort;
        }
    }

    rt_dev_close(can_fd);
    return 0;

abort:
    rt_dev_close(can_fd);
    return ret;
}

```

## 8.4 rtcanrecv.c

```
#include <stdio.h>
#include <stdlib.h>
#include <signal.h>
#include <unistd.h>
#include <time.h>
#include <errno.h>
#include <getopt.h>
#include <sys/mman.h>

#include <native/task.h>
#include <native/pipe.h>

#include <rtcm/rtdm.h>

static void print_usage(char *prg)
{
    fprintf(stderr,
        "Usage: %s [<can-interface>] [Options]\n"
        "Options:\n"
        " -f --filter=id:mask[:id:mask]... apply filter\n"
        " -e --error=mask      receive error messages\n"
        " -t, --timeout=MS     timeout in ms\n"
        " -T, --timestamp      with absolute timestamp\n"
        " -R, --timestamp-rel  with relative timestamp\n"
        " -v, --verbose        be verbose\n"
        " -p, --print=MODULO   print every MODULO message\n"
        " -h, --help          this help\n",
        prg);
}

extern int optind, opterr, optopt;

static int s = -1, verbose = 0, print = 1;
static nanosecs_rel_t timeout = 0, with_timestamp = 0, timestamp_rel = 0;

RT_TASK rt_task_desc;

#define BUF_SIZE 255
#define MAX_FILTER 16

struct sockaddr_can recv_addr;
struct can_filter recv_filter[MAX_FILTER];
static int filter_count = 0;

int add_filter(u_int32_t id, u_int32_t mask)
{
    if (filter_count >= MAX_FILTER)
        return -1;
    recv_filter[filter_count].can_id = id;
    recv_filter[filter_count].can_mask = mask;
    printf("Filter #d: id=0x%08x mask=0x%08x\n", filter_count, id, mask);
    filter_count++;
    return 0;
}

void cleanup(void)
{
    int ret;

    if (verbose)
        printf("Cleaning up...\n");

    if (s >= 0) {
        ret = rt_dev_close(s);
    }
}
```

```

        s = -1;
        if (ret) {
            fprintf(stderr, "rt_dev_close: %s\n", strerror(-ret));
        }
        rt_task_delete(&rt_task_desc);
    }
}

void cleanup_and_exit(int sig)
{
    if (verbose)
        printf("Signal %d received\n", sig);
    cleanup();
    exit(0);
}

void rt_task(void)
{
    int i, ret, count = 0;
    struct can_frame frame;
    struct sockaddr_can addr;
    socklen_t addrlen = sizeof(addr);
    struct msghdr msg;
    struct iovec iov;
    nanosecs_abs_t timestamp, timestamp_prev = 0;

    if (with_timestamp) {
        msg.msg_iov = &iov;
        msg.msg_iovlen = 1;
        msg.msg_name = (void *)&addr;
        msg.msg_namelen = sizeof(struct sockaddr_can);
        msg.msg_control = (void *)&timestamp;
        msg.msg_controllen = sizeof(nanosecs_abs_t);
    }

    while (1) {
        if (with_timestamp) {
            iov.iov_base = (void *)&frame;
            iov.iov_len = sizeof(can_frame_t);
            ret = rt_dev_recvmsg(s, &msg, 0);
        } else
            ret = rt_dev_recvfrom(s, (void *)&frame, sizeof(can_frame_t), 0,
                                (struct sockaddr *)&addr, &addrlen);

        if (ret < 0) {
            switch (ret) {
                case -ETIMEDOUT:
                    if (verbose)
                        printf("rt_dev_recv: timed out");
                    continue;
                case -EBADF:
                    if (verbose)
                        printf("rt_dev_recv: aborted because socket was closed");
                    break;
                default:
                    fprintf(stderr, "rt_dev_recv: %s\n", strerror(-ret));
            }
            break;
        }

        if (print && (count % print) == 0) {
            printf("#%d: (%d) ", count, addr.can_ifindex);
            if (with_timestamp && msg.msg_controllen) {
                if (timestamp_rel) {
                    printf("%lldns ", (long long)(timestamp - timestamp_prev));
                    timestamp_prev = timestamp;
                } else
                    printf("%lldns ", (long long)timestamp);
            }
        }
    }
}

```

```

    }
    if (frame.can_id & CAN_ERR_FLAG)
        printf("!0x%08x!", frame.can_id & CAN_ERR_MASK);
    else if (frame.can_id & CAN EFF_FLAG)
        printf("<0x%08x>", frame.can_id & CAN EFF_MASK);
    else
        printf("<0x%03x>", frame.can_id & CAN_SFF_MASK);

    printf(" [%d]", frame.can_dlc);
    if (!(frame.can_id & CAN_RTR_FLAG))
        for (i = 0; i < frame.can_dlc; i++) {
            printf(" %02x", frame.data[i]);
        }
    if (frame.can_id & CAN_ERR_FLAG) {
        printf(" ERROR ");
        if (frame.can_id & CAN_ERR_BUSOFF)
            printf("bus-off");
        if (frame.can_id & CAN_ERR_CRTL)
            printf("controller problem");
    } else if (frame.can_id & CAN_RTR_FLAG)
        printf(" remote request");
    printf("\n");
}
count++;
}
}

int main(int argc, char **argv)
{
    int opt, ret;
    u_int32_t id, mask;
    u_int32_t err_mask = 0;
    struct ifreq ifr;
    char *ptr;
    char name[32];

    struct option long_options[] = {
        { "help", no_argument, 0, 'h' },
        { "verbose", no_argument, 0, 'v' },
        { "filter", required_argument, 0, 'f' },
        { "error", required_argument, 0, 'e' },
        { "timeout", required_argument, 0, 't' },
        { "timestamp", no_argument, 0, 'T' },
        { "timestamp-rel", no_argument, 0, 'R' },
        { 0, 0, 0, 0 },
    };

    mlockall(MCL_CURRENT | MCL_FUTURE);

    signal(SIGTERM, cleanup_and_exit);
    signal(SIGINT, cleanup_and_exit);

    while ((opt = getopt_long(argc, argv, "hve:f:t:p:RT",
                             long_options, NULL)) != -1) {
        switch (opt) {
            case 'h':
                print_usage(argv[0]);
                exit(0);

            case 'p':
                print = strtoul(optarg, NULL, 0);
                break;

            case 'v':
                verbose = 1;
                break;
        }
    }

```

```

    case 'e':
        err_mask = strtoul(optarg, NULL, 0);
        break;

    case 'f':
        ptr = optarg;
        while (1) {
            id = strtoul(ptr, NULL, 0);
            ptr = strchr(ptr, ':');
            if (!ptr) {
                fprintf(stderr, "filter must be applied in the form id:mask[:id:mask]...\n");
                exit(1);
            }
            ptr++;
            mask = strtoul(ptr, NULL, 0);
            ptr = strchr(ptr, ':');
            add_filter(id, mask);
            if (!ptr)
                break;
            ptr++;
        }
        break;

    case 't':
        timeout = (nanosecs_rel_t)strtoul(optarg, NULL, 0) * 1000000;
        break;

    case 'R':
        timestamp_rel = 1;
    case 'T':
        with_timestamp = 1;
        break;

    default:
        fprintf(stderr, "Unknown option %c\n", opt);
        break;
}

ret = rt_dev_socket(PF_CAN, SOCK_RAW, CAN_RAW);
if (ret < 0) {
    fprintf(stderr, "rt_dev_socket: %s\n", strerror(-ret));
    return -1;
}
s = ret;

if (argv[optind] == NULL) {
    if (verbose)
        printf("interface all\n");

    ifr.ifr_ifindex = 0;
} else {
    if (verbose)
        printf("interface %s\n", argv[optind]);

    strncpy(ifr.ifr_name, argv[optind], IFNAMSIZ);
    if (verbose)
        printf("s=%d, ifr_name=%s\n", s, ifr.ifr_name);

    ret = rt_dev_ioctl(s, SIOCGIFINDEX, &ifr);
    if (ret < 0) {
        fprintf(stderr, "rt_dev_ioctl GET_IFINDEX: %s\n", strerror(-ret));
        goto failure;
    }
}

if (err_mask) {

```

```

    ret = rt_dev_setsockopt(s, SOL_CAN_RAW, CAN_RAW_ERR_FILTER,
                           &err_mask, sizeof(err_mask));
    if (ret < 0) {
        fprintf(stderr, "rt_dev_setsockopt: %s\n", strerror(-ret));
        goto failure;
    }
    if (verbose)
        printf("Using err_mask=0x%x\n", err_mask);
}

if (filter_count) {
    ret = rt_dev_setsockopt(s, SOL_CAN_RAW, CAN_RAW_FILTER,
                           &recv_filter, filter_count *
                           sizeof(struct can_filter));

    if (ret < 0) {
        fprintf(stderr, "rt_dev_setsockopt: %s\n", strerror(-ret));
        goto failure;
    }
}

recv_addr.can_family = AF_CAN;
recv_addr.can_ifindex = ifr.ifr_ifindex;
ret = rt_dev_bind(s, (struct sockaddr *)&recv_addr,
                  sizeof(struct sockaddr_can));
if (ret < 0) {
    fprintf(stderr, "rt_dev_bind: %s\n", strerror(-ret));
    goto failure;
}

if (timeout) {
    if (verbose)
        printf("Timeout: %lld ns\n", (long long)timeout);
    ret = rt_dev_ioctl(s, RTCAN_RTIOC_RCV_TIMEOUT, &timeout);
    if (ret) {
        fprintf(stderr, "rt_dev_ioctl RCV_TIMEOUT: %s\n", strerror(-ret));
        goto failure;
    }
}

if (with_timestamp) {
    ret = rt_dev_ioctl(s, RTCAN_RTIOC_TAKE_TIMESTAMP, RTCAN_TAKE_TIMESTAMPS);
    if (ret) {
        fprintf(stderr, "rt_dev_ioctl TAKE_TIMESTAMP: %s\n", strerror(-ret));
        goto failure;
    }
}

snprintf(name, sizeof(name), "rtcanrecv-%d", getpid());
ret = rt_task_shadow(&rt_task_desc, name, 0, 0);
if (ret) {
    fprintf(stderr, "rt_task_shadow: %s\n", strerror(-ret));
    goto failure;
}

rt_task();
/* never returns */

failure:
    cleanup();
    return -1;
}

```

## 8.5 rtcanseend.c

```

#include <stdio.h>
#include <stdlib.h>
#include <signal.h>
#include <unistd.h>
#include <time.h>
#include <errno.h>
#include <getopt.h>
#include <sys/mman.h>

#include <native/task.h>
#include <native/timer.h>
#include <native/pipe.h>

#include <rtdev/rtcan.h>

extern int optind, opterr, optopt;

static void print_usage(char *prg)
{
    fprintf(stderr,
        "Usage: %s <can-interface> [Options] <can-msg>\n"
        "<can-msg> can consist of up to 8 bytes given as a space separated list\n"
        "Options:\n"
        " -i, --identifier=ID    CAN Identifier (default = 1)\n"
        " -r --rtr               send remote request\n"
        " -e --extended          send extended frame\n"
        " -l --loop=COUNT       send message COUNT times\n"
        " -c, --count            message count in data[0-3]\n"
        " -d, --delay=MS         delay in ms (default = 1ms)\n"
        " -s, --send             use send instead of sendto\n"
        " -t, --timeout=MS       timeout in ms\n"
        " -L, --loopback=0|1     switch local loopback off or on\n"
        " -v, --verbose          be verbose\n"
        " -p, --print=MODULO     print every MODULO message\n"
        " -h, --help             this help",
        prg);
}

RT_TASK rt_task_desc;

static int s=-1, dlc=0, rtr=0, extended=0, verbose=0, loops=1;
static SRTIME delay=1000000;
static int count=0, print=1, use_send=0, loopback=-1;
static nanosecs_rel_t timeout = 0;
static struct can_frame frame;
static struct sockaddr_can to_addr;

void cleanup(void)
{
    int ret;

    if (verbose)
        printf("Cleaning up...\n");

    usleep(100000);

    if (s >= 0) {
        ret = rt_dev_close(s);
        s = -1;
        if (ret) {
            fprintf(stderr, "rt_dev_close: %s\n", strerror(-ret));
        }
        rt_task_delete(&rt_task_desc);
    }
}

```

```

    }
}

void cleanup_and_exit(int sig)
{
    if (verbose)
        printf("Signal %d received\n", sig);
    cleanup();
    exit(0);
}

void rt_task(void)
{
    int i, j, ret;

    for (i = 0; i < loops; i++) {
        rt_task_sleep(rt_timer_ns2ticks(delay));
        if (count)
            memcpy(&frame.data[0], &i, sizeof(i));
        /* Note: sendto avoids the definition of a receive filter list */
        if (use_send)
            ret = rt_dev_send(s, (void *)&frame, sizeof(can_frame_t), 0);
        else
            ret = rt_dev_sendto(s, (void *)&frame, sizeof(can_frame_t), 0,
                                (struct sockaddr *)&to_addr, sizeof(to_addr));

        if (ret < 0) {
            switch (ret) {
                case -ETIMEDOUT:
                    if (verbose)
                        printf("rt_dev_send(to): timed out");
                    break;
                case -EBADF:
                    if (verbose)
                        printf("rt_dev_send(to): aborted because socket was closed");
                    break;
                default:
                    fprintf(stderr, "rt_dev_send: %s\n", strerror(-ret));
                    break;
            }
            i = loops;          /* abort */
            break;
        }
        if (verbose && (i % print) == 0) {
            if (frame.can_id & CAN_EFF_FLAG)
                printf("<0x%08x>", frame.can_id & CAN_EFF_MASK);
            else
                printf("<0x%03x>", frame.can_id & CAN_SFF_MASK);
            printf(" [%d]", frame.can_dlc);
            for (j = 0; j < frame.can_dlc; j++) {
                printf(" %02x", frame.data[j]);
            }
            printf("\n");
        }
    }
}

int main(int argc, char **argv)
{
    int i, opt, ret;
    struct ifreq ifr;
    char name[32];

    struct option long_options[] = {
        { "help", no_argument, 0, 'h' },
        { "identifier", required_argument, 0, 'i' },
        { "rtr", no_argument, 0, 'r' },
        { "extended", no_argument, 0, 'e' },
    };

```



```

    { "verbose", no_argument, 0, 'v'},
    { "count", no_argument, 0, 'c'},
    { "print", required_argument, 0, 'p'},
    { "loop", required_argument, 0, 'l'},
    { "delay", required_argument, 0, 'd'},
    { "send", no_argument, 0, 's'},
    { "timeout", required_argument, 0, 't'},
    { "loopback", required_argument, 0, 'L'},
    { 0, 0, 0, 0},
};

mlockall(MCL_CURRENT | MCL_FUTURE);

signal(SIGTERM, cleanup_and_exit);
signal(SIGINT, cleanup_and_exit);

frame.can_id = 1;

while ((opt = getopt_long(argc, argv, "hvi:l:red:t:cp:sL:",
                           long_options, NULL)) != -1) {
    switch (opt) {
        case 'h':
            print_usage(argv[0]);
            exit(0);

        case 'p':
            print = strtoul(optarg, NULL, 0);

        case 'v':
            verbose = 1;
            break;

        case 'c':
            count = 1;
            break;

        case 'l':
            loops = strtoul(optarg, NULL, 0);
            break;

        case 'i':
            frame.can_id = strtoul(optarg, NULL, 0);
            break;

        case 'r':
            rtr = 1;
            break;

        case 'e':
            extended = 1;
            break;

        case 'd':
            delay = strtoul(optarg, NULL, 0) * 1000000LL;
            break;

        case 's':
            use_send = 1;
            break;

        case 't':
            timeout = strtoul(optarg, NULL, 0) * 1000000LL;
            break;

        case 'L':
            loopback = strtoul(optarg, NULL, 0);
            break;
    }
}

```

```

        default:
            fprintf(stderr, "Unknown option %c\n", opt);
            break;
    }
}

if (optind == argc) {
    print_usage(argv[0]);
    exit(0);
}

if (argv[optind] == NULL) {
    fprintf(stderr, "No Interface supplied\n");
    exit(-1);
}

if (verbose)
    printf("interface %s\n", argv[optind]);

ret = rt_dev_socket(PF_CAN, SOCK_RAW, CAN_RAW);
if (ret < 0) {
    fprintf(stderr, "rt_dev_socket: %s\n", strerror(-ret));
    return -1;
}
s = ret;

if (loopback >= 0) {
    ret = rt_dev_setsockopt(s, SOL_CAN_RAW, CAN_RAW_LOOPBACK,
                           &loopback, sizeof(loopback));

    if (ret < 0) {
        fprintf(stderr, "rt_dev_setsockopt: %s\n", strerror(-ret));
        goto failure;
    }
    if (verbose)
        printf("Using loopback=%d\n", loopback);
}

strncpy(ifr.ifr_name, argv[optind], IFNAMSIZ);
if (verbose)
    printf("s=%d, ifr_name=%s\n", s, ifr.ifr_name);

ret = rt_dev_ioctl(s, SIOCGIFINDEX, &ifr);
if (ret < 0) {
    fprintf(stderr, "rt_dev_ioctl: %s\n", strerror(-ret));
    goto failure;
}

memset(&to_addr, 0, sizeof(to_addr));
to_addr.can_ifindex = ifr.ifr_ifindex;
to_addr.can_family = AF_CAN;
if (use_send) {
    /* Suppress definiton of a default receive filter list */
    ret = rt_dev_setsockopt(s, SOL_CAN_RAW, CAN_RAW_FILTER, NULL, 0);
    if (ret < 0) {
        fprintf(stderr, "rt_dev_setsockopt: %s\n", strerror(-ret));
        goto failure;
    }
}

ret = rt_dev_bind(s, (struct sockaddr *)&to_addr, sizeof(to_addr));
if (ret < 0) {
    fprintf(stderr, "rt_dev_bind: %s\n", strerror(-ret));
    goto failure;
}
}

if (count)

```

```
    frame.can_dlc = sizeof(int);
else {
    for (i = optind + 1; i < argc; i++) {
        frame.data[dlc] = strtoul(argv[i], NULL, 0);
        dlc++;
        if( dlc == 8 )
            break;
    }
    frame.can_dlc = dlc;
}

if (rtr)
    frame.can_id |= CAN_RTR_FLAG;

if (extended)
    frame.can_id |= CAN_EFF_FLAG;

if (timeout) {
    if (verbose)
        printf("Timeout: %lld ns\n", (long long)timeout);
    ret = rt_dev_ioctl(s, RTCAN_RTIOC_SND_TIMEOUT, &timeout);
    if (ret) {
        fprintf(stderr, "rt_dev_ioctl SND_TIMEOUT: %s\n", strerror(-ret));
        goto failure;
    }
}

snprintf(name, sizeof(name), "rtcansend-%d", getpid());
ret = rt_task_shadow(&rt_task_desc, name, 1, 0);
if (ret) {
    fprintf(stderr, "rt_task_shadow: %s\n", strerror(-ret));
    goto failure;
}

rt_task();

cleanup();
return 0;

failure:
    cleanup();
    return -1;
}
```

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