RX Family

RSCAN Module Using Firmware Integration Technology

Introduction

This document describes the API for the RSCAN driver for the RX200 Series. Message transfers can be done using 1-message deep mailboxes, 4-message deep FIFOs, or any combination thereof.

NOTE: When developing an application with the E1 emulator, and the E1 emulator is powering the target board, be sure that it is supplying 5.0V and not 3.3V (specified in Debug Configuration) or the RSCAN will not operate properly.

Target Devices

The following is a list of devices that are currently supported by this API:

- RX230, RX231 Group
- RX24T Group
- RX23W Group
- RX24U Group

When using this application note with other Renesas MCUs, careful evaluation is recommended after making modifications to comply with the alternate MCU.

Target Compilers

- Renesas Electronics C/C++ Compiler Package for RX Family
- GCC for Renesas RX
- IAR C/C++ Compiler for Renesas RX

For details of the confirmed operation contents of each compiler, refer to “6.1 Confirmed Operation Environment".

Contents

1. Overview

This driver is compatible with the RSCAN driver provided with the RZ/A1. Although the RSCAN peripheral on the RX200 Series is single channel, the API remains the same. A static configuration of mailboxes and FIFOs (boxes) is hardcoded as is done with the RZ/A1, but much fewer resources are available for use.

All mailboxes are one-message deep. There are 4 transmit mailboxes and 4 receive mailboxes. The transmit mailboxes can optionally be configured for interrupt operation, whereas the receive mailboxes cannot. The transmit mailboxes do not accept a message for transmit until the previous message has been sent. The receive mailboxes always contain the most recent message received, overwriting the previous contents without an error condition being generated. There is no hardware interrupt option available.

The transmit and receive FIFOs are 4-messages deep. FIFOs are used for the sending and receiving of messages just like a mailbox. These can optionally be configured to be interrupt driven. Setting a receive FIFO to interrupt on every message received would behave similar to a receive mailbox with interrupt support.

There is a special FIFO called the Transmit History FIFO, and this FIFO is 8 entries deep. The History FIFO logs all messages tagged in an R_CAN_SendMsg() call in the order they are sent. Note that any FIFO usage is optional and are not required for normal operation.

The RSCAN hardware processes all messages transmitted on the bus, but uses Receive Rules to determine which messages to keep and which to ignore. A Receive Rule consists of two parts. The first part performs filtering on different parts of the message to see if the message should be kept. The second part specifies which box (receive mailbox or receive FIFO) to route the message to. After the hardware routes a message to a box, the function R_CAN_GetMsg() is used to read a message from the box.

There are two types of interrupts available- global interrupts and channel interrupts. The global interrupts indicate when a receive FIFO has received a message as well as when a global error occurs. These interrupts are enabled in the r_rscan_rx_config.h file. The driver detects the interrupt and calls a user callback function specified in R_CAN_Open() to process the particular event(s). The channel interrupts handle several transmit conditions as well as channel errors. These interrupts are also enabled in the r_rscan_rx_config.h file. The driver detects the interrupt and calls a user callback function specified in R_CAN_InitChan() to process the particular event(s).

By default, the following interrupts are enabled:

- RX, TX, or History FIFO threshold reached
- RX, TX, or History FIFO overflow occurred
- Channel entered Error Passive state
- Channel entered Bus Off state
- Channel recovered from Bus Off state

The following sequence of function calls is used to setup the CAN:

```
R_CAN_Open();
R_CAN_InitChan();   // do for 1 channel
R_CAN_ConfigFIFO(); // do for 0 or more FIFOs
R_CAN_AddRxRule();  // do for 1-16 rules
```

Once the CAN is setup, the peripheral should enter normal communications mode or a test mode.

```
R_CAN_Control();    // Use CAN_CMD_SET_MODE_COMM or CAN_CMD_SET_MODE_TST_xxx
```

2. API Information

This Driver API follows the Renesas API naming standards.

2.1 Hardware Requirements

This driver utilizes the RSCAN peripheral.

2.2 Hardware Resource Requirements

In addition to the RSCAN peripheral, the driver requires:

- Two pins allocated for the CAN channel

2.3 Software Requirements

This driver is dependent upon the following FIT module:

- Renesas Board Support Package (r_bsp) v5.20 or higher

2.4 Limitations

Not all features of the peripheral are utilized. These include:

- Configurable depth transmit and receive FIFOs (all fixed at 4 instead of configurable 1 to 16)
- Transmit by message ID priority (will be done by mailbox number, 0 being highest priority)
- Transmit FIFO interval transmission
- Transmit mirroring
- Filter on mirrored messages
- DLC substitution
- Multiple destinations for each received message (will fix at 1 destination; could be up to 3)
- Different methods of Bus Off recovery (will be ISO11898-1 compliant)
- Forcible return from Bus Off
- Selection of protocol error flag accumulation vs first occurrence (will hard-code to accumulative for all channels)

2.5 Supported Toolchains

This driver has been confirmed to work with the toolchain listed in 6.1, Confirmed Operation Environment.

2.6 Header Files

All API calls and their supporting interface definitions are located in “r_rscan_rx_if.h”.

Build-time configuration options are set in the file "r_rscan_rx_config.h” (the default values are defined in the file “r_rscan_rx_config_reference.h”).

Both of these files should be included by the user’s application.

2.7 Integer Types

This project uses ANSI C99 “Exact width integer types” in order to make the code clearer and more portable. These types are defined in stdint.h.

2.8 Configuration Overview

Static configuration options for this driver are set by the user via the file r_rscan_rx_config.h.

Configuration options in *r_rscan_rx_config.h*		
Equate	**Default Value**	**Description**
CAN_CFG_PARAM_CHECKING_ENABLE	1	Setting to 0 removes parameter checking from the code. Setting to 1 includes parameter checking in the code.
CAN_CFG_CLOCK_SOURCE	0	If this equate is 0, the CAN clock source is ½ the peripheral clock speed (clkc). If this equate is 1, the source is the external CAN_CLOCK (clk_xincan).
CAN_CFG_INT_PRIORITY	5	Priority level for all CAN interrupts (0-31)
CAN_CFG_INT_RXFIFO_THRESHOLD	1	Setting to 0 disables interrupt when an RXFIFO threshold is reached. Setting to 1 enables interrupt. Requires FIFO to be initialized via R_CAN_ConfigFIFO(). CAN_EVT_RXFIFO_THRESHOLD is passed to the main callback function.
CAN_CFG_INT_DLC_ERR	0	Setting to 0 disables interrupt when a DLC error is detected. Setting to 1 enables interrupt. CAN_EVT_GLOBAL_ERR is passed to the main callback function.
CAN_CFG_INT_FIFO_OVFL	1	Setting to 0 disables interrupt when a TX, GW, or RX FIFO overflows. Setting to 1 enables interrupt. Requires FIFO to be initialized via R_CAN_ConfigFIFO(). CAN_EVT_ GLOBAL_ERR is passed to the main callback function.
CAN_CFG_INT_HIST_FIFO_OVFL	1	Setting to 0 disables interrupt when a History FIFO overflows. Setting to 1 enables interrupt. Requires FIFO to be initialized via R_CAN_ConfigFIFO(). CAN_EVT_ GLOBAL_ERR is passed to the main callback function.
CAN_CFG_INT_TXFIFO_THRESHOLD	1	Setting to 0 disables interrupt when a TXFIFO threshold is reached. Setting to 1 enables interrupt. Requires FIFO to be initializes via R_CAN_ConfigFIFO(). CAN_EVT_TRANSMIT is passed to the channel callback function.
CAN_CFG_INT_HIST_FIFO_THRESHOLD	1	Setting to 0 disables interrupt when the HIST_FIFO threshold is reached. Setting to 1 enables interrupt. Requires FIFO to be initialized via R_CAN_ConfigFIFO(). CAN_EVT_ TRANSMIT is passed to the channel callback function.
CAN_CFG_INT_MBX_TX_COMPLETE	0	Setting to 0 disables interrupt when the mailbox completes transmission.

		Setting to 1 enables interrupt. CAN_EVT_ TRANSMIT is passed to the channel callback function.
CAN_CFG_INT_MBX_TX_ABORTED	0	Setting to 0 disables interrupt when the mailbox transmit is aborted. Setting to 1 enables interrupt. CAN_EVT_ TRANSMIT is passed to the channel callback function.
CAN_CFG_INT_BUS_ERROR	0	Setting to 0 disables interrupt when a bus error is detected. Setting to 1 enables interrupt. CAN_EVT_CHANNEL_ERR is passed to the channel callback function.
CAN_CFG_INT_ERR_WARNING	0	Setting to 0 disables interrupt when an error warning is detected. Setting to 1 enables interrupt. CAN_EVT_CHANNEL_ERR is passed to the channel callback function.
CAN_CFG_INT_ERR_PASSIVE	1	Setting to 0 disables interrupt when an error passive is detected. Setting to 1 enables interrupt. CAN_EVT_CHANNEL_ERR is passed to the channel callback function.
CAN_CFG_INT_BUS_OFF_ENTRY	1	Setting to 0 disables interrupt when a Bus Off error is detected. Setting to 1 enables interrupt. CAN_EVT_CHANNEL_ERR is passed to the channel callback function.
CAN_CFG_INT_BUS_OFF_RECOVERY	1	Setting to 0 disables interrupt when a Bus Off recovery is detected. Setting to 1 enables interrupt. CAN_EVT_CHANNEL_ERR is passed to the channel callback function.
CAN_CFG_INT_OVERLOAD_FRAME_TX	0	Setting to 0 disables interrupt when an overload is detected. Setting to 1 enables interrupt. CAN_EVT_CHANNEL_ERR is passed to the channel callback function.
CAN_CFG_INT_BUS_LOCK	0	Setting to 0 disables interrupt when a bus lock is detected. Setting to 1 enables interrupt. CAN_EVT_CHANNEL_ERR is passed to the channel callback function.
CAN_CFG_INT_ARB_LOST	0	Setting to 0 disables interrupt when arbitration loss is detected. Setting to 1 enables interrupt. CAN_EVT_CHANNEL_ERR is passed to the channel callback function.

Table 1: Info about the configuration

2.9 Code Size

The code size is based upon optimization level 2 for the RXC Toolchain. **These code sizes include all interrupt handlers (configured active or not), as well as all FIFO support code.**

The values in the table below are confirmed under the following conditions.

Module Revision: r_rscan_rx_v2.00

Compiler Version: Renesas Electronics C/C++ Compiler Package for RX Family V3.01.00

(The option of "lang = c99" is added to the default settings of the integrated development environment.)

GCC for Renesas RX 4.8.4.201803

(The option of "lang = c99" is added to the default settings of the integrated development environment.)

IAR C/C++ Compiler for Renesas RX version 4.11.1

(The default settings of the integrated development environment.)

Configuration Options: Default settings

ROM, RAM and Stack Code Sizes

Device	Category	Memory Used					
		Renesas Compiler		GCC		IAR Compiler	
		With Parameter Checking	Without Parameter Checking	With Parameter Checking	Without Parameter Checking	With Parameter Checking	Without Parameter Checking
RX231	ROM	3211 bytes	2683 bytes	5824 bytes	4976 bytes	5547 bytes	4916 bytes
	RAM	20 bytes	20 bytes	20 bytes	20 bytes	20 bytes	20 bytes
	STACK	36 bytes	36 bytes	-	-	144 bytes	144 bytes
RX23W	ROM	3211 bytes	2683 bytes	-	-	-	-
	RAM	20 bytes	20 bytes	-	-	-	-
	STACK	72 bytes	72 bytes	-	-	-	-

2.10 API Data Types

This section details the data types that are used with the driver's API functions.

2.10.1 Box IDs (mailboxes and FIFOs)

```
typedef enum e_can_box
{
    CAN_BOX_NONE              = 0,  // unused parameter value

    CAN_BOX_CH0_TXMBX_0       = (CAN_FLG_TXMBX | 0),
    CAN_BOX_CH0_TXMBX_1       = (CAN_FLG_TXMBX | 1),
    CAN_BOX_CH0_TXMBX_2       = (CAN_FLG_TXMBX | 2),
    CAN_BOX_CH0_TXMBX_3       = (CAN_FLG_TXMBX | 3),

    CAN_BOX_RXMBX_0           = (CAN_FLG_RXMBX | 0),
    CAN_BOX_RXMBX_1           = (CAN_FLG_RXMBX | 1),
    CAN_BOX_RXMBX_2           = (CAN_FLG_RXMBX | 3),
    CAN_BOX_RXMBX_4           = (CAN_FLG_RXMBX | 4),

    CAN_BOX_RXFIFO_0          = (CAN_FLG_FIFO | CAN_MASK_RXFIFO_0),
    CAN_BOX_RXFIFO_1          = (CAN_FLG_FIFO | CAN_MASK_RXFIFO_1),

    CAN_BOX_TXFIFO            = (CAN_FLG_FIFO | CAN_MASK_CH0_TXFIFO_0),

    CAN_BOX_HIST_FIFO         = (CAN_FLG_FIFO | CAN_MASK_CH0_HIST_FIFO),
} can_box_t;
```

2.10.2 R_CAN_Open() Data Types

```
typedef enum e_can_timestamp_src
{
    CAN_TIMESTAMP_SRC_HALF_PCLK = 0,
    CAN_TIMESTAMP_SRC_CANMCLK   = 1,    // obtained from EXTAL pin
    CAN_TIMESTAMP_SRC_END_ENUM
} can_timestamp_src_t;

typedef enum e_can_timestamp_div
{
    CAN_TIMESTAMP_DIV_1     = 0,
    CAN_TIMESTAMP_DIV_2     = 1,
    CAN_TIMESTAMP_DIV_4     = 2,
    CAN_TIMESTAMP_DIV_8     = 3,
    CAN_TIMESTAMP_DIV_16    = 4,
    CAN_TIMESTAMP_DIV_32    = 5,
    CAN_TIMESTAMP_DIV_64    = 6,
    CAN_TIMESTAMP_DIV_128   = 7,
    CAN_TIMESTAMP_DIV_256   = 8,
    CAN_TIMESTAMP_DIV_512   = 9,
    CAN_TIMESTAMP_DIV_1024  = 10,
    CAN_TIMESTAMP_DIV_2048  = 11,
    CAN_TIMESTAMP_DIV_4096  = 12,
    CAN_TIMESTAMP_DIV_8192  = 13,
    CAN_TIMESTAMP_DIV_16384 = 14,
    CAN_TIMESTAMP_DIV_32768 = 15,
    CAN_TIMESTAMP_DIV_END_ENUM
} can_timestamp_div_t;

typedef struct st_can_cfg
{
    can_timestamp_src_t     timestamp_src;
    can_timestamp_div_t     timestamp_div;
```

```
} can_cfg_t;
```

2.10.3 Callback function events

```
typedef enum e_can_cb_evt        // callback function events
{
    // Main Callback Events
    CAN_EVT_RXFIFO_THRESHOLD,    // RX FIFO threshold
    CAN_EVT_GLOBAL_ERR,          // RX or Hist FIFO overflow, or DLC error

    // Channel Callback Events
    CAN_EVT_TRANSMIT,            // mbx tx complete or aborted,
                                 //   tx or history FIFO threshold
    CAN_EVT_CHANNEL_ERR,
} can_cb_evt_t;
```

2.10.4 R_CAN_InitChan() Data Types

```
typedef struct st_can_bitrate
{
    uint16_t    prescaler;  // 1-1024
    uint8_t     tseg1;      // 4-16
    uint8_t     tseg2;      // 2-8
    uint8_t     sjw;        // 1-4
} can_bitrate_t;

/* Sample settings for 500kbps */
#define CAN_RSK_27MHZ_PCLKB_500KBPS_PRESCALER   3
#define CAN_RSK_27MHZ_PCLKB_500KBPS_TSEG1       5
#define CAN_RSK_27MHZ_PCLKB_500KBPS_TSEG2       3
#define CAN_RSK_27MHZ_PCLKB_500KBPS_SJW         1

#define CAN_RSK_32MHZ_PCLKB_500KBPS_PRESCALER   2
#define CAN_RSK_32MHZ_PCLKB_500KBPS_TSEG1       11
#define CAN_RSK_32MHZ_PCLKB_500KBPS_TSEG2       4
#define CAN_RSK_32MHZ_PCLKB_500KBPS_SJW         4
                                                    // alternate settings
#define CAN_RSK_8MHZ_XTAL_500KBPS_PRESCALER     1       // 2
#define CAN_RSK_8MHZ_XTAL_500KBPS_TSEG1         10      // 5
#define CAN_RSK_8MHZ_XTAL_500KBPS_TSEG2         5       // 2
#define CAN_RSK_8MHZ_XTAL_500KBPS_SJW           1       // 1
```

2.10.5 R_CAN_ConfigFIFO() Data Types

```
typedef enum e_can_fifo_threshold       // NOTE: History FIFO can only have a
{                                       //       threshold of 1 or 12
    CAN_FIFO_THRESHOLD_2    = 3,        // 4/8 of 4
    CAN_FIFO_THRESHOLD_3    = 5,        // 6/8 of 4
    CAN_FIFO_THRESHOLD_6    = 5,        // History FIFO Only!
    CAN_FIFO_THRESHOLD_FULL = 7,        // 8/8 of 4
    CAN_FIFO_THRESHOLD_1    = 8,        // every message
    CAN_FIFO_THRESHOLD_END_ENUM
} can_fifo_threshold_t;
```

2.10.6 R_CAN_AddRxRule() Data Types

```
typedef struct st_can_filter
{
    bool_t      check_ide;
    uint8_t     ide;
    bool_t      check_rtr;
    uint8_t     rtr;
```

```
    uint32_t    id;
    uint32_t    id_mask;
    uint8_t     min_dlc;
    uint16_t    label;          // 12-bit label
} can_filter_t;
```

2.10.7 R_CAN_SendMsg() Data Types

```
typedef struct st_can_txmsg
{
    uint8_t     ide;
    uint8_t     rtr;
    uint32_t    id;
    uint8_t     dlc;
    uint8_t     data[8];
    bool_t      one_shot;       // no retries on error; txmbx only
    bool_t      log_history;    // true if want to log
    uint8_t     label;          // 8-bit label for History FIFO
} can_txmsg_t;
```

2.10.8 R_CAN_GetMsg() Data Types

```
typedef struct st_can_rxmsg
{
    uint8_t     ide;
    uint8_t     rtr;
    uint32_t    id;
    uint8_t     dlc;
    uint8_t     data[8];
    uint16_t    label;          // 12-bit label from receive rule
    uint16_t    timestamp;
} can_rxmsg_t;
```

2.10.9 R_CAN_GetHistoryEntry() Data Types

```
typedef struct st_can_history
{
    can_box_t   box_id;         // box which sent message
    uint8_t     label;          // associated 8-bit label
} can_history_t;
```

2.10.10 R_CAN_GetStatusMask() Data Types

```
typedef enum e_can_stat
{
    CAN_STAT_FIFO_EMPTY,
    CAN_STAT_FIFO_THRESHOLD,
    CAN_STAT_FIFO_OVFL,         // bits reset after reading
    CAN_STAT_RXMBX_FULL,
    CAN_STAT_GLOBAL_ERR,        // DLC error bit is reset after reading
    CAN_STAT_CH_TXMBX_SENT,     // bits reset after reading
    CAN_STAT_CH_TXMBX_ABORTED,  // bits reset after reading
    CAN_STAT_CH_ERROR,          // bits reset after reading
    CAN_STAT_END_ENUM
} can_stat_t;

/* Returned mask values (multiple bits may be set at the same time)

/* CAN_STAT_CH_TXMBX_SENT, CAN_STAT_CH_TXMBX_ABORTED */
#define CAN_MASK_TXMBX_0            (0x0001)
#define CAN_MASK_TXMBX_1            (0x0002)
#define CAN_MASK_TXMBX_2            (0x0004)
```

```
#define CAN_MASK_TXMBX_3            (0x0008)

/* CAN_STAT_RXMBX_FULL */
#define CAN_MASK_RXMBX_0            (0x0001)
#define CAN_MASK_RXMBX_1            (0x0002)
#define CAN_MASK_RXMBX_2            (0x0004)
#define CAN_MASK_RXMBX_3            (0x0008)

/* CAN_STAT_FIFO_EMPTY, CAN_STAT_FIFO_THRESHOLD, CAN_STAT_FIFO_OVFL */
#define CAN_MASK_RXFIFO_0           (0x00000001)
#define CAN_MASK_RXFIFO_1           (0x00000002)
#define CAN_MASK_TXFIFO             (0x00000100)
#define CAN_MASK_HIST_FIFO          (0x00800000)

/* CAN_STAT_GLOBAL_ERR */
#define CAN_MASK_ERR_DLC            (0x0001)
#define CAN_MASK_ERR_RX_OVFL        (0x0002)
#define CAN_MASK_ERR_HIST_OVFL      (0x0004)
#define CAN_MASK_ERR_FIFO_OVFL      (0x0006)

/* CAN_STAT_CH_ERROR */
#define CAN_MASK_ERR_PROTOCOL       (0x0001)
#define CAN_MASK_ERR_WARNING        (0x0002)
#define CAN_MASK_ERR_PASSIVE        (0x0004)
#define CAN_MASK_ERR_BUS_OFF_ENTRY  (0x0008)
#define CAN_MASK_ERR_BUS_OFF_EXIT   (0x0010)
#define CAN_MASK_ERR_OVERLOAD       (0x0020)
#define CAN_MASK_ERR_DOMINANT_LOCK  (0x0040)
#define CAN_MASK_ERR_ARB_LOST       (0x0080)
#define CAN_MASK_ERR_STUFF          (0x0100)
#define CAN_MASK_ERR_FORM           (0x0200)
#define CAN_MASK_ERR_ACK            (0x0400)
#define CAN_MASK_ERR_CRC            (0x0800)
#define CAN_MASK_ERR_RECESSIVE_BIT  (0x1000)
#define CAN_MASK_ERR_DOMINANT_BIT   (0x2000)
#define CAN_MASK_ERR_ACK_DELIMITER  (0x4000)
```

2.10.11 R_CAN_GetCountErr() Data Types

```
typedef enum e_can_count
{
    CAN_COUNT_RX_ERR,
    CAN_COUNT_TX_ERR,
    CAN_COUNT_END_ENUM
} can_count_t;
```

2.10.12 R_CAN_Control() Data Types

```
typedef enum e_can_cmd
{
    CAN_CMD_ABORT_TX,                       // argument: transmit mailbox id
    CAN_CMD_RESET_TIMESTAMP,
    CAN_CMD_SET_MODE_COMM,                  // start normal bus communications
    CAN_CMD_SET_MODE_TST_STANDARD,
    CAN_CMD_SET_MODE_TST_LISTEN,
    CAN_CMD_SET_MODE_TST_EXT_LOOPBACK,
    CAN_CMD_SET_MODE_TST_INT_LOOPBACK,
    CAN_CMD_END_ENUM
} can_cmd_t;
```

2.11 Return Values

API function return values. This enum is found in r_rscan_rx_if.h along with the API function declarations.

```
typedef enum e_can_err          // CAN API error codes
{
    CAN_SUCCESS=0,
    CAN_ERR_OPENED,             // Call to Open already made
    CAN_ERR_NOT_OPENED,         // Call to Open not yet made
    CAN_ERR_INIT_DONE,          // Call to InitChan already made for channel
    CAN_ERR_CH_NO_INIT,         // Channel not initialized
    CAN_ERR_INVALID_ARG,        // Invalid argument passed to function
    CAN_ERR_MISSING_CALLBACK,   // Callback func not provided and ints requested
    CAN_ERR_MAX_RULES,          // Max configured rules already present
    CAN_ERR_BOX_FULL,           // Transmit mailbox or FIFO is full
    CAN_ERR_BOX_EMPTY,          // Receive mailbox or FIFO is full
    CAN_ERR_ILLEGAL_MODE        // Not in proper mode for request
} can_err_t;
```

2.12 Adding the Module to Your Project

For detailed explanation of how to add a FIT Module to your project, see document R01AN1723EU “Adding FIT Modules to Projects”.

In general, a FIT Module may be added in 3 ways:

1. Using e2studio File>New>Renesas FIT Module. This adds the module and project include paths.
2. Using e2studio File>Import>General>Archive File from the project context menu.
3. Unzipping the .zip file into the project directory directly from Windows.

When using methods 2or 3, the include paths must be manually added to the project. This is done in e2studio from the project context menu by selecting Properties>C/C++ Build>Settings and selecting Compiler>Source in the ToolSettings tab. The green “+” sign in the box to the right is used to pop a dialog box to add the include paths. In that box, click on the Workspace button and select the directories needed from the project tree structure displayed. The directories needed for this module are:

- ${workspace_loc:/${ProjName}/r_rscan_rx
- ${workspace_loc:/${ProjName}/r_rscan_rx/src
- ${workspace_loc:/${ProjName}/r_config

Regardless of the method used to add the FIT Module and include paths to your project, it is necessary to configure the module for your application. Options available for configuration may be found and edited in:

- \r_config\r_rscan_rx_config.h.

A reference copy (not for editing) containing the default values for this file is stored in:

- \r_rscan_rx\ref\r_rscan_rx_config_reference.h.

Any application file which calls a module’s API function should include the interface file “r_rscan_rx_if.h” and configuration file “r_rscan_rx_config.h”. This file contains the API function declarations and all structures and enumerations necessary to use the module.

3. API Functions

3.1 Summary

The following functions are included in this design:

Function	Description
R_CAN_Open()	Initializes the driver's internal structures and all of the receive mailboxes.
R_CAN_InitChan()	Sets the bit rate clock for the channel and initializes all of the transmit mailboxes.
R_CAN_ConfigFIFO()	Initializes a FIFO for usage. This function should not be called if FIFOs are not used.
R_CAN_AddRxRule()	Adds a receive rule to a channel. Specifies receive message filter and destination routing.
R_CAN_SendMsg()	Loads a message into a transmit mailbox or FIFO for transmission.
R_CAN_GetMsg()	Fetches a message from a receive mailbox or FIFO.
R_CAN_GetHistoryEntry()	Fetches a log entry from a transmit history FIFO.
R_CAN_GetStatusMask()	Returns a 32-bit mask based upon the status requested. Bit #defines have the form CAN_MASK_xxx.
R_CAN_GetCountFIFO()	Returns the number of messages in a FIFO.
R_CAN_GetCountErr()	Returns the number of transmit or receive errors.
R_CAN_Control()	Handles special operations and mode changes.
R_CAN_Close()	Removes power to the CAN peripheral and disables the associated interrupts.
R_CAN_GetVersion()	Returns the driver version number.

3.2 R_CAN_Open()

This function initializes the driver's internal structures and all of the receive mailboxes.

Format

```
can_err_t  R_CAN_Open(can_cfg_t  *p_cfg,
                      void      (* const p_callback)(can_cb_evt_t  event,
                                                     void          *p_args));
```

Parameters

p_cfg

Pointer to configuration structure. The element type definitions are provided in Section 2.10.1.

```
typedef struct st_can_cfg
{
    can_timestamp_src_t     ts_source;
    can_timestamp_div_t     ts_divisor;
} can_cfg_t;
```

p_callback

Optional pointer to main callback function. Must be present if interrupts are enabled in r_rscan_rx_config.h for RX FIFOs or global errors

event

First parameter for callback function. Specifies the interrupt source (see Section 2.10.3)

p_args

Second parameter for callback function (unused).

Return Values

CAN_SUCCESS:	*Successful*
CAN_ERR_OPENED:	*Call to Open already made*
CAN_ERR_INVALID_ARG:	*An element of the p_cfg structure contains an invalid value.*
CAN_ERR_MISSING_CALLBACK:	*A callback function was not provided and a main callback interrupt is enabled in config.h*

Properties

Prototyped in file "r_rscan_rx_if.h"

Description

This function initializes the driver's internal structures, applies clock to the peripheral, and sets the Global and Channel Modes to Reset. The timestamp is configured as per the p_cfg argument, and all receive mailboxes are initialized.

If interrupts are enabled in r_rscan_rx_config.h for receive FIFO thresholds, or DLC or FIFO overflow errors, a callback function must be provided here. Otherwise, NULL is entered.

Reentrant

No.

Example: Polling Configuration

```
    /* All main callback interrupt sources are set to 0 in r_rscan_rx_config.h
*/

    can_cfg_t    config;
    can_err_t    err;

    /* Configure timestamp and Open driver */
    config.timestamp_src = CAN_TIMESTAMP_SRC_HALF_PCLK;
```

```
    config.timestamp_div = CAN_TIMESTAMP_DIV_1024;
    err = R_CAN_Open(&config, NULL);
```

Example: Interrupt Configuration

```
    /* 1+ main callback interrupt sources are set to 1 in r_rscan_rx_config.h */

    can_cfg_t    config;
    can_err_t    err;

    /* Configure timestamp and Open driver */
    config.timestamp_src = CAN_TIMESTAMP_SRC_HALF_PCLK;
    config.timestamp_div = CAN_TIMESTAMP_DIV_1024;
    err = R_CAN_Open(&config, MyCallback);
```

```
/* Sample callback function */
void MyCallback(can_cb_evt_t event, void *p_args)
{
uint32_t   mask;
can_err_t  err;

    if (event == CAN_EVT_RXFIFO_THRESHOLD)
    {
        mask = R_CAN_GetStatusMask(CAN_STAT_FIFO_THRESHOLD, NULL, &err);

        /* check RXFIFOs in use */
        if (mask & CAN_MASK_RXFIFO_1)
        {
             /* read messages */
        }
    }
    else if (event == CAN_EVT_GLOBAL_ERR)
    {
        mask = R_CAN_GetStatusMask(CAN_STAT_GLOBAL_ERR, NULL, &err);

        if (mask & CAN_MASK_ERR_DLC)
        {
            /* handle DLC error */
        }

        if (mask & CAN_MASK_ERR_FIFO_OVFL)
        {
            mask = R_CAN_GetStatusMask(CAN_STAT_FIFO_OVFL, NULL, &err);

            /* check the RXFIFOs, GWFIFO, and HIST_FIFOs in use */
            if (mask & CAN_MASK_HIST_FIFO)
            {
                /* handle error */
            }
        }
    }
}
```

Special Notes:
The ports pins used by the RSCAN peripheral should be initialized prior to calling R_CAN_Open(). Here are some examples:

RX231:

```
    R_BSP_RegisterProtectDisable(BSP_REG_PROTECT_MPC);

    PORT5.PODR.BIT.B5 = 1;
    PORT5.PODR.BIT.B4 = 0;
    MPC.P54PFS.BYTE = 0x10;     // Pin Func Select P54 CTXD0
    MPC.P55PFS.BYTE = 0x10;     // Pin Func Select P55 CRXD0
    PORT5.PDR.BIT.B4 = 1;       // set TX pin direction to output
    PORT5.DSCR.BIT.B4 = 1;      // High-drive output
    PORT5.PDR.BIT.B5 = 0;       // set RX pin direction to input (dflt)
    PORT5.PMR.BIT.B4 = 1;       // set TX pin mode to peripheral
    PORT5.PMR.BIT.B5 = 1;       // set RX pin mode to peripheral

    R_BSP_RegisterProtectEnable(BSP_REG_PROTECT_MPC);
```

RX24T:

```
    R_BSP_RegisterProtectDisable(BSP_REG_PROTECT_MPC);

    PORTA.PODR.BIT.B1 = 1;
    PORTA.PODR.BIT.B0 = 0;
    MPC.PA0PFS.BYTE = 0x10;     // Pin Func Select PA0 CTXD0
    MPC.PA1PFS.BYTE = 0x10;     // Pin Func Select PA1 CRXD0
    PORTA.PDR.BIT.B0 = 1;       // set TX pin direction to output
    PORTA.DSCR.BIT.B0 = 1;      // High-drive output
    PORTA.PDR.BIT.B1 = 0;       // set RX pin direction to input (dflt)
    PORTA.PMR.BIT.B0 = 1;       // set TX pin mode to peripheral
    PORTA.PMR.BIT.B1 = 1;       // set RX pin mode to peripheral

    R_BSP_RegisterProtectEnable(BSP_REG_PROTECT_MPC);
```

RX24U:

```
    R_BSP_RegisterProtectDisable(BSP_REG_PROTECT_MPC);

    PORTF.PODR.BIT.B3 = 1;
    PORTF.PODR.BIT.B2 = 0;
    MPC.PF2PFS.BYTE = 0x10;     // Pin Func Select PF2 CTXD0
    MPC.PF3PFS.BYTE = 0x10;     // Pin Func Select PF3 CRXD0
    PORTF.PDR.BIT.B2 = 1;       // set TX pin direction to output
    PORTF.DSCR.BIT.B2 = 1;      // High-drive output
    PORTF.PDR.BIT.B3 = 0;       // set RX pin direction to input (dflt)
    PORTF.PMR.BIT.B2 = 1;       // set TX pin mode to peripheral
    PORTF.PMR.BIT.B3 = 1;       // set RX pin mode to peripheral

    R_BSP_RegisterProtectEnable(BSP_REG_PROTECT_MPC);
```

3.3 R_CAN_InitChan()

This function sets the bit rate clock for the channel and initializes all of the transmit mailboxes.

Format

```
can_err_t  R_CAN_InitChan(uint8_t        chan,
                          can_bitrate_t  *p_baud,
                          void   (* const p_chcallback)(uint8_t       chan,
                                                        can_cb_evt_t  event,
                                                        void          *p_args));
```

Parameters

chan

Channel to initialize (0 is only valid value).

p_baud

Pointer to bit rate structure. See the “Bit Timing Setting” section under CAN Module in the Hardware Manual or section 5.3 in the RSCAN Firmware Integration Technology Usage Manual (R01AN3455EU) for calculating settings. Some default values are provided in r_rscan_rx_if.h.

```
typedef struct st_can_bitrate
{
    uint16_t    prescaler;
    uint8_t     tseg1;
    uint8_t     tseg2;
    uint8_t     sjw;
} can_bitrate_t;
```

p_chcallback

Optional pointer to channel callback function. Must be present if interrupts are enabled in r_rscan_rx_config.h for TX mailboxes, TX FIFOs, History FIFOs, or bus errors.

channel

First parameter for channel callback function. Specifies the channel interrupt occurred on (always 0).

event

Second parameter for channel callback function. Specifies the interrupt source (see Section 2.10.3)

p_args

Third parameter for callback function (unused).

Return Values

CAN_SUCCESS:	*Successful*
CAN_ERR_ILLEGAL_MODE:	*Not in global reset mode (results from call to Open())*
CAN_ERR_INVALID_ARG:	*An invalid argument was provided*
CAN_ERR_MISSING_CALLBACK:	*A callback function was not provided and a channel interrupt is enabled in config.h*

Properties

Prototyped in file “r_rscan_rx_if.h”

Description

This function initializes all of the channel’s transmit mailboxes, sets the bit rate, and enables interrupt sources for the channel as specified in the r_rscan_rx_config.h file. Default values for *p_baud* are provided in r_rscan_rx_if.h.

If interrupts are enabled in r_rscan_rx_config.h for TX mailboxes, TX FIFOs, History FIFOs, or bus errors, a callback function must be provided here. Otherwise, NULL is entered.

Reentrant

Yes, for different channels.

Example: Polling Configuration

```
    /* All channel interrupt sources are set to 0 in r_rscan_rx_config.h */

    can_bitrate_t    baud;
    can_err_t        err;

    /* Initialize channel 0 for RSKRX231 */
    baud.prescaler = CAN_RSK_8MHZ_XTAL_500KBPS_PRESCALER;
    baud.tseg1 = CAN_RSK_8MHZ_XTAL_500KBPS_TSEG1;
    baud.tseg2 = CAN_RSK_8MHZ_XTAL_500KBPS_TSEG2;
    baud.sjw = CAN_RSK_8MHZ_XTAL_500KBPS_SJW;

    err = R_CAN_InitChan(CAN_CH0, &baud, NULL);
```

Example: Interrupt Configuration

```
    /* 1+ channel interrupt sources are set to 1 in r_rscan_rx_config.h */

    can_bitrate_t    baud;
    can_err_t        err;

    /* Initialize channel 0 for RSKRX231 */
    baud.prescaler = CAN_RSK_8MHZ_XTAL_500KBPS_PRESCALER;
    baud.tseg1 = CAN_RSK_8MHZ_XTAL_500KPS_TSEG1;
    baud.tseg2 = CAN_RSK_8MHZ_XTAL_500KPS_TSEG2;
    baud.sjw = CAN_RSK_8MHZ_XTAL_500KPS_SJW;

    err = R_CAN_InitChan(CAN_CH0, &baud, MyChanCallback);
```

```
/* Sample callback function template */
void MyChanCallback(uint8_t       chan,
                    can_cb_evt_t  event,
                    void          *p_args)
{
uint32_t   mask;
can_err_t  err;

    if (event == CAN_EVT_TRANSMIT)
    {
        mask = R_CAN_GetStatusMask(CAN_STAT_CH_TXMBX_SENT, chan, &err);

        /* check transmit mailboxes in use */
        if (mask & CAN_MASK_TXMBX_3)
        {
            /* do stuff */
        }

        mask = R_CAN_GetStatusMask(CAN_STAT_CH_TXMBX_ABORTED, chan, &err);

        /* check transmit mailboxes in use */
        if (mask & CAN_MASK_TXMBX_0)
        {
            /* do stuff */
        }

        mask = R_CAN_GetStatusMask(CAN_STAT_FIFO_THRESHOLD, NULL, &err);

        /* check transmit and history FIFOs in use */
```

```
        if (mask & CAN_MASK_TXFIFO)
        {
            /* load next batch of messages for transmit */
        }
    }

    else if (event == CAN_EVT_CHANNEL_ERR)
    {
        mask = R_CAN_GetStatusMask(CAN_STAT_CH_ERROR, chan, &err);

        /* check individual errors if desired */
        if (mask & CAN_MASK_ERR_BUS_OFF_ENTRY)
        {
            /* handle error */
        }

        if (mask & CAN_MASK_ERR_BUS_OFF_EXIT)
        {
            /* handle recovery */
        }
    }
}
```

Special Notes:
None.

3.4 R_CAN_ConfigFIFO()

This function initializes a FIFO for usage. This function should not be called if FIFOs are not used.

Format

```
can_err_t  R_CAN_ConfigFIFO(can_box_t             fifo,
                            can_fifo_threshold_t  threshold,
                            can_box_t             txmbx);
```

Parameters

fifo_id

Box id for FIFO (see Section 2.10.1)

threshold

Number of messages needed in FIFO to set interrupt flag (see Section 2.10.5). Note that the only valid thresholds for the History FIFOs is 1 or 6 entries. All others may use 1, 2, 3, or full (4).

txmbx

Box id for associated transmit mailbox (for transmit FIFOs only). This argument is ignored for receive and history FIFOs.

Return Values

CAN_SUCCESS:	*Successful*
CAN_ERR_ILLEGAL_MODE:	*Not in global reset mode (results from call to Open())*
CAN_ERR_CH_NO_INIT:	*Channel not initialized yet*
CAN_ERR_INVALID_ARG:	*An invalid argument was provided*
CAN_ERR_MAX_ONE_GWFIFO:	*Can only configure one gateway FIFO*

Properties

Prototyped in file “r_rscan_rx_if.h”

Description

FIFO usage is optional.

This function is used to activate a FIFO. Transmit and receive FIFOs are 4 entries deep (history FIFO is 8 deep). The transmit FIFO must have associated with it a standard transmit mailbox. The number of the mailbox determines the priority of the FIFO when transmitting (mailbox 0 = highest priority; mailbox 3 = lowest).

Reentrant

Yes, for different FIFOs.

Example: RX FIFO

```
    can_err_t        err;

    /*
     * Set interrupt flag on every message received on RX FIFO 0.
     * Interrupt occurs if CAN_CFG_INT_RXFIFO_THRESHOLD is set to 1 in config.h.
     * Interrupt calls main callback function with CAN_EVT_RXFIFO_THRESHOLD.
     */
    err = R_CAN_ConfigFIFO(CAN_BOX_RXFIFO_0,
                           CAN_FIFO_THRESHOLD_1,
                           CAN_BOX_NONE);              // unused field here
```

Example: TX FIFO

```
    can_err_t        err;

    /*
```

```
     * Associate mailbox 3 with TX FIFO 0 on channel 0.
     * Set interrupt flag when 2 messages remain in FIFO.
     * Interrupt occurs if CAN_CFG_INT_TXFIFO_THRESHOLD is set to 1 in config.h.
     * Interrupt calls channel callback function with CAN_EVT_TRANSMIT.
     */
    err = R_CAN_ConfigFIFO(CAN_BOX_TXFIFO,
                           CAN_FIFO_THRESHOLD_2,
                           CAN_BOX_CH0_TXMBX_3);
```

Example: History FIFO

```
  can_err_t        err;

 /*
  * Set threshold to 6 for History FIFO.
  * Interrupt occurs if CAN_CFG_INT_HIST_FIFO_THRESHOLD is set to 1 in config.h.
  * Interrupt calls channel callback function with CAN_EVT_TRANSMIT.
  */
  err = R_CAN_ConfigFIFO(CAN_BOX_HIST_FIFO,
                         CAN_FIFO_THRESHOLD_6,
                         CAN_BOX_NONE);                // unused field here
```

Special Notes:
None.

3.5 R_CAN_AddRxRule()

This function adds a receive rule to a channel. Specifies receive message filter and destination routing.

Format

```
can_err_t  R_CAN_AddRxRule(uint8_t        chan,
                           can_filter_t   *p_filter,
                           can_box_t      dst_box);
```

Parameters

chan

Channel to apply rule to (always 0)

p_filter

Pointer to rule information.

```
typedef struct st_can_filter
{
    bool_t      check_ide;
    uint8_t     ide;
    bool_t      check_rtr;
    uint8_t     rtr;
    uint32_t    id;
    uint32_t    id_mask;
    uint8_t     min_dlc;
    uint16_t    label;          // 12-bit label
} can_filter_t;
```

dst_box

Destination box (receive mailbox or receive FIFO) to route message to (see Section 2.10.1).

Return Values

CAN_SUCCESS:	*Successful*
CAN_ERR_ILLEGAL_MODE:	*Not in global reset mode (results from call to Open())*
CAN_ERR_CH_NO_INIT:	*Channel not initialized yet*
CAN_ERR_INVALID_ARG:	*An invalid argument was provided*
CAN_ERR_MAX_RULES:	*Max rules already present (as defined in r_rscan_rx_config.h,*

Properties

Prototyped in file “r_rscan_rx_if.h”

Description

This function is used to add a receive rule to a channel. There are two parts to this. The first part is specifying a filter as to which fields to inspect on received messages. The second part is to specify a destination to route the message to if it passes the filter test.

A “1” in the *id_mask* field indicates that the corresponding bit in a received message ID will be checked against the bit in the *id* field in this filter (see Examples).

The *label* field in the rule is optional. It is associated with each message that passes the filter. This may serve as a quick identification of a message when it is fetched from a receive box (mailbox or FIFO) using R_CAN_GetMsg()..

Reentrant

No.

Example 1: Match a range of messages

```
    can_filter_t  filter;
    can_err_t     err;

    /* Setup filter */
    filter.check_ide = TRUE;  // check the IDE field in message
```

```
    filter.ide = 0;           // 11-bit ID
    filter.check_rtr = FALSE; // do not check the RTR field in message
    filter.rtr = 0;           // (value does not matter here; not checking)
    filter.id = 0x040;        // message ID
    filter.id_mask = 0x7F0;   // messages with IDs of 0x040-0x04F are accepted
    filter.min_dlc = 4;       // message data must be at least four bytes long
    filter.label = 0x800;     // arbitrary label applied to msgs of this type


    /* Add rule to channel 0. Route filtered messages to receive mailbox 3. */
    err = R_CAN_AddRxRule(CAN_CH0, &filter, CAN_BOX_RXMBX_3);
```

Example 2: Exact match for message

```
    can_filter_t  filter;
    can_err_t     err;

    /* Setup filter */
    filter.check_ide = TRUE;  // check the IDE field in message
    filter.ide = 0;           // 11-bit ID
    filter.check_rtr = FALSE; // do not check the RTR field in message
    filter.rtr = 0;           // (value does not matter here; not checking)
    filter.id = 0x040;        // message ID
    filter.id_mask = 0x7FF;   // ID must match 0x040 exactly
    filter.min_dlc = 6;       // message data must be at least six bytes long
    filter.label = 0x700;     // arbitrary label applied to msgs of this type


    /* Add rule to channel 0. Route filtered messages to receive mailbox 2. */
    err = R_CAN_AddRxRule(CAN_CH0, &filter, CAN_BOX_RXMBX_2);
```

Special Notes:

Rules cannot be entered after entering communications mode.

3.6 R_CAN_Control()

This function handles special operations and mode changes.

Format

```
can_err_t  R_CAN_Control(can_cmd_t  cmd,
                         uint32_t   arg1);
```

Parameters

cmd

Specifies which command to run.

```
typedef enum e_can_cmd
{
    CAN_CMD_ABORT_TX,                   // argument: transmit mailbox id
    CAN_CMD_RESET_TIMESTAMP,
    CAN_CMD_SET_MODE_COMM,              // start normal bus communications
    CAN_CMD_SET_MODE_TST_STANDARD,
    CAN_CMD_SET_MODE_TST_LISTEN,
    CAN_CMD_SET_MODE_TST_EXT_LOOPBACK,
    CAN_CMD_SET_MODE_TST_INT_LOOPBACK,
    CAN_CMD_END_ENUM
} can_cmd_t;
```

arg1

Argument which is specific to command. Most commands do not require an argument.
For the command CAN_CMD_ABORT_TX, the argument is a transmit mailbox id (see Section 2.10.1).

Return Values

CAN_SUCCESS:	*Successful*
CAN_ERR_INVALID_ARG:	*An invalid argument was provided*
CAN_ERR_ILLEGAL_MODE:	*Changing to requested mode is illegal from current mode.*

Properties

Prototyped in file “r_rscan_rx_if.h”

Description

This function is used for resetting the timestamp counter, aborting transmission of mailbox messages, and changing the CAN mode.

The following sequence of function calls is used to setup the CAN:

```
R_CAN_Open();
R_CAN_InitChan();
R_CAN_ConfigFIFO(); // do for 0 or more FIFOs
R_CAN_AddRxRule();  // do for 1-16 rules
```

Once the CAN is setup, the peripheral should enter normal communications mode or a test mode.

```
R_CAN_Control();    // Use CAN_CMD_SET_MODE_COMM or CAN_CMD_SET_MODE_TST_xxx
```

Note: If a Bus Off condition is detected on a channel, the channel enters Halt Mode and all communications cease. They cannot resume until after a Bus Off Recovery condition is detected and the application calls R_CAN_Control(CAN_CMD_SET_MODE_COMM).

Reentrant

Yes.

Example: Enter Normal Communications Mode

```
can_err_t  err;
```

```
    err = R_CAN_Control(CAN_CMD_SET_MODE_COMM, 0);
```

Example: Abort Transmit

```
    can_err_t  err;

    /* Abort transmit on mailbox 6 on channel 0*/
    err = R_CAN_Control(CAN_CMD_ABORT_TX, CAN_BOX_CH0_TXMBX_6);
```

Special Notes:

Summary of different test modes:

- Standard Test Mode: Allows for CRC testing
- Listen-only Mode: Used for detecting communication speed. Cannot call R_CAN_SendMsg() in this mode.
- Internal Loopback Mode: Messages sent on a channel are handled as received messages and processed on that same channel. Here, the CAN transceiver is bypassed.
- External Loopback Mode: Same as Internal Loopback mode, only the transceiver is used.

3.7 R_CAN_SendMsg()

This function loads a message into a transmit mailbox or FIFO for transmission.

Format

```
can_err_t  R_CAN_SendMsg(can_box_t    box_id,
                         can_txmsg_t  *p_txmsg);
```

Parameters

box_id

Transmit box id (mailbox or FIFO; see Section 2.10.1)

p_msg

Pointer to message to send

```
typedef struct st_can_txmsg
{
    uint8_t     ide;
    uint8_t     rtr;
    uint32_t    id;
    uint8_t     dlc;
    uint8_t     data[8];
    bool_t      one_shot;       // no retries on error; txmbx only
    bool_t      log_history;    // true if want to log
    uint8_t     label;          // 8-bit label for History FIFO
} can_txmsg_t;
```

Return Values

CAN_SUCCESS:	*Successful*
CAN_ERR_INVALID_ARG:	*An invalid argument was provided*
CAN_ERR_BOX_FULL:	*Transmit mailbox or FIFO is full*
CAN_ERR_ILLEGAL_MODE:	*Cannot send message in current mode.*

Properties

Prototyped in file “r_rscan_rx_if.h”

Description

This function places a message into a 1-message deep transmit mailbox or 4-message deep transmit FIFO. If there is already a message waiting to send in the mailbox, or 4 messages already exist in the FIFO, CAN_ERR_BOX_FULL is returned immediately. If the box_id is for a transmit mailbox and interrupts are not enabled (CAN_CFG_INT_MBX_TX_COMPLETE is 0), this function blocks until the message is sent. If interrupts are enabled or the message is for a transmit FIFO, the function will return immediately after loading the message into the transmit registers.

Reentrant

Yes, for different boxes.

Example:

```
    can_txmsg_t   txmsg;
    can_err_t     err;

    /* Setup message */
    txmsg.ide = 0;                // ID field is 11-bits
    txmsg.rtr = 0;                // local message
    txmsg.id = 0x022;             // destination ID
    txmsg.dlc = 5;                // data length
    txmsg.data[0] = ‘h’;          // data…
    txmsg.data[1] = ‘e’;
    txmsg.data[2] = ‘l’;
    txmsg.data[3] = ‘l’;
```

```
    txmsg.data[4] = ‘o’;
    txmsg.one_shot = false;       // do normal retries on error
    txmsg.log_history = false;    // do not log in History FIFO
    txmsg.label = 0;              // (label ignored because not logging message)

    /*
     * Place message in transmit mailbox 2
     * If transmit complete interrupt is not enabled, the function returns
     *   after the message has been sent (assuming no error occurred).
     */
    err = R_CAN_SendMsg(CAN_BOX_CH0_TXMBX_2, &txmsg);
```

Special Notes:
None.

3.8 R_CAN_GetMsg()

This function fetches a message from a receive mailbox or FIFO.

Format

```
can_err_t  R_CAN_GetMsg(can_box_t    box_id,
                        can_rxmsg_t  *p_rxmsg);
```

Parameters

box_id

Receive box id (mailbox or FIFO; see Section 2.10.1)

p_rxmsg

Pointer to message buffer to load

```
typedef struct st_can_rxmsg
{
    uint8_t     ide;
    uint8_t     rtr;
    uint32_t    id;
    uint8_t     dlc;
    uint8_t     data[8];
    uint16_t    label;          // 12-bit label from receive rule
    uint16_t    timestamp;
} can_rxmsg_t;
```

Return Values

CAN_SUCCESS:	*Successful*
CAN_ERR_CH_NO_INIT:	*Channel not initialized yet*
CAN_ERR_INVALID_ARG:	*An invalid argument was provided*
CAN_ERR_BOX_EMPTY:	*No message available to fetch*

Properties

Prototyped in file “r_rscan_rx_if.h”

Description

This function loads the message from a receive mailbox or FIFO into the message buffer provided. If there are no messages in the box, this function does not block and returns a CAN_ERR_BOX_EMPTY.

Reentrant

Yes, for different boxes.

Example:

```
    can_rxmsg_t   rxmsg;
    can_err_t     err;

    /* Wait for message to appear in receive mailbox 3 */
    while (R_CAN_GetMsg(CAN_BOX_RXMBX_3, &rxmsg) == CAN_ERR_BOX_EMPTY)
        ;

    /* rxmsg contains message */
```

Special Notes:

None.

3.9 R_CAN_GetHistoryEntry()

This function fetches a log entry from a transmit history FIFO.

Format

```
can_err_t  R_CAN_GetHistoryEntry(can_box_t      box_id,
                                 can_history_t  *p_entry);
```

Parameters

box_id

Transmit history FIFO (see Section 2.10.1)

p_rxmsg

Pointer to entry buffer to load

```
typedef struct st_can_history
{
    can_box_t   box_id;   // box which sent message
    uint8_t     label;    // associated 8-bit label
} can_history_t;
```

Return Values

CAN_SUCCESS:	*Successful*
CAN_ERR_INVALID_ARG:	*An invalid argument was provided*
CAN_ERR_BOX_EMPTY:	*No entry available to fetch*

Properties

Prototyped in file “r_rscan_rx_if.h”

Description

An entry is added to the history FIFO each time an R_CAN_SendMsg() is called with the “log_history” in the argument structure is set to TRUE. This function loads a log entry from a transmit history FIFO into the entry buffer provided. If there are no entries in the FIFO, this function does not block and returns a CAN_ERR_BOX_EMPTY. The use of this feature is not required for normal operations.

Reentrant

Yes, for different boxes.

Example:

```
can_history_t   entry;
can_err_t       err;

/* Process all entries in transmit history FIFO */
while (R_CAN_GetMsg(CAN_BOX_HIST_FIFO, &entry) == CAN_SUCCESS)
{
    /* process entries here */
}
```

Special Notes:

None.

3.10 R_CAN_GetStatusMask()

This function returns a 32-bit mask based upon the status requested. Bit #defines have the form CAN_MASK_xxx.

Format

```
uint32_t  R_CAN_GetStatusMask(can_stat_t  type,
                              uint8_t     chan,
                              can_err_t   *p_err);
```

Parameters

type

Specifies which status to return.

```
typedef enum e_can_stat
{
    CAN_STAT_FIFO_EMPTY,
    CAN_STAT_FIFO_THRESHOLD,
    CAN_STAT_FIFO_OVFL,          // bits reset after reading
    CAN_STAT_RXMBX_FULL,
    CAN_STAT_GLOBAL_ERR,         // DLC error bit is reset after reading
    CAN_STAT_CH_TXMBX_SENT,      // bits reset after reading
    CAN_STAT_CH_TXMBX_ABORTED,   // bits reset after reading
    CAN_STAT_CH_ERROR,           // bits reset after reading
    CAN_STAT_END_ENUM
} can_stat_t;
```

chan

Specifies which channel to return status for (must be 0). Applies only to `CAN_STAT_CH_xxx` requests.

p_err

Pointer to returned error code.

CAN_SUCCESS:	*Successful*
CAN_ERR_INVALID_ARG:	*An invalid argument was provided*

Return Values

32-bit box or error mask whose bit definitions have the form CAN_MASK_xxx and are defined in Section 2.10.10.

Properties

Prototyped in file “r_rscan_rx_if.h”

Description

This function returns a mask based upon the status type requested. All bit masks have the form CAN_MASK_xxx (see Section 2.10.10).

Reentrant

Yes.

Example

```
can_err_t   err;
can_rxmsg_t rxmsg;


/* Wait for a message to come in on any receive mailbox */
while (R_CAN_GetStatusMask(CAN_STAT_RXMBX_FULL, 0, &err) == 0)
    ;

/* Check if receive mailbox 3 is full */
if (R_CAN_GetStatusMask(CAN_STAT_RXMBX_FULL, 0, &err) & CAN_MASK_RXMBX_3)
{
    /* get message */
    R_CAN_GetMsg(CAN_BOX_RXMBX_3, &rxmsg);
}
```

Special Notes:
None.

3.11 R_CAN_GetCountFIFO()

This function returns the number of items in a FIFO.

Format

```
uint32_t  R_CAN_GetCountFIFO(can_box_t  box_id,
                             can_err_t  *p_err);
```

Parameters

box_id

Specifies which FIFO to check (see Section 2.10.1).

p_err

Pointer to returned error code.

CAN_SUCCESS:	*Successful*
CAN_ERR_INVALID_ARG:	*An invalid argument was provided*

Return Values

Number of items in the FIFO

Properties

Prototyped in file “r_rscan_rx_if.h”

Description

This function returns the number of items in the FIFO specified by *box_id*. This function is not required for normal operations.

Reentrant

Yes.

Example

```
    uint32_t   cnt;
    can_err_t  err;

    /* Determine the number of messages in the History FIFO for channel 0 */
    cnt = R_CAN_GetCountFIFO(CAN_BOX_CH1_HIST_FIFO, &err);
```

Special Notes:

All FIFO usage is optional.

3.12 R_CAN_GetCountErr()

Returns the number of transmit or receive errors.

Format

```
uint32_t  R_CAN_GetCountErr(can_count_t  type,
                            uint8_t      chan,
                            can_err_t    *p_err);
```

Parameters

type

Specifies which status to return.

```
typedef enum e_can_count
{
    CAN_COUNT_RX_ERR,
    CAN_COUNT_TX_ERR,
    CAN_STAT_END_ENUM
} can_count_t;
```

chan

Specifies which channel to return error count for (must be 0).

p_err

Pointer to returned error code.

CAN_SUCCESS:	*Successful*
CAN_ERR_INVALID_ARG:	*An invalid argument was provided*

Return Values

The number of errors detected.

Properties

Prototyped in file “r_rscan_rx_if.h”

Description

This function returns the number of receive or transmit errors on a channel based upon the count type requested.

Reentrant

Yes.

Example

```
uint32_t   rxcnt,txcnt;
can_err_t  err;

/* Get the number of errors detected */
rxcnt = R_CAN_GetCountErr(CAN_COUNT_RX_ERR, CAN_CH0, &err);
txcnt = R_CAN_GetCountErr(CAN_COUNT_TX_ERR, CAN_CH0, &err);
```

Special Notes:

This use of this function is optional. It can be used to detect the health of the network and how close the network is to entering the Error Passive state (128 errors) or Bus Off state (255 errors).

:

3.13 R_CAN_Close()

This function removes clock from the CAN peripheral and disables the associated interrupts.

Format

```
void  R_CAN_Close(void);
```

Parameters

None

Return Values

None

Properties

Prototyped in file “r_rscan_rx_if.h”

Description

This function halts all existing communications, disables all interrupts (if any), and shuts down the peripheral.

Reentrant

Yes, but no need to ever call more than once.

Example

```
    R_CAN_Close();
```

Special Notes:

None.

3.14 R_CAN_GetVersion()

This function returns the driver version number at runtime.

Format

```
uint32_t  R_CAN_GetVersion(void);
```

Parameters

None

Return Values

Version number.

Properties

Prototyped in file “r_rscan_rx_if.h”

Description

Returns the version of this module. The version number is encoded such that the top two bytes are the major version number and the bottom two bytes are the minor version number.

4. Pin Setting

To use the RSCAN FIT module, assign input/output signals of the peripheral function to pins with the multi-function pin controller (MPC). The pin assignment is referred to as the “Pin Setting” in this document. Please perform the pin setting after calling the R_CAN_Open function.

5. Demo Project

Demo projects are complete stand-alone programs. They include function main() that utilizes the module and its dependent modules (e.g.. r_bsp). The standard naming convention for the demo project is <module>_demo_<board> where <module> is the peripheral acronym (e.g. s12ad, cmt, sci) and the <board> is the standard RSK (e.g. rskrx231). For example, rscan FIT module demo project for RSKRX231 will be named as rscan_demo_rskrx231. Similarly the exported .zip file will be <module>_demo_<board>.zip. For the same example, the zipped export/import file will be named as rscan_demo_rskrx231.zip.

5.1 rscan_demo_rskrx231

This program requires the connection of a CAN device (such as a sniffer) capable of receiving and sending messages. The program spins in a loop sending then receiving one message at a time. The messages received must have an ID of 0x60-0x6F and contain at least 4 bytes of data.

The baud rate is set to 500Kbps.

This program can run using either mailboxes without interrupts or FIFOs with interrupts. The desired operation is configured by changing the value of USE_FIFOS in main.c to 0 for mailboxes or 1 for FIFOs.
.

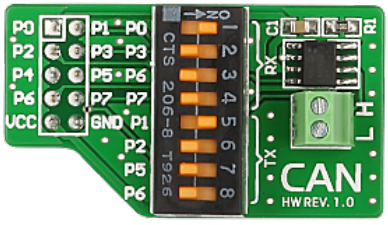
5.2 rscan_demo_rskrx24t

This program requires the connection of a CAN device (such as a sniffer) capable of receiving and sending messages. The program spins in a loop sending then receiving one message at a time. The messages received must have an ID of 0x60-0x6F and contain at least 4 bytes of data.

The baud rate is set to 500Kbps.

This program can run using either mailboxes without interrupts or FIFOs with interrupts. The desired operation is configured by changing the value of USE_FIFOS in main.c to 0 for mailboxes or 1 for FIFOs.

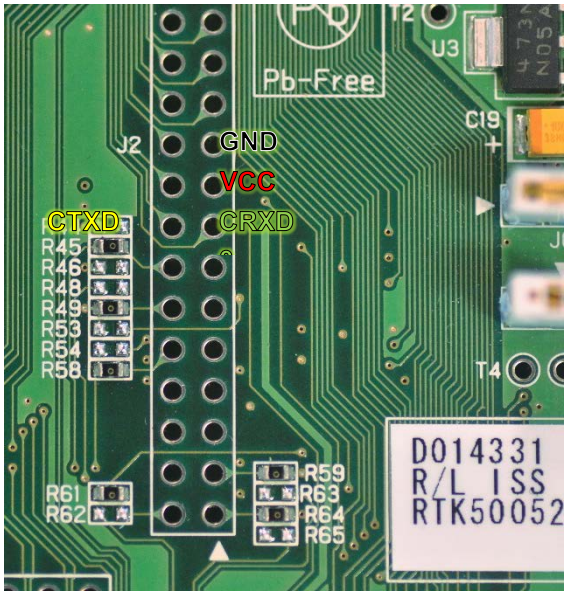
The RSKRX24T must be populated with a large memory version of the RX24T (such as the 512Kb EAxFP) in order to have CAN peripheral support. Additionally, an external CAN transceiver board is required. The following is an example using the MikroElektronika CAN-1 board (www.mikroe.com/add-on-boards/communication/can).

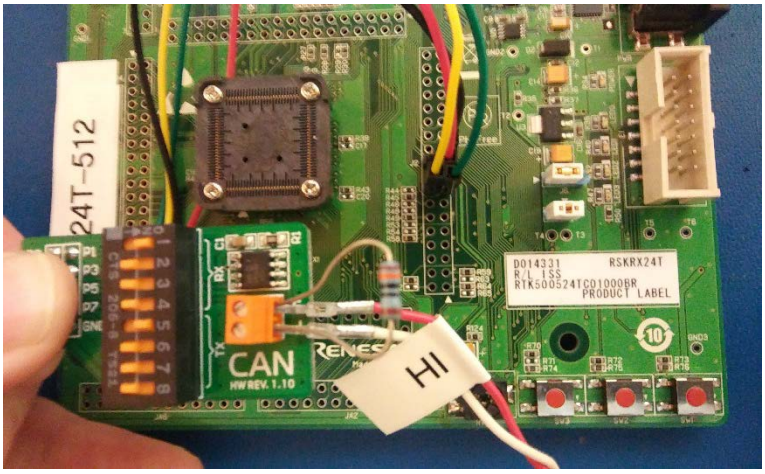


It is recommended to solder a 2x3 header across J2 pins 15-20 on the RSKRX24T. Dip switch lines 1 and 5 should be in the ON position on the CAN-1 board. Connect the boards in the following manner:

	RSKRX24T	CAN-1
CRXD0	J2 pin 15	P0
CTXD0	J2 pin 16	P1
VCC	J2 pin 17	VCC

GND	J2 pin 19	GND
120Ω resistor		P0-P1 *(opt. termination resistor depending upon your network)*





5.3 rscan_demo_rskrx24u

This program requires the connection of a CAN device (such as a sniffer) capable of receiving and sending messages. The program spins in a loop sending then receiving one message at a time. The messages received must have an ID of 0x60-0x6F and contain at least 4 bytes of data.

The baud rate is set to 500Kbps.

This program can run using either mailboxes without interrupts or FIFOs with interrupts. The desired operation is configured by changing the value of USE_FIFOS in main.c to 0 for mailboxes or 1 for FIFOs.

6. Appendices

6.1 Confirmed Operation Environment

This section describes confirmed operation environment for the RSCAN FIT module.

Table 6.1 Confirmed Operation Environment (Rev.2.10)

Item	Contents
Integrated development environment	Renesas Electronics e^2 studio Version 7.5.0
C compiler	Renesas Electronics C/C++ Compiler Package for RX Family V3.01.00 Compiler option: The following option is added to the default settings of the integrated development environment. -lang = c99
Endian	Big endian/little endian
Revision of the module	Rev.2.10
Board used	Renesas Starter Kit+ for RX23W (product No.: RTK5523Wxxxxxxxxx)

Table 6.2 Confirmed Operation Environment (Rev.2.00)

Item	Contents
Integrated development environment	Renesas Electronics e^2 studio Version 7.4.0 IAR Embedded Workbench for Renesas RX 4.10.1
C compiler	Renesas Electronics C/C++ Compiler Package for RX Family V3.01.00 Compiler option: The following option is added to the default settings of the integrated development environment. -lang = c99
	GCC for Renesas RX 4.8.4.201803 Compiler option: The following option is added to the default settings of the integrated development environment. -std=gnu99 Linker option: The following user defined option should be added to the default settings of the integrated development environment, if “Optimize size (-Os)” is used: -Wl,--no-gc-sections This is to work around a GCC linker issue whereby the linker erroneously discard interrupt functions declared in FIT peripheral module
	IAR C/C++ Compiler for Renesas RX version 4.10.1 Compiler option: The default settings of the integrated development environment.
Endian	Big endian/little endian
Revision of the module	Rev.2.00
Board used	Renesas Starter Kit for RX231 (product No.: R0K505231xxxxxx)

6.2 Troubleshooting

(1) Q: I have added the FIT module to the project and built it. Then I got the error: Could not open source file “platform.h”.

A: The FIT module may not be added to the project properly. Check if the method for adding FIT modules is correct with the following documents:

- Using CS+:

  Application note “Adding Firmware Integration Technology Modules to CS+ Projects (R01AN1826)”
- Using e^2 studio:

  Application note “Adding Firmware Integration Technology Modules to Projects (R01AN1723)”

When using a FIT module, the board support package FIT module (BSP module) must also be added to the project. Refer to the application note “Board Support Package Module Using Firmware Integration Technology (R01AN1685)”.

(2) Q: I have added the FIT module to the project and built it. Then I got the error: This MCU is not supported by the current r_rscan_rx module.

A: The FIT module you added may not support the target device chosen in your project. Check the supported devices of added FIT modules.

(3) Q: I have added the FIT module to the project and built it. Then I got an error for when the configuration setting is wrong.

A: The setting in the file “r_rscan_rx_config.h” may be wrong. Check the file “r_rscan_rx_config.h”. If there is a wrong setting, set the correct value for that. Refer to 2.8, Configuration Overview for details.

Revision History

		Description	
Rev.	**Date**	**Page**	**Summary**
1.00	May 20, 2015	—	Initial release
1.10	Sep 12, 2016	1,4,5,17, 18	Added support for RX230, RX24U, and RX24T-512
1.20	Dec 06, 2018	—	Fixed big endian bug. Added __evenaccess to private structure and union definitions.
1.21	Feb 01, 2019	—	Changes associated with functions: Added support setting function of configuration option Using GUI on Smart Configurator. [Description] Added a setting file to support configuration option setting function by GUI.
2.00	May.20.19	—	Supported the following compilers: - GCC for Renesas RX - IAR C/C++ Compiler for Renesas RX
		1	Target Devices: Removed 512KB from RX24T group Added the section of Target compilers. Deleted related documents.
		5	2.3 Software Requirements Requires r_bsp v5.20 or higher
		7	Updated the section of 2.9 Code Size.
		37	Added 4. Pin Setting
		38	Changed section “5. Demo Projects”
		40	Deleted the section of Website and Support.
		40	Added 6. Appendices
		40	6.1 Confirmed Operation Environment: Added table for Rev.2.00
		program	Changed bellow for support GCC and IAR compiler: 1. Deleted the inline expansion of the R_CAN_GetVersion function. 2. Replaced nop with the intrinsic functions of BSP. 3. Replaced the declaration of interrupt functions with the macro definition of BSP.
2.10	Jun.28.19	1	Added support for RX23W
		8	Added code size corresponding to RX23W
		40	6.1 Confirmed Operation Environment: Added Table for Rev.2.10
		Program	Added support for RX23W.

General Precautions in the Handling of Microprocessing Unit and Microcontroller Unit Products

The following usage notes are applicable to all Microprocessing unit and Microcontroller unit products from Renesas. For detailed usage notes on the products covered by this document, refer to the relevant sections of the document as well as any technical updates that have been issued for the products.

1. Precaution against Electrostatic Discharge (ESD)

   A strong electrical field, when exposed to a CMOS device, can cause destruction of the gate oxide and ultimately degrade the device operation. Steps must be taken to stop the generation of static electricity as much as possible, and quickly dissipate it when it occurs. Environmental control must be adequate. When it is dry, a humidifier should be used. This is recommended to avoid using insulators that can easily build up static electricity. Semiconductor devices must be stored and transported in an anti-static container, static shielding bag or conductive material. All test and measurement tools including work benches and floors must be grounded. The operator must also be grounded using a wrist strap. Semiconductor devices must not be touched with bare hands. Similar precautions must be taken for printed circuit boards with mounted semiconductor devices.

2. Processing at power-on

   The state of the product is undefined at the time when power is supplied. The states of internal circuits in the LSI are indeterminate and the states of register settings and pins are undefined at the time when power is supplied. In a finished product where the reset signal is applied to the external reset pin, the states of pins are not guaranteed from the time when power is supplied until the reset process is completed. In a similar way, the states of pins in a product that is reset by an on-chip power-on reset function are not guaranteed from the time when power is supplied until the power reaches the level at which resetting is specified.

3. Input of signal during power-off state

   Do not input signals or an I/O pull-up power supply while the device is powered off. The current injection that results from input of such a signal or I/O pull-up power supply may cause malfunction and the abnormal current that passes in the device at this time may cause degradation of internal elements. Follow the guideline for input signal during power-off state as described in your product documentation.

4. Handling of unused pins

   Handle unused pins in accordance with the directions given under handling of unused pins in the manual. The input pins of CMOS products are generally in the high-impedance state. In operation with an unused pin in the open-circuit state, extra electromagnetic noise is induced in the vicinity of the LSI, an associated shoot-through current flows internally, and malfunctions occur due to the false recognition of the pin state as an input signal become possible.

5. Clock signals

   After applying a reset, only release the reset line after the operating clock signal becomes stable. When switching the clock signal during program execution, wait until the target clock signal is stabilized. When the clock signal is generated with an external resonator or from an external oscillator during a reset, ensure that the reset line is only released after full stabilization of the clock signal. Additionally, when switching to a clock signal produced with an external resonator or by an external oscillator while program execution is in progress, wait until the target clock signal is stable.

6. Voltage application waveform at input pin

   Waveform distortion due to input noise or a reflected wave may cause malfunction. If the input of the CMOS device stays in the area between V_{IL} (Max.) and V_{IH} (Min.) due to noise, for example, the device may malfunction. Take care to prevent chattering noise from entering the device when the input level is fixed, and also in the transition period when the input level passes through the area between V_{IL} (Max.) and V_{IH} (Min.).

7. Prohibition of access to reserved addresses

   Access to reserved addresses is prohibited. The reserved addresses are provided for possible future expansion of functions. Do not access these addresses as the correct operation of the LSI is not guaranteed.

8. Differences between products

   Before changing from one product to another, for example to a product with a different part number, confirm that the change will not lead to problems. The characteristics of a microprocessing unit or microcontroller unit products in the same group but having a different part number might differ in terms of internal memory capacity, layout pattern, and other factors, which can affect the ranges of electrical characteristics, such as characteristic values, operating margins, immunity to noise, and amount of radiated noise. When changing to a product with a different part number, implement a system-evaluation test for the given product.

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