RX Family
SD Mode SD Memory Card Driver Firmware Integration Technology

Introduction

This application note describes the SD Mode SD Memory Card driver which uses Firmware Integration Technology (FIT). This driver controls SD Memory Cards in SD mode using the SD Host Interface (SDHI) module included in Renesas Electronics RX Family microcontrollers. In this document, this driver is referred to as the SD Memory Card driver.

When developing host devices that are compliant with the SD Specifications, the user must enter into the SD Host/Ancillary Product License Agreement (SD HALA).

Please refer for details to SD Association homepage.
https://www.sdcard.org/

Target Device

- RX Family

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”.

Related Documents

- RX Family Board Support Package Module Using Firmware Integration Technology (R01AN1685)
- RX Family DMA Controller DMACA Control Module Using Firmware Integration Technology (R01AN2063EJ)
- RX Family DTC Module Using Firmware Integration Technology (R01AN1819EJ)
- RX Family CMT Module Using Firmware Integration Technology (R01AN1856EJ)
- RX Family LONGQ Module Using Firmware Integration Technology (R01AN1889EJ)
- RX Family SDHI Module Using Firmware Integration Technology (R01AN3852EJ)
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</tr>
</tbody>
</table>
1. Overview

1.1 SD Memory Card driver

By using this product in conjunction with the lower-layer SDHI FIT module, which is available free of charge, it is possible to control an SD Memory Card. By using this product in conjunction with a separately supplied FAT file system, files can be accessed on an SD Memory Card.

Note that the SDHI control software that is common to SD memory and SDIO is referred to as the SD Card driver.

The SD Memory Card driver can be used by being implemented in a project as an API. See section 2.12 Adding the FIT Module to Your Project for details on methods to implement this FIT module into a project.

1.2 Overview of the SD Memory Card driver

Table 1.1 and Table 1.2 list this driver function.

### Table 1.1 SDHI Functions

<table>
<thead>
<tr>
<th>Item</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDHI control driver</td>
<td>Block type device driver with 512-byte/sector</td>
</tr>
<tr>
<td>Target SD Cards</td>
<td>SD Memory Card</td>
</tr>
<tr>
<td>SD Card operating voltage</td>
<td>Only 2.7-3.6 V (high voltage) operation, with 3.3 V signal levels, is supported.</td>
</tr>
<tr>
<td>SD Card bus interface</td>
<td>SD mode (4-bit) is supported.</td>
</tr>
<tr>
<td>Number of SD Cards that can be controlled</td>
<td>One device/channel</td>
</tr>
<tr>
<td>SD Card speed mode</td>
<td>The Default Speed mode are supported. This SD Card driver discriminates the speed mode and initializes the card</td>
</tr>
<tr>
<td>SD Card memory Capacity</td>
<td>Standard Capacity SD Memory Cards (SDSC) and High Capacity SD Memory Cards (SDHC, SDXC) are supported.</td>
</tr>
<tr>
<td>SD Card memory control objects</td>
<td>Only a user area is supported. Protected area control is not supported.</td>
</tr>
<tr>
<td>SD Card detection function</td>
<td>Only detection using the CD pin is supported.</td>
</tr>
</tbody>
</table>

### Table 1.2 Microcontroller Functions

<table>
<thead>
<tr>
<th>Item</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Target microcontroller</td>
<td>RX Family microcontrollers that include the SDHI</td>
</tr>
<tr>
<td>Microcontroller internal data transfer method</td>
<td>Either software, DMAC, or DTC transfer can be selected. When DMAC or DTC transfer is used, separate DMAC transfer or DTC transfer software is required.</td>
</tr>
<tr>
<td>Wait time processing</td>
<td>Waiting using a 1 ms counter standard is supported. It is necessary for the user to provide, separately every 1 ms, calls to an interval timer count processing function for calling every 1 ms.</td>
</tr>
<tr>
<td>Replaceable processing when an OS is used</td>
<td>The wait processing can be replaced with the invoking task delay processing provided by the OS.</td>
</tr>
<tr>
<td>Endian order</td>
<td>Both big endian and little endian are supported.</td>
</tr>
<tr>
<td>Other functions</td>
<td>Firmware Integration Technology (FIT) is supported.</td>
</tr>
</tbody>
</table>
1.2.1 Application Structure

Figure 1.1 shows the application structure when a FAT file system is constructed using this SD Memory Card driver.

![Diagram showing the application structure of an SD Memory Card driver]

- **Pin control module**: Port control, MPC control
- **Peripheral function control module**: Timers, CMT control, DMAC control, DTC control
- **SD memory card driver**: (SD Specifications Part 1 Physical Layer Simplified Specification)
  - **SDHI FIT module**
  - **Target microcontroller settings**: (Target microcontroller interface functions)
  - **Media**
  - **Microcontroller hardware**
  - **Application**
  - **FAT file system layer**: FAT file system
  - **Driver interface function**
  - **Device driver layer**: (SD memory protocol control)
  - **Device driver layer**: (SDHI hardware control)
  - **Hardware layer**

**Figure 1.1 Application Structure**

- Items provided with this SD memory card driver
- Sample programs that can be provided separately
(1) **FAT File System**

This is the software used for SD memory file management. A FAT file system must be provided separately. Please obtain it from the following as necessary.

Open Source FAT File System M3S-TFAT-Tiny: [https://www.renesas.com/mw/tfat-rx](https://www.renesas.com/mw/tfat-rx)

(2) **Driver Interface Functions**

This is the software that implements the layer that connects the Renesas Electronics FAT file system API with the SD Memory Card driver API. If necessary, please obtain it from the M3S-TFAT-Tiny web page above.

RX Family M3S-TFAT-Tiny Memory Driver Interface Module Firmware Integration Technology

(3) **SD Memory Card Driver**

This software implements the SD Specifications Part 1 Physical Layer Simplified Specification SD memory protocol control.

(4) **SDHI FIT Module**

This software controls the SDHI hardware. It also includes microcontroller-dependent target microcontroller interface functions and interrupt setting files.

(5) **Peripheral Function Control Module (Sample Program)**

This software implements timer control, DMAC control, and DTC control. It can be acquired as a sample program. See, Related Documents on the first page, for details on acquiring this software.

(6) **Pin Control Module (Sample Program)**

This is the pin control software used for SDHI control. The microcontroller resources used consist of the port control (SDHI function control and SD Card power supply port control) and MPC control (SDHI function control).

Regarding pin allocation, we recommend allocating system pins at the same time so that the pins used do not conflict. Note that a sample program that matches the RX Family MCU RSK board is included. This is stored in the FITDemos directory. Refer to this demo program to embed this functionality in an application system.
### 1.3 API Overview

This SD Memory Card driver uses the SD Specifications Part 1 Physical Layer Simplified Specification protocol. The table below lists the library functions.

Table 1.4 shows the API Functions for this driver.

<table>
<thead>
<tr>
<th>Function</th>
<th>Functional Overview</th>
</tr>
</thead>
<tbody>
<tr>
<td>R_SDC_SD_Open()</td>
<td>Driver open processing</td>
</tr>
<tr>
<td>R_SDC_SD_Close()</td>
<td>Driver close processing</td>
</tr>
<tr>
<td>R_SDC_SD_GetCardDetection()</td>
<td>Insertion verification processing</td>
</tr>
<tr>
<td>R_SDC_SD_Initialize()</td>
<td>Initialization processing</td>
</tr>
<tr>
<td>R_SDC_SD_End()</td>
<td>End processing</td>
</tr>
<tr>
<td>R_SDC_SDMEM_Read()</td>
<td>Read processing *1</td>
</tr>
<tr>
<td>R_SDC_SDMEM_ReadSoftwareTrans()</td>
<td>Read processing (software transfers)</td>
</tr>
<tr>
<td>R_SDC_SDMEM_ReadSoftwareTransSingleCmd()</td>
<td>Read processing (CMD17 single software transfers)</td>
</tr>
<tr>
<td>R_SDC_SDMEM_Write()</td>
<td>Write processing *1</td>
</tr>
<tr>
<td>R_SDC_SDMEM_WriteSoftwareTrans()</td>
<td>Write processing (software transfers)</td>
</tr>
<tr>
<td>R_SDC_SD_Control()</td>
<td>Driver control processing</td>
</tr>
<tr>
<td></td>
<td>SDC_SD_SET_STOP command</td>
</tr>
<tr>
<td>R_SDC_SD_GetModeStatus()</td>
<td>Mode status information processing</td>
</tr>
<tr>
<td>R_SDC_SD_GetCardStatus()</td>
<td>Card status information processing</td>
</tr>
<tr>
<td>R_SDC_SD_GetCardInfo()</td>
<td>Register information processing</td>
</tr>
<tr>
<td>R_SDC_SDMEM_GetSpeed()</td>
<td>Speed class information processing</td>
</tr>
<tr>
<td>R_SDC_SD_CdInt()</td>
<td>Insertion/removal interrupt setup (including registration of the insertion/removal interrupt callback functions)</td>
</tr>
<tr>
<td>R_SDC_SD_IntCallback()</td>
<td>Protocol status interrupt callback function registration processing</td>
</tr>
<tr>
<td>R_SDC_SD_GetErrCode()</td>
<td>Driver error code processing</td>
</tr>
<tr>
<td>R_SDC_SD_GetBuffRegAddress()</td>
<td>SD buffer register address processing</td>
</tr>
<tr>
<td>R_SDC_SD_1msInterval()</td>
<td>Interval timer count processing</td>
</tr>
<tr>
<td>R_SDC_SD_SetDmacDtcTransFlg()</td>
<td>DMAC/DTC transfer complete flag setting processing</td>
</tr>
<tr>
<td>R_SDC_SD_SetLogHdlAddress()</td>
<td>LONGQ module handler address setup processing *2</td>
</tr>
<tr>
<td>R_SDC_SD_Log()</td>
<td>Error log processing *2</td>
</tr>
<tr>
<td>R_SDC_SD_GetVersion()</td>
<td>Driver version information processing</td>
</tr>
</tbody>
</table>

Notes:
1. When DMAC transfers or DTC transfers are set as the data transfer for the operating mode during initialization processing, either a DMAC control program or a DTC control program is required. See section 1.4.4.2, DMAC and DTC Control Methods, for the setup procedure.
2. The LONGQ FIT module is also required.
1.4 Processing Example

1.4.1 Quick Start Guide

The procedure for performing read and write access to an SD Card using a Renesas Starter Kit (RSK) is described below.

1.4.1.1 Hardware Settings

Settings must be made on the RSK for each target microcontroller. In the case of the RSK for RX231, the PMOD SD Card conversion board must be obtained separately.

(1) RSK for RX64M or RX71M

Make the settings described below to enable the SD Card socket.

<table>
<thead>
<tr>
<th>Pin Number</th>
<th>Setting</th>
<th>Pin Number</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin 1</td>
<td>OFF</td>
<td>Pin 1</td>
<td>OFF</td>
</tr>
<tr>
<td>Pin 2</td>
<td>ON</td>
<td>Pin 2</td>
<td>ON</td>
</tr>
<tr>
<td>Pin 3</td>
<td>OFF</td>
<td>Pin 3</td>
<td>OFF</td>
</tr>
<tr>
<td>Pin 4</td>
<td>ON</td>
<td>Pin 4</td>
<td>ON</td>
</tr>
<tr>
<td>Pin 5</td>
<td>OFF</td>
<td>Pin 5</td>
<td>OFF</td>
</tr>
<tr>
<td>Pin 6</td>
<td>OFF</td>
<td>Pin 6</td>
<td>ON</td>
</tr>
<tr>
<td>Pin 7</td>
<td>OFF</td>
<td>Pin 7</td>
<td>OFF</td>
</tr>
<tr>
<td>Pin 8</td>
<td>ON</td>
<td>Pin 8</td>
<td>ON</td>
</tr>
<tr>
<td>Pin 9</td>
<td>OFF</td>
<td>Pin 9</td>
<td>OFF</td>
</tr>
<tr>
<td>Pin 10</td>
<td>OFF</td>
<td>Pin 10</td>
<td>ON</td>
</tr>
</tbody>
</table>

(2) RSK for RX65N

Make the settings described below to enable the SD Card socket.

<table>
<thead>
<tr>
<th>Pin Number</th>
<th>Setting</th>
<th>Pin Number</th>
<th>Setting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin 1</td>
<td>OFF</td>
<td>Pin 1</td>
<td>OFF</td>
</tr>
<tr>
<td>Pin 2</td>
<td>ON</td>
<td>Pin 2</td>
<td>ON</td>
</tr>
<tr>
<td>Pin 3</td>
<td>OFF</td>
<td>Pin 3</td>
<td>OFF</td>
</tr>
<tr>
<td>Pin 4</td>
<td>ON</td>
<td>Pin 4</td>
<td>ON</td>
</tr>
<tr>
<td>Pin 5</td>
<td>OFF</td>
<td>Pin 5</td>
<td>OFF</td>
</tr>
<tr>
<td>Pin 6</td>
<td>ON</td>
<td>Pin 6</td>
<td>ON</td>
</tr>
<tr>
<td>Pin 7</td>
<td>OFF</td>
<td>Pin 7</td>
<td>OFF</td>
</tr>
<tr>
<td>Pin 8</td>
<td>ON</td>
<td>Pin 8</td>
<td>ON</td>
</tr>
<tr>
<td>Pin 9</td>
<td>OFF</td>
<td>Pin 9</td>
<td>OFF</td>
</tr>
<tr>
<td>Pin 10</td>
<td>ON</td>
<td>Pin 10</td>
<td>OFF</td>
</tr>
</tbody>
</table>

(3) RSK for RX65N-2MB

No settings are necessary.

(4) RSK for RX231

Install the PMOD SD Card conversion board in PMOD2 on the RSK for RX231 board.
1.4.1.2 Software Settings

Follow the procedure below to add the software to your project.

1. Create a new project in e² studio and download the RX Driver Package.
2. Copy r_sdc_sdmem_rx_vX.XX.zip, r_sdc_sdmem_rx_vX.XX.xml, and r_sdc_sdmem_rx_vX.XX_extend.mdf to the folder containing the e² studio FIT modules (normally C:\Renesas\e²_studio\FITModules).
3. Refer to Renesas e² studio Smart Configurator User Guide (R01AN0451), and add r_bsp, r_sdc_sdmem_rx, r_sdhi_rx, r_cmt_rx, r_dma_rx, r_dmc_rx, and r_front to your project.
4. Copy the sample program r_sdc_sdmem_rx_demo_main* to the src folder of your project.
5. Make settings to the configuration options of the sample program. For how to make these settings, see 5.3, Configuration Overview.

Note: * Contained in the FITDemos\rx65n_1mb_rsk.zip\src folder in the product package.

1.4.2 Basic Control

1.4.2.1 Supported Commands

This SD Memory Card driver uses the following commands.

The table below lists the SD Card commands, the User's Manual: Hardware and the status of support in this SD Memory Card driver.

**Table 1.4 Commands Supported by this SD Memory Card Driver**

<table>
<thead>
<tr>
<th>Command</th>
<th>Microcontroller Supported</th>
<th>This Driver Supported</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMD0</td>
<td>O</td>
<td>O</td>
<td>Used in SD memory initialization</td>
</tr>
<tr>
<td>CMD2</td>
<td>O</td>
<td>O</td>
<td>Used in SD memory initialization</td>
</tr>
<tr>
<td>CMD3</td>
<td>O</td>
<td>O</td>
<td>Used in SD memory initialization</td>
</tr>
<tr>
<td>CMD4</td>
<td>O</td>
<td>O</td>
<td>Used in SD memory initialization</td>
</tr>
<tr>
<td>CMD5</td>
<td>O</td>
<td>×</td>
<td>Unused</td>
</tr>
<tr>
<td>CMD6</td>
<td>O</td>
<td>×</td>
<td>Unused</td>
</tr>
<tr>
<td>CMD7</td>
<td>O</td>
<td>O</td>
<td>Used in SD memory initialization</td>
</tr>
<tr>
<td>CMD8</td>
<td>O</td>
<td>O</td>
<td>Used in SD memory initialization</td>
</tr>
<tr>
<td>CMD9</td>
<td>O</td>
<td>O</td>
<td>Used in SD memory initialization</td>
</tr>
<tr>
<td>CMD10</td>
<td>O</td>
<td>×</td>
<td>Unused</td>
</tr>
<tr>
<td>CMD11</td>
<td>O</td>
<td>×</td>
<td>Unused</td>
</tr>
<tr>
<td>CMD12</td>
<td>O</td>
<td>O</td>
<td>Used for SD memory read/write processing</td>
</tr>
<tr>
<td>CMD13</td>
<td>O</td>
<td>O</td>
<td>Used for SD memory read/write processing</td>
</tr>
<tr>
<td>CMD15</td>
<td>O</td>
<td>×</td>
<td>Unused</td>
</tr>
<tr>
<td>CMD16</td>
<td>O</td>
<td>O</td>
<td>Used in SD memory initialization</td>
</tr>
<tr>
<td>CMD17</td>
<td>O</td>
<td>O</td>
<td>Used for SD memory read/write processing</td>
</tr>
<tr>
<td>CMD18</td>
<td>O</td>
<td>O</td>
<td>Used for SD memory read/write processing</td>
</tr>
<tr>
<td>CMD20</td>
<td>O</td>
<td>×</td>
<td>Unused</td>
</tr>
<tr>
<td>CMD24</td>
<td>O</td>
<td>O</td>
<td>Used for SD memory read/write processing</td>
</tr>
<tr>
<td>CMD25</td>
<td>O</td>
<td>O</td>
<td>Used for SD memory read/write processing</td>
</tr>
<tr>
<td>CMD27</td>
<td>O</td>
<td>×</td>
<td>Unused</td>
</tr>
<tr>
<td>CMD28</td>
<td>O</td>
<td>×</td>
<td>Unused</td>
</tr>
<tr>
<td>CMD29</td>
<td>O</td>
<td>×</td>
<td>Unused</td>
</tr>
<tr>
<td>CMD30</td>
<td>O</td>
<td>×</td>
<td>Unused</td>
</tr>
<tr>
<td>CMD32</td>
<td>O</td>
<td>×</td>
<td>Unused</td>
</tr>
<tr>
<td>CMD33</td>
<td>O</td>
<td>×</td>
<td>Unused</td>
</tr>
<tr>
<td>CMD38</td>
<td>O</td>
<td>×</td>
<td>Unused</td>
</tr>
<tr>
<td>CMD42</td>
<td>O</td>
<td>×</td>
<td>Unused</td>
</tr>
<tr>
<td>Command</td>
<td>Microcontrollers Supported</td>
<td>This Driver</td>
<td>Remarks</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------------------</td>
<td>-------------</td>
<td>----------------------------------------</td>
</tr>
<tr>
<td>CMD52</td>
<td>O</td>
<td>×</td>
<td>Unused</td>
</tr>
<tr>
<td>CMD53</td>
<td>O</td>
<td>×</td>
<td>Unused</td>
</tr>
<tr>
<td>CMD55</td>
<td>O</td>
<td>O</td>
<td>Used in SD memory initialization</td>
</tr>
<tr>
<td>CMD56</td>
<td>O</td>
<td>×</td>
<td>Unused</td>
</tr>
<tr>
<td>ACMD6</td>
<td>O</td>
<td>O</td>
<td>Used in SD memory initialization</td>
</tr>
<tr>
<td>ACMD13</td>
<td>O</td>
<td>O</td>
<td>Used in SD memory initialization</td>
</tr>
<tr>
<td>ACMD22</td>
<td>O</td>
<td>O</td>
<td>Used for SD memory write processing</td>
</tr>
<tr>
<td>ACMD23</td>
<td>O</td>
<td>O</td>
<td>Used for SD memory write processing</td>
</tr>
<tr>
<td>ACMD41</td>
<td>O</td>
<td>O</td>
<td>Used in SD memory initialization</td>
</tr>
<tr>
<td>ACMD42</td>
<td>O</td>
<td>O</td>
<td>Used in SD memory initialization</td>
</tr>
<tr>
<td>ACMD51</td>
<td>O</td>
<td>O</td>
<td>Used in SD memory initialization</td>
</tr>
</tbody>
</table>
1.4.2.2 Relation Between Data Buffers and Data in the SD Card

This SD Card driver is set up with the transmit/receive data pointers passed as arguments. As shown in Figure 1.2, the relationship between the transmit/receive order and the order of the data in the data buffers in RAM is such that data in the transmit buffer is transmit data in the order it appears in the buffer and data is written to the receive buffer in the order received regardless of the endian order.

![Figure 1.2 Transmission Data Storage](image)

1.4.2.3 Operating Voltage Settings When Initialization

The operating voltage must be set as an argument to the R_SDC_SD_Initialize() function. During SD Card initialization, if it is determined that the SD Card cannot operate at the set voltage, the SD Card will transition to the inactive state.

For an SD Card, call the R_SDC_SD_End() function and after it reaches the initializable state, the SD Card should be removed. After that, reinsert the card, set the operating voltage again, and perform initialization processing again.

For an SD module, call the R_SDC_SD_End() function and after it reaches the initializable state, stop supply of power to the SD module. After that, restart supply voltage supply to the SD module, set the operating voltage again, and perform the initialization processing again.
1.4.2.4 Stopping SDHI_CLK

To save power, this SD Card driver only outputs the SDHI_CLK signal during library function execution, and stops output of the SDHI_CLK signal when the library function terminates.

1.4.2.5 SDHI Status Verification

To use the SD Card, it is necessary to verify the SDHI status, such as detecting communication completion and detect the SD Card insertion/removal state. This section describes the status verification methods when this SD Card driver library functions are used.

Status Verification Methods

This SD Card driver allows users to select either SDHI interrupts or software poling as SDHI status verification methods.

The follow status items can be verified.

- SD Card insertion/removal detection
- SD protocol
- SDHI interrupt

Table 1.6 lists the status items verified by the SD Card driver library functions.

**Table 1.5 Status Items Verified**

<table>
<thead>
<tr>
<th>Type</th>
<th>Status</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD Card insertion/removal</td>
<td>SD Card inserted/removed</td>
<td>Detection is possible with the R_SDC_SD_GetCardDetection() function.</td>
</tr>
<tr>
<td>(Interrupt enable/disable setting</td>
<td>state</td>
<td></td>
</tr>
<tr>
<td>with the R_SDC_SD_CdInt() function)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD protocol</td>
<td>Response reception complete</td>
<td>Occurs on each command transmission</td>
</tr>
<tr>
<td>(Interrupt enable setting with the</td>
<td>Data transfer request</td>
<td>Occurs on each 512 bytes of transmission</td>
</tr>
<tr>
<td>R_SDC_SD_Initialize() function)</td>
<td>Protocol error</td>
<td>Occurs when a CRC or other error occurs</td>
</tr>
<tr>
<td></td>
<td>Timeout error</td>
<td>Occurs when a no response state is detected</td>
</tr>
</tbody>
</table>

Setup Methods

When interrupts are selected as the SD Card insertion verification method, interrupts (the SDC_SD_MODE_HWINT setting) should also be selected for SD protocol status verification with the R_SDC_SD_Initialize() function.

Note that the R_SDHI_IntHandlerX() functions (where X is the channel number) of the SDHI FIT module are already registered in the system as the interrupt handlers for the SDHI interrupts.
**SD Card Insertion Verification by Software Poling and Interrupt**

The SD Card insertion state can be verified using the R_SDC_SD_GetCardDetection() function regardless of the enabled/disabled setting of the SD Card insertion interrupt.

When the interrupt has been enabled (SDC_SD_CD_INT_ENABLE) with the R_SDC_SD_CdInt() function, a callback function can also be executed when the interrupt occurs when an SD Card is inserted. This allows real-time processing for SD Card insertion. Use the R_SDC_SD_CdInt() function to register the SD Card insertion interrupt callback function.

**SD Protocol Status Verification Using Software Poling**

When poling (SDC_SD_MODE_POLL) is set with the R_SDC_SD_Initialize() function as the SD protocol status verification method, status items such as data transfer complete wait or response reception wait during communication with the SD can be verified with software poling.

When software poling is set up, use the r_sdc_sd_int_wait() function, within that function call the SD status register 1 and 2 acquisition processing (the r_sdc_sd_get_intstatus() function), and check the values of the SD status registers 1 and 2 (SDSTS1 and SDSTS2).

Figure 1.3 shows the flowchart for SD protocol status verification when poling is used.

![Figure 1.3 SD Protocol Status Verification Using Software Poling](image)

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SD Protocol Status Verification Using Interrupts

When interrupts (SDC_SD_MODE_HWINT) are set as the SD protocol status verification method with the R_SDC_SD_Initialize() function, the status is stored in an internal buffer when the status verification interrupt occurs.

A user registered callback function can be called when a status verification interrupt occurs. The user should register an SD protocol status interrupt callback function with the R_SDC_SD_IntCallback() function.

When interrupt waiting is set up, applications use the r_sdc_sd_int_wait() function, and within this function acquire the information in SD status registers 1 and 2 (by calling the r_sdc_sd_get_intstatus() function), to verify the interrupt occurrence state.

Figure 1.4 shows the flowchart for SD protocol status verification when interrupts are used.

![Flowchart](image-url)

Figure 1.4 SD Protocol Status Verification Using Interrupts
1.4.3 Control After an Error

1.4.3.1 Handling When an Error Occur

We recommend retrying the processing when an error occurs in read, write, or other processing.

If an error occurs even after retrying the processing, remove the SD Card and initialize the card again. See section 4.1, 4.2, for details on the processing related to SD Card insertion and removal. For the SD module, temporarily turn off the power supply, then reapply power, and then initialize it.

Also, if using a file system as the upper level application for this SD Card driver, before removing and reinserting the SD Card, implement any required processing in advance in that upper level application.

1.4.3.2 Handling Error Termination After Transition to the Transfer State (tran)

If an error occurs after transition to the transfer state (tran), a CMD12 command is issued regardless of whether or not there was a data transfer. The purpose of issuing the CMD12 command is to transition to the transfer state (tran). Note, however, that the CMD12 is issued during write processing, the SD Card may transition to the busy state. This can cause the next read or write function call to return an error.

1.4.3.3 Error Log Acquisition Methods

Use SD memory card driver source code. Also, the LONGQ FIT module should be acquired separately as well.

Use the following setup procedure to acquire an error log.

R_LONGQ_Open() Setup

Set the third argument of the R_LONGQ_Open() function in the LONGQ FIT module, ignore_overflow, to 1. This will make it possible to use the error buffer as a ring buffer.

Control Procedures

Before calling the R_SDC_SD_Open() function, call the following functions in the order shown. See section 3.22, R_SDC_SD_SetLogHdlAddress(), for a setup example.

1. R_LONGQ_Open()
2. R_SDC_SD_SetLogHdlAddress()

Set Up R_SDC_SD_Log()

Call this function to terminate error acquisition. See section 3.23, R_SDC_SD_Log(), for a setup example.
### 1.4.4 Control of Other Modules

#### 1.4.4.1 Timers

Timers are used to detect timeouts. Applications should call `R_SDC_SD_1msInterval()` at 1 ms intervals. Note, however, that this is not required when the `r_sdc_sd_int_wait()` and `r_sdc_sd_wait()` functions in `r_sdc_sd_config.c` have been replaced with operating system processing.

#### 1.4.4.2 DMAC and DTC Control Methods

This section describes the control methods used when DMAC or DTC transfers are used.

This SD Card driver performs DMAC or DTC transfer starts and transfer complete waiting. For other DMAC or DTC register settings, either use the DMAC or DTC FIT module, or implement your own user processing.

Note that when DMAC transfers are set up, clearing the DMAC transfer complete flag when a DMAC start completes must be performed by user code.

![Figure 1.5 Processing for DMAC/DTC Transfer Setup](image-url)
1.5 State Transition Diagram

Figure 1.6 shows the state transition diagram for this driver.

![State Transition Diagram](image)

For SD Cards, a card insertion causes a transition to the initializable state.

Driver uninitialized state

R_SDC_SD_Open()

R_SDC_SD_IntCallback()

R_SDC_SD_CdInt()

Driver initialized state
(No SD Card inserted state)

R_SDC_SD_Disp()

R_SDC_SD_Close()

Initializable state of SD card
(SD Card inserted state)

R_SDC_SD_Init()

R_SDC_SD_End()

Driver idle state

[SD memory transfer state (tran)]

R_SDC_SDMEM_Read()

*1

R_SDC_SDMEM_Write()

*2

R_SDC_SD_Control()

forcibly termination

Read execution state
(SD Card transfer state)

Write execution state
(SD Card receive state)

Notes:
1. The SD Card transfer state transition command processing, which includes the R_SDC_SDMEM_ReadSoftwareTrans() function, is similar.
2. The SD Card receive state transition command processing, which includes the R_SDC_SDMEM_WriteSoftwareTrans() function, is similar.
3. [ ] indicates the state of the SD memory card as described in SD Specifications, Part 1: Physical Layer Simplified Specification.

Figure 1.6 SD Memory Card driver State Transition Diagram
1.6 Limitations

1.6.1 Usage Notes

- Argument setup rules and register warranty rules
  The functions provided by this library are coded assuming that they will be called from application programs coded in the C language. The argument setup rules and register warranty rules used by this SD Card driver conform to those of the C compiler. See the related manuals for details.

- Sections
  Sections with no initialization value should be initialized to 0.

- Notes on using interrupt callback functions
  The interrupt callback functions are called as subroutines from the interrupt handlers.

- All software settings should conform to the hardware actually used.

1.6.2 Notes on SD Card Power Supply

After an SD Card is inserted, the power supply voltage stipulated by the SD Card specifications must be applied. See the Power Scheme section in the SD Specifications Part 1 Physical Layer Simplified Specification.

In particular, when reinserting control of the SD Card after removal of the SD Card or reentering control after turning off the SD Card, refer to the regulations on the voltage value and voltage sustain period, provide control timing for cutting/reentering by the system.

If correct power supply application and cutoff processing is not performed, the power supply system may become unstable due to SD Card insertion or removal and this could cause the microcontroller to go to the reset state.

After the operating voltage is reached, call the R_SDC_SD_Initialize() initialize processing function. Applications must adjust the time between the application of the power supply voltage and the point when the operating voltage is reached.

Also, the application program must provide the wait time processing for the time from the point when supply of the supply voltage is stopped until a voltage that allows removal of the SD Card is reached.

1.6.3 Software Write Protection

This SD Card driver does not support software protection state control functions.
2. API Information

This FIT module has been confirmed to operate under the following conditions.

2.1 Hardware Requirements

The MCU used must support the following functions:
- SDHI

2.2 Software Requirements

This SD Card driver depends on the following packages.
- r_bsp(Rev. 5.20 or more)
- r_sdhi_rx
- r_dmaca_rx (Only when DMAC transfers using the DMACA FIT module are used)
- r_dtc_rx (Only when DTC transfers using the DTC FIT module are used)
- r_cmt_rx (Only when the compare match timer CMT FIT module is used)
- r_longq_rx (Only when an error log acquisition function is used)

Other timers or software times can be used for this functionality.

2.3 Supported Toolchain

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

2.4 Interrupt Vector

If the macro definition SDHI_CFG_MODE_INT is set to SDHI_MODE_HWINT, SDHI interrupts are enabled. Put the system in the interrupts permitted state before the SD Memory Card driver's open processing, R_SDC_SD_Open(), is called. For details regarding SDHI interrupts, refer to the application note for the SDHI FIT module.

(1) API Functions that Can be Called from Within Interrupt Handling

Table 2.1 lists the API functions (recommended) that can be called from within interrupt handling.

Note that the interrupt callback functions are called as subroutines from the interrupt handlers.

Table 2.1 SD Card Driver Library Functions that may be Called from Within an Interrupt Handler

<table>
<thead>
<tr>
<th>Function</th>
<th>Functional Overview</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>R_SDC_SD_Control()</td>
<td>Driver control processing</td>
<td>SDC_SD_SET_STOP (Forced stop request command)</td>
</tr>
</tbody>
</table>

2.5 Header Files

The API calls and interface definitions used are defined in r_sdc_sd_rx_if.h.

The configuration options for each build are selected in r_sdc_sd_rx_config.h.

#include "r_sdc_sd_rx_if.h"

2.6 Integer Types

This SD Card driver is coded in ANSI C99. These types are defined in stdint.h.
### 2.7 Configuration Overview

This SD Card driver configuration options are set in r_sdc_sd_rx_config.h. When using Smart Configurator, the configuration option can be set on software component configuration screen. The setting value is automatically reflected in r_sdc_sd_rx_config.h when adding modules to user project. The option names and setting values are listed in the table below.

<table>
<thead>
<tr>
<th>Configuration options in r_sdc_sd_rx_config.h</th>
<th>Description</th>
</tr>
</thead>
</table>
| #define SDC_SD_CFG_STATUS_CHECK_MODE SDC_SD_MODE_HWINT  
Note: The default value is SDC_SD_MODE_HWINT "status verification: hardware interrupt". | This definition can be used as the argument p_sdc_sd_config->mode to the R_SDC_SD_Initialize() initialization processing function. Refer to the section "Initialization processing function R_SDC_SD_Initialize()" and define p_sdc_sd_config->mode. |
| #define SDC_SD_CFG_TRANSFER  
Note: The default value is SDC_SD_MODE_SW " data transfer type: software". | This definition can be used as the argument p_sdc_sd_config->mode to the R_SDC_SD_Initialize() initialization processing function. Refer to the section "Initialization processing function R_SDC_SD_Initialize()" and define p_sdc_sd_config->mode. |
| #define SDC_SD_CFG_ERROR_LOG_ACQUISITION  
Note: The default value is "0". | This must be set "1" when an error log acquisition function using the LONGQ FIT module is used. When this function is used, the LONGQ FIT module must be included. |
The sizes of ROM, RAM and maximum stack usage associated with this module are listed below. Information is listed for a single representative device of the RX200 Series, and RX600 Series, respectively.

The ROM (code and constants) and RAM (global data) sizes are determined by the build-time configuration options described in 2.7, Configuration Overview.

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

- **Module Revision:** r_sdc_sdmem_rx rev.3.00
- **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 4.8.4.201902**
  - (The option of “lang = c99” is added to the default settings of the integrated development environment.)
- **IAR C/C++ Compiler for Renesas RX version 4.12.1**
  - (The default settings of the integrated development environment.)

**Configuration Options:** Default settings

<table>
<thead>
<tr>
<th>Device</th>
<th>Category</th>
<th>Memory Used</th>
<th>Renesas Compiler</th>
<th>GCC</th>
<th>IAR Compiler</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>With Parameter Checking</td>
<td>Without Parameter Checking</td>
<td>With Parameter Checking</td>
</tr>
<tr>
<td>RX231</td>
<td>ROM</td>
<td>2,636 bytes</td>
<td>2,079 bytes</td>
<td>4,460 bytes</td>
<td>3,396 bytes</td>
</tr>
<tr>
<td></td>
<td>RAM</td>
<td>12 bytes</td>
<td>12 bytes</td>
<td>8 bytes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>STACK</td>
<td>164 bytes</td>
<td>-</td>
<td>124 bytes</td>
<td></td>
</tr>
<tr>
<td>RX65N</td>
<td>ROM</td>
<td>5,595 bytes</td>
<td>4,424 bytes</td>
<td>9,588 bytes</td>
<td>7,324 bytes</td>
</tr>
<tr>
<td></td>
<td>RAM</td>
<td>40 bytes</td>
<td>40 bytes</td>
<td>32 bytes</td>
<td></td>
</tr>
<tr>
<td></td>
<td>STACK</td>
<td>188 bytes</td>
<td>-</td>
<td>148 bytes</td>
<td></td>
</tr>
</tbody>
</table>

**Note 1.** The sizes of maximum usage stack of Interrupts functions is included.
2.9 Parameters

This section presents the structures used as arguments to the API functions. These structures are included in the file r_sdc_sd_rx_if.h along with the API function prototype declarations.

(1) **e_enum_sdc_sd_cmd Structure Definition**

```c
enum e_enum_sdc_sd_cmd
{
    SDC_SD_SET_STOP,
    SDC_SD_SET_BUFFER
} enum_sdc_sd_cmd_t;
```

(2) **e_enum_sdc_sd_trans Structure Definition**

```c
enum e_enum_sdc_sd_trans
{
    SDC_SD_SET_TRANS_STOP,
    SDC_SD_SET_TRANS_START
} enum_sdc_sd_trans_t;
```

(3) **sdc_sd_cmd_t Structure Definition**

```c
typedef struct
{
    uint32_t    cmd;
    uint32_t    mode;
    uint8_t     *p_buff;
    uint32_t    size;
}sdc_sd_cmd_t;
```

(4) **sdc_sd_cfg_t Structure Definition**

```c
typedef struct
{
    uint32_t    mode;
    uint32_t    voltage;
}sdc_sd_cfg_t;
```

(5) **sdc_sd_access_t Structure Definition**

```c
typedef struct
{
    uint8_t     *p_buff;
    uint32_t    lbn;
    int32_t     cnt;
    uint32_t    mode;
    uint32_t    write_mode;
}sdc_sd_access_t;
```
(6) **sdc_sd_card_status_t Structure Definition**

```c
typedef struct {
    uint32_t card_sector_size;
    uint32_t prot_sector_size;
    uint8_t  write_protect;
    uint8_t  csd_structure;
    uint8_t  speed_mode;
    uint8_t  io_speed_mode;
    uint8_t  rsv[3];
} sdc_sd_card_status_t;
```

(7) **sdc_sd_card_reg_t Structure Definition**

```c
typedef struct {
    uint32_t    sdio_ocr[1];
    uint32_t    ocr[1];
    uint32_t    cid[4];
    uint32_t    csd[4];
    uint32_t    dsr[1];
    uint32_t    rca[2];
    uint32_t    scr[2];
    uint32_t    sdstatus[4];
    uint32_t    switch_func_status[5];
} sdc_sd_card_reg_t;
```

### 2.10 Return Values / Error Codes

This section presents the return values from the API functions. This enumeration type is defined in the file `r_sdc_sd_rx_if.h` along with the API function prototype declarations.

If an error occurs during processing, these SD Card driver library functions return an error code in their return value. Also, the error code can be acquired using the `R_SDC_SD_GetErrCode()` function after execution of the `R_SDC_SD_Initialize()`, `R_SDC_SDMEM_Read()`, and `R_SDC_SDMEM_Write()` functions.

Table 2.3 lists the error codes. Note that values not listed in the table are reserved for future expansion.

Note: * The `R_SDC_SDMEM_ReadSoftwareTrans()`, `R_SDC_SDMEM_ReadSoftwareTransSingleCmd()`, and `R_SDC_SDMEM_WriteSoftwareTrans()` functions operate similarly.

#### Table 2.2 Error Codes

<table>
<thead>
<tr>
<th>Macro Definition</th>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDC_SD_SUCCESS_LOCKED_CARD</td>
<td>1</td>
<td>Successful operation but the SD Card was locked.</td>
</tr>
<tr>
<td>SDC_SD_SUCCESS</td>
<td>0</td>
<td>Successful operation</td>
</tr>
<tr>
<td>SDC_SD_ERR</td>
<td>-1</td>
<td>General error</td>
</tr>
<tr>
<td>SDC_SD_ERR_WP</td>
<td>-2</td>
<td>Write protect error</td>
</tr>
<tr>
<td>SDC_SD_ERR_RO</td>
<td>-3</td>
<td>Read only error</td>
</tr>
<tr>
<td>SDC_SD_ERR_RES_TOE</td>
<td>-4</td>
<td>Response timeout error</td>
</tr>
</tbody>
</table>

* The `R_SDC_SDMEM_ReadSoftwareTrans()`, `R_SDC_SDMEM_ReadSoftwareTransSingleCmd()`, and `R_SDC_SDMEM_WriteSoftwareTrans()` functions operate similarly.
<table>
<thead>
<tr>
<th>Macro Definition</th>
<th>Value</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDC_SD_ERR_CARD_TOE</td>
<td>-5</td>
<td>Card timeout error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Card busy state timeout, data reception timeout after read command, or</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CRC status reception timeout after write command*.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Note: * Depends on the setting of bits 7 to 4 (TOP) in the card access</td>
</tr>
<tr>
<td></td>
<td></td>
<td>option register (SDOPT).</td>
</tr>
<tr>
<td>SDC_SD_ERR_END_BIT</td>
<td>-6</td>
<td>End bit error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No end bit was detected.</td>
</tr>
<tr>
<td>SDC_SD_ERR_CRC</td>
<td>-7</td>
<td>CRC error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The host detected a CRC error.</td>
</tr>
<tr>
<td>SDC_SD_ERR_CARD_RES</td>
<td>-8</td>
<td>Card response error</td>
</tr>
<tr>
<td>SDC_SD_ERR_HOST_TOE</td>
<td>-9</td>
<td>Host timeout error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Error in the r_sdc_sd_int_wait() function.</td>
</tr>
<tr>
<td>SDC_SD_ERR_CARD_ERASE</td>
<td>-10</td>
<td>Card erase error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R1 response card status error R1 response card status error (ERASE_SEQ_ERROR or ERASE_PARAM)</td>
</tr>
<tr>
<td>SDC_SD_ERR_CARD_LOCK</td>
<td>-11</td>
<td>Card lock error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R1 response card status error (CARD_IS_LOCKED)</td>
</tr>
<tr>
<td>SDC_SD_ERR_CARD_UNLOCK</td>
<td>-12</td>
<td>Card unlock error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R1 response card status error (LOCK_UNLOCK_FAILED)</td>
</tr>
<tr>
<td>SDC_SD_ERR_CARD_CRC</td>
<td>-13</td>
<td>Card CRC error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R1 response card status error (COM_CRC_ERROR)</td>
</tr>
<tr>
<td>SDC_SD_ERR_CARD_ECC</td>
<td>-14</td>
<td>Card ECC error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R1 response card status error (CARD_ECC_FAILED)</td>
</tr>
<tr>
<td>SDC_SD_ERR_CARD_CC</td>
<td>-15</td>
<td>Card CC error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R1 response card status error (CC_ERROR)</td>
</tr>
<tr>
<td>SDC_SD_ERR_CARD_ERROR</td>
<td>-16</td>
<td>Card error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R1 response card status error (ERROR)</td>
</tr>
<tr>
<td>SDC_SD_ERR_CARD_TYPE</td>
<td>-17</td>
<td>Unsupported card</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The card was recognized as an unsupported card</td>
</tr>
<tr>
<td>SDC_SD_ERR_NO_CARD</td>
<td>-18</td>
<td>No card inserted error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>No card is inserted</td>
</tr>
<tr>
<td>SDC_SD_ERR_I LL_READ</td>
<td>-19</td>
<td>Illegal read error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>An illegal SD buffer register read method was used</td>
</tr>
<tr>
<td>SDC_SD_ERR_I LL_WRITE</td>
<td>-20</td>
<td>Illegal write error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>An illegal SD buffer register write method was used</td>
</tr>
<tr>
<td>SDC_SD_ERR_AKE_SEQ</td>
<td>-21</td>
<td>Card AKE error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R1 response card status error (AKE_SEQ_ERROR)</td>
</tr>
<tr>
<td>SDC_SD_ERR_OVERWRITE</td>
<td>-22</td>
<td>Card OVERWRITE error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R1 response card status error (CSD_OVERWRITE)</td>
</tr>
<tr>
<td>SDC_SD_ERR_CPU_IF</td>
<td>-30</td>
<td>Target microcontroller interface function error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Target microcontroller interface function error (other than the r_sdc_sd_int_wait() function)</td>
</tr>
<tr>
<td>SDC_SD_ERR_STOP</td>
<td>-31</td>
<td>Forced stop error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Forced stop state due to the R_SDC_SD_Control() function</td>
</tr>
<tr>
<td>SDC_SD_ERR_CSD_VER</td>
<td>-50</td>
<td>Version error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CSD register version error</td>
</tr>
<tr>
<td>SDC_SD_ERR_FILE_FORMAT</td>
<td>-52</td>
<td>File format error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>CSD register file format error</td>
</tr>
<tr>
<td>SDC_SD_ERR_I LL_FUNC</td>
<td>-60</td>
<td>Function number error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Error that occurs when the function number requested is invalid</td>
</tr>
<tr>
<td>SDC_SD_ERR_IFCOND_VOLT</td>
<td>-71</td>
<td>Interface condition: voltage error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The interface condition voltage is incorrect</td>
</tr>
<tr>
<td>Macro Definition</td>
<td>Value</td>
<td>Meaning</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>-------</td>
<td>-------------------------------------------------------------------------</td>
</tr>
<tr>
<td>SDC_SD_ERR_IFCOND_ECHO</td>
<td>-72</td>
<td>Interface condition: echo back error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The interface condition echo back pattern is incorrect</td>
</tr>
<tr>
<td>SDC_SD_ERR_OUT_OF_RANGE</td>
<td>-80</td>
<td>Argument range error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R1 response card status error (OUT_OF_RANGE)</td>
</tr>
<tr>
<td>SDC_SD_ERR_ADDRESS_ERROR</td>
<td>-81</td>
<td>Address error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R1 response card status error (ADDRESS_ERROR)</td>
</tr>
<tr>
<td>SDC_SD_ERR_BLOCK_LEN_ERROR</td>
<td>-82</td>
<td>Block length error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R1 response card status error (BLOCK_LEN_ERROR)</td>
</tr>
<tr>
<td>SDC_SD_ERR_ILLEGAL_COMMAND</td>
<td>-83</td>
<td>Illegal command error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>R1 response card status error (ILLEGAL_COMMAND)</td>
</tr>
<tr>
<td>SDC_SD_ERR_CMD_ERROR</td>
<td>-86</td>
<td>Command index error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Internal error (The transmission command index and the reception command index differ)</td>
</tr>
<tr>
<td>SDC_SD_ERR_CBSY_ERROR</td>
<td>-87</td>
<td>Command error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SDHI internal error (Command busy)</td>
</tr>
<tr>
<td>SDC_SD_ERR_NO_RESP_ERROR</td>
<td>-88</td>
<td>No response error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>SDHI internal error (Response could not be received)</td>
</tr>
<tr>
<td>SDC_SD_ERR_ADDRESS_BOUNDARY</td>
<td>-89</td>
<td>Buffer address error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Argument buffer address error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The address does not fall on a 4-byte boundary</td>
</tr>
<tr>
<td>SDC_SD_ERR_UNSUPPORTED_TYPE</td>
<td>-97</td>
<td>Unsupported SDIO access error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unsupported SDIO access error</td>
</tr>
<tr>
<td>SDC_SD_ERR_API_LOCK</td>
<td>-98</td>
<td>API lock error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Error that occurs when an API is called while another is being called</td>
</tr>
<tr>
<td>SDC_SD_ERR_INTERNAL</td>
<td>-99</td>
<td>Internal error</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Internal driver error</td>
</tr>
</tbody>
</table>
2.11 Callback Function

This driver calls the callback function specified by the user when the SD protocol status interrupt, or SD Card insertion interrupt occurs.

For information regarding how to register callback functions, see "3.16, R_SDC_SD_CdInt()" and "3.17, R_SDC_SD_IntCallback()".

For the timing at which the callback function occurs, see "1.4.2.5 SDHI Status Verification".

2.12 Adding the FIT Module to Your Project

This driver must be added to each project in which it is used. Renesas recommends using "Smart Configurator" described in (1) or (3). However, "Smart Configurator" only supports some RX devices. Please use the methods of (2) or (4) for unsupported RX devices.

(1) Adding the FIT module to your project using "Smart Configurator" in e² studio
By using the "Smart Configurator" in e² studio, the FIT module is automatically added to your project. Refer to "Renesas e² studio Smart Configurator User Guide (R20AN0451)" for details.

(2) Adding the FIT module to your project using "FIT Configurator" in e² studio
By using the "FIT Configurator" in e² studio, the FIT module is automatically added to your project. Refer to "Adding Firmware Integration Technology Modules to Projects (R01AN1723)" for details.

(3) Adding the FIT module to your project using "Smart Configurator" on CS+
By using the "Smart Configurator Standalone version" in CS+, the FIT module is automatically added to your project. Refer to "Renesas e² studio Smart Configurator User Guide (R20AN0451)" for details.

(4) Adding the FIT module to your project in CS+
In CS+, please manually add the FIT module to your project. Refer to "Adding Firmware Integration Technology Modules to CS+ Projects (R01AN1826)" for details.
2.13 “for”, “while” and “do while” statements

In this module, “for”, “while” and “do while” statements (loop processing) are used in processing to wait for register to be reflected and so on. For these loop processing, comments with “WAIT_LOOP” as a keyword are described. Therefore, if user incorporates fail-safe processing into loop processing, user can search the corresponding processing with “WAIT_LOOP”.

The following shows example of description.

```
while statement example :
  /* WAIT_LOOP */
  while(0 == SYSTEM.OSCOVFSR.BIT.PLOVF)
  {
    /* The delay period needed is to make sure that the PLL has stabilized. */
  }

for statement example :
  /* Initialize reference counters to 0. */
  /* WAIT_LOOP */
  for (i = 0; i < BSP_REG_PROTECT_TOTAL_ITEMS; i++)
  {
    g_protect_counters[i] = 0;
  }

do while statement example :
  /* Reset completion waiting */
  do
  {
    reg = phy_read(ether_channel, PHY_REG_CONTROL);
    count++;
  } while ((reg & PHY_CONTROL_RESET) && (count < ETHER_CFG_PHY_DELAY_RESET)); /* WAIT_LOOP */
```
3. API Functions

3.1 R_SDC_SD_Open()

This is the first function called when this SD Card driver API is used.

Format

```c
sdc_sd_status_t R_SDC_SD_Open(
    uint32_t card_no,
    uint32_t channel,
    void *p_sdc_sd_workarea
)
```

Parameters

- `card_no`:
  - SD Card number
  - The number of the SD Card used (numbering starts at 0)

- `channel`:
  - Channel number
  - The number of the SDHI channel used (numbering starts at 0)

- `p_sdc_sd_workarea`:
  - Pointer to a working area on a 4-byte boundary (area size: 200 bytes)

Return Values

- `SDC_SD_SUCCESS`:
  - Successful operation
- `SDC_SD_ERR`
  - General error
- `SDC_SD_ERR_CPU_IF`
  - Target microcontroller interface error
- `SDC_SD_ERR_ADDRESS_BOUNDARY`
  - Argument buffer address error

Properties

A prototype declaration for this function appears in `r_sdc_sd_rx_if.h`.

Description

Gets the SDHI channel resource controlled by the argument `card_no` and initializes the SD Card driver specified by the argument channel and the SDHI FIT module. Also, this function exclusively acquires that SDHI channel resource.

The working area is also retained until SD Card driver close processing completes, and the application must not modify the working area contents.

Example

```c
uint32_t   g_sdc_sd_work[200/sizesof(uint32_t)];

/* ==== Please add the processing to set the pins. ==== */
if (R_SDC_SD_Open(SDC_SD_CARD0, &g_sdc_sd_work) != SDC_SD_SUCCESS)
{
    /* Error */
}
```

Special Notes

The pins must be set up before this function is called. See section 4.1, SD Card Insertion and Power-On Timing, for details.

If this function does not complete successfully, do not call any library functions other than `R_SDC_SD_GetVersion()`, `R_SDC_SD_Log()`, or `R_SDC_SD_SetLogHdlAddress()`.

If this function does complete successfully, the card insertion interrupt may be enabled. If the SD Card insertion interrupt is used, after this function has run, use the `R_SDC_SD_CdInt()` function to enable the card insertion interrupt.

Note that the error code cannot be acquired with the `R_SDC_SD_GetErrCode()` function.
The microcontroller pin states do not change from before to after the execution of this function.
3.2 R_SDC_SD_Close()

This function releases the resources being used by the SD Card driver.

Format

```c
sdc_sd_status_t R_SDC_SD_Close(
    uint32_t card_no
)
```

Parameters

- `card_no`: SD Card number
  - The number of the SD Card used (numbering starts at 0)

Return Values

- `SDC_SD_SUCCESS`: Successful operation
- `SDC_SD_ERR`: General error

Properties

A prototype declaration for this function appears in `r_sdc_sd_rx_if.h`.

Description

This function terminates all SD Card driver processing and releases the resources for the SDHI channel specified in the argument `card_no`.

That SDHI channel is set to the module stop state.

After this function is called, the insertion interrupt will be in the disabled state.

The working area specified with the `R_SDC_SD_Open()` function is not used after this function has been executed. This area may be used for other purposes.

Reentrant

This function is reentrant with respect to other channels.

Example

```c
/* ==== Please add the processing to set the pins. ==== */

if (R_SDC_SD_Close(SDC_SD_CARD0) != SDC_SD_SUCCESS)
{
    /* Error */
}
```

Special Notes

The pins must be set up after this function is called. See section 4.2, SD Card Removal and Power-Off Timing, for details. Before running this function, driver open processing must be performed by the `R_SDC_SD_Open()` function.

Note that the error code cannot be acquired with the `R_SDC_SD_GetErrCode()` function.
3.3 R_SDC_SD_GetCardDetection()

This function verifies the SD Card insertion state.

**Format**

```c
sdc_sd_status_t R_SDC_SD_GetCardDetection(
    uint32_t card_no
);
```

**Parameters**

- `card_no`  
  SD Card number  
  The number of the SD Card used (numbering starts at 0)

**Return Values**

- **SDC_SD_SUCCESS**  
  The SDHI_CD pin was at the low level or card detection was invalid.
- **SDC_SD_ERR**  
  The SDHI_CD pin was at the high level.

**Properties**

A prototype declaration for this function appears in `r_sdc_sd_rx_if.hh`.

**Description**

This function verifies the SD Card insertion state.

<When SDHI_CFG_CHx_CD_ACTIVE == 1 (card detection enabled)>

- If the SDHI_CD pin is low, this function returns SDC_SD_SUCCESS.
- If the SDHI_CD pin is high, this function returns SDC_SD_ERR.

<When SDHI_CFG_CHx_CD_ACTIVE == 0 (card detection disabled)>

- This function will always return SDC_SD_SUCCESS.

**Example**

```c
if (R_SDC_SD_GetCardDetection(SDC_SD_CARD0) != SDC_SD_SUCCESS)
{
    /* Error */
}
```

**Special Notes**

To enable card detection, set `#define SDHI_CFG_CHx_CD_ACTIVE` to 1 in the SDHI FIT module.

When using the card insertion detection function, pin setting is necessary after this function is executed. See section 4.1, SD Card Insertion and Power-On Timing, for details. Before running this function, driver open processing must be performed by the `R_SDC_SD_Open()` function.

When using with card removal detection, pin setting is required before this function is executed. See section 4.2, SD Card Removal and Power-Off Timing, for details.

The SDHI_CD pin, which is connected to the SD Card socket CD pin, is used as the SD Card insertion detection pin.

Note that the error code cannot be acquired with the `R_SDC_SD_GetErrCode()` function.

After an SD Card has been detected, the processing that provides the power supply voltage to the SD Card must be performed.
3.4 R_SDC_SD_Initialize()

This function initializes the SD Card and transitions the state from the SD Card initialization state to the driver idle state.

**Format**

```c
sdc_sd_status_t R_SDC_SD_Initialize(
    uint32_t card_no,
    sdc_sd_cfg_t *p_sdc_sd_config,
    uint32_t init_type
)
```

**Parameters**

- `card_no`  
  SD Card number  
  The number of the SD Card used (numbering starts at 0)

- `*p_sdc_sd_config`  
  Structure that holds the operating settings

- `mode`  
  The operating mode
  The application should set the operating mode to the logical OR of each of the types shown as macro definitions in Table 3.1, SD Card Driver Operating Mode (mode).

- `voltage`  
  The power supply voltage
  Specify the voltage supplied to the SD Card (For the setting values, see the macro definitions in Table 3.2, Supply Voltages (voltage). An SD Card that cannot operate at the specified supply voltage will not be initialized. See section 1.4.2.3, Operating Voltage Settings When Initialization.

**Table 3.1 SD Card Driver Operating Mode (mode)**

<table>
<thead>
<tr>
<th>Type</th>
<th>Macro Definition</th>
<th>Value (Bits)</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD Protocol Status</td>
<td>SDC_SD_MODE_POLL</td>
<td>0x0000</td>
<td>Software polling</td>
</tr>
<tr>
<td>Verification</td>
<td>SDC_SD_MODE_HWINT</td>
<td>0x0001</td>
<td>Hardware interrupt</td>
</tr>
<tr>
<td>Data transfer type</td>
<td>SDC_SD_MODE_SW</td>
<td>0x0000</td>
<td>Software transfers</td>
</tr>
<tr>
<td></td>
<td>SDC_SD_MODE_DMA</td>
<td>0x0002</td>
<td>DMAC transfers&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>SDC_SD_MODE_DTC</td>
<td>0x0004</td>
<td>DTC transfers&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Media support type</td>
<td>SDC_SD_MODE_MEM</td>
<td>0x0000</td>
<td>SD Memory Card/SD memory</td>
</tr>
<tr>
<td>SD bus support type</td>
<td>SDC_SD_MODE_4BIT</td>
<td>0x0200</td>
<td>SD mode 4-bit bus</td>
</tr>
</tbody>
</table>

Notes:
1. DMAC control software must be provided separately.
2. DTC control software must be provided separately.
3. Software transfers are performed by the functions used.
4. Do not set up SDC_SD_MODE_DMA and SDC_SD_MODE_DTC at the same time.
Table 3.2 Supply Voltage (voltage)

<table>
<thead>
<tr>
<th>Supply Voltage [V]</th>
<th>Macro Definition</th>
<th>Value (Bits)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.7-2.8</td>
<td>SDC_SD_VOLT_2_8</td>
<td>0x000008000</td>
</tr>
<tr>
<td>2.8-2.9</td>
<td>SDC_SD_VOLT_2_9</td>
<td>0x00010000</td>
</tr>
<tr>
<td>2.9-3.0</td>
<td>SDC_SD_VOLT_3_0</td>
<td>0x00020000</td>
</tr>
<tr>
<td>3.0-3.1</td>
<td>SDC_SD_VOLT_3_1</td>
<td>0x00040000</td>
</tr>
<tr>
<td>3.1-3.2</td>
<td>SDC_SD_VOLT_3_2</td>
<td>0x00080000</td>
</tr>
<tr>
<td>3.2-3.3</td>
<td>SDC_SD_VOLT_3_3</td>
<td>0x00100000</td>
</tr>
<tr>
<td>3.3-3.4</td>
<td>SDC_SD_VOLT_3_4</td>
<td>0x00200000</td>
</tr>
<tr>
<td>3.4-3.5</td>
<td>SDC_SD_VOLT_3_5</td>
<td>0x00400000</td>
</tr>
<tr>
<td>3.5-3.6</td>
<td>SDC_SD_VOLT_3_6</td>
<td>0x00800000</td>
</tr>
</tbody>
</table>

*init_type: Initialization type*

Specify the initialization target. As the value, use the media support type macro definition listed in Table 3.1, SD Card Driver Operating Mode (mode).

**Return Values**

- **SDC_SD_SUCCESS**: Successful operation
- **SDC_SD_SUCCESS_LOCKED_CARD**: Successful operation, and, furthermore, SD Card is in the locked state
- **Other than the above**: Error termination
  (See the error code for details.)

**Properties**

A prototype declaration for this function appears in `r_sdc_sd_rx_if.h`.

**Description**

This function performs SD Card initialize processing. Applications should call this function after detecting an SD Card.

When the card is recognized as an SD Card, the internal pulled-up function of CD/DAT3 pin in SD Card will be disabled.

When the return value is SDC_SD_SUCCESS, the SD Card will have transitioned to the transfer state (tran) and SD Card read and write access will be possible. When the return value is SDC_SD_SUCCESS_LOCKED_CARD, the SD Card will have transitioned to the transfer state (tran), but SD Card read and write access will not be possible. In this case, SDC_SD_ERR_CARD_LOCK will be registered as the error code. A locked SD Card only accepts certain commands. To read or write to a locked SD Card, the SD Card must first be set to the unlocked state and then must be initialized again.
Example

```c
sdc_sd_cfg_t sdc_sd_config;

/* ==== Please add the processing to set the pins. ==== */

sdc_sd_config.mode = SDC_SD_CFG_DRIVER_MODE;
sdc_sd_config.voltage = SDC_SD_VOLT_3_3;
if (R_SDC_SD_Initialize(SDC_SD_CARD0, &sdc_sd_config, SDC_SD_MODE_MEM) !=
SDC_SD_SUCCESS)
{
    /* Error */
}
```

Special Notes

This SD Card driver sets Default Speed mode when initializing.

The pins must be set up before executing this function. See section 4.1, SD Card Insertion and Power-On Timing, for details. Also, before running this function, driver open processing must be performed by the R_SDC_SD_Open() function.

If this function returns an error, after setting the hardware to the SD Card initialization possible state by calling the R_SDC_SD_End() function, perform the initialization processing again.

After initialization completes, perform end processing before running reinitialization processing.

When voltage in p_sdc_sd_config is set to an arbitrary value in the range 2.7 to 3.6 V, the output voltage will be taken to be in the 2.7 to 3.6 V range.

If the R_SDC_SD_CdInt() function is used, set SDC_SD_MODE_HWINT as the p_sdc_sd_config mode status.

The SDHI only supports 3.3 V signal levels. Therefore, this SD Card driver sets the S18R bit in the command arguments to 0 during SD Card initialization and issues either an ACMD41 command.
3.5 R_SDC_SD_End()

This function clears the value of the work area and transitions from the driver idle state to the SD Card initialization possible state. Running this function does not change the state of the SD Card.

Format

```c
sdc_sd_status_t R_SDC_SD_End(
    uint32_t card_no,
    uint32_t end_type
)
```

Parameters

- `card_no`
  - SD Card number
  - The number of the SD Card used (numbering starts at 0)

- `end_type`
  - End type
  - Specify the end target. As the value, use the macro definition of a mode supported by the media listed in Table 3.1, SD Card Driver Operating Mode (mode), in the description of the R_SDC_SD_Initialize() function.

Return Values

- `SDC_SD_SUCCESS` Successful operation
- `SDC_SD_ERR` General error

Properties

A prototype declaration for this function appears in r_sdc_sd_rx_if.h.

Description

This function performs SD Card end processing.

For SD Cards, it switches to the SD Card removable state. Note that even if this function has been called and the SD Card initialized state has been cleared, the SD Card insertion interrupt and the SD Card insertion verification interrupt callback function remain enabled.

Example

```c
if (R_SDC_SD_End(SDC_SD_CARD0, SDC_SD_MODE_MEM) != SDC_SD_SUCCESS)
{
    /* Error */
}
/* ==== Please add the processing to set the pins. ==== */
```

Special Notes

If the SD Card is removed after this function has been called, the pins must be set up. See section 4.2, SD Card Removal and Power-Off Timing, for details. Also, before running this function, driver open processing must be performed by the R_SDC_SD_Open() function.

Note that the error code cannot be acquired with the R_SDC_SD_GetErrCode() function.
3.6 R_SDC_SDMEM_Read()

This function performs read processing.

Format

```c
sdc_sd_status_t R_SDC_SDMEM_Read(
    uint32_t card_no,
    sdc_sd_access_t *p_sdc_sd_access
)
```

Parameters

- **card_no**: SD Card number
  - The number of the SD Card used (numbering starts at 0)
- **p_sdc_sd_access**: Access information structure
  - **p_buff**: Read buffer pointer
    - This must be set to an address on a 4-byte boundary.
  - **lbn**: Read start block number
  - **cnt**: Block count
    - The maximum value that this argument may be set to is 65,535.
  - **mode**: Transfer mode (Does not need to be set and may not be changed)
  - **write_mode**: Write mode (Does not need to be set)

Return Values

- **SDC_SD_SUCCESS**: Successful operation
- **Other than the above**: Error termination (See the error code for details.)

Properties

A prototype declaration for this function appears in r_sdc_sd_rx_if.h.

Description

Reads the number of blocks of data specified by cnt in the argument p_sdc_sd_access starting at the block specified by lbn in the argument p_sdc_sd_access and stores that data in the buffer specified by p_buff in the argument p_sdc_sd_access.

If SD Card removal is detected at the start of this function’s execution, processing is interrupted and processing is terminated and an error (SDC_SD_ERR_STOP) is returned.

If a forced stop request due to an R_SDC_SD_Control() function SDC_SD_SET_STOP (forced stop request) command is detected at the start of this function’s execution, the forced stop is cleared and processing is terminated and an error (SDC_SD_ERR_STOP) is returned.

The following commands are used to read out the block data.
- Up to 2 blocks: READ_SINGLE_BLOCK command (CMD17)
- 3 blocks or more: READ_MULTIPLE_BLOCK command (CMD18)

Reentrant

This function is reentrant with respect to other channels.
Example

```c
#define TEST_BLOCK_CNT (4)
#define BLOCK_NUM     (512)

sdc_sd_access_t  sdc_sd_access;
uint32_t   g_test_r_buff[(TEST_BLOCK_CNT*BLOCK_NUM)/sizeof(uint32_t)];

sdc_sd_access.p_buff = (uint8_t *)&g_test_r_buff[0];
sdc_sd_access.lbn    = 0x10000000;
sdc_sd_access.cnt    = TEST_BLOCK_CNT;

if(R_SDC_SDMEM_Read(SDC_SD_CARD0, &sdc_sd_access) != SDC_SD_SUCCESS)
{
    /* Error */
}
```

Special Notes

Before running this function, driver open processing must be performed by the R_SDC_SD_Open() function and initialization by the R_SDC_SD_Initialize() function.

We recommend repeating the read operation when this function terminates with a read error.

This function disables the SD Card insertion/removal interrupt during the data transfer period for DMAC or DTC transfers.

If the number of blocks to be transferred exceeds 65,535, break up the read into multiple function calls. This issue requires care when this functionality is called from upper layer application programs such as the FAT file system.

Note that the size of a block is 512 bytes.
### 3.7 R_SDC_SDMEM_ReadSoftwareTrans()

This function performs read processing (software transfers).

**Format**

```c
sdc_sd_status_t R_SDC_SDMEM_ReadSoftwareTrans(  
    uint32_t card_no,  
    sdc_sd_access_t *p_sdc_sd_access
)
```

**Parameters**

- `card_no`  
  SD Card number  
  The number of the SD Card used (numbering starts at 0)
- `*p_sdc_sd_access`  
  Access information structure
- `*p_buff`: Read buffer pointer  
  There are no address boundary restrictions. We recommend using an address that falls on a 4-byte boundary for faster processing.
- `lbn`: Read start block number
- `cnt`: Block count  
  The maximum value that this argument may be set to is 65,535.
- `mode`: Transfer mode (Does not need to be set and may not be changed)
- `write_mode`: Write mode (Does not need to be set)

**Return Values**

- `SDC_SD_SUCCESS`  
  Successful operation
- Other than the above  
  Error termination (See the error code for details.)

**Properties**

A prototype declaration for this function appears in r_sdc_sd_rx_if.h.

**Description**

Reads the number of blocks of data specified by `cnt` in the argument `p_sdc_sd_access` starting at the block specified by `lbn` in the argument `p_sdc_sd_access` and stores that data in the buffer specified by `p_buff` in the argument `p_sdc_sd_access`. Software transfer is used, regardless of the operating mode data transfer setting at command processing time.

If SD Card removal is detected at the start of this function’s execution, processing is interrupted and processing is terminated and an error (SDC_SD_ERR_STOP) is returned.

If a forced stop request due to an `R_SDC_SD_Control()` function SDC_SD_SET_STOP (forced stop request) command is detected at the start of this function’s execution, the forced stop is cleared and processing is terminated and an error (SDC_SD_ERR_STOP) is returned.

The following commands are used to read out the block data.

- Up to 2 blocks: `READ_SINGLE_BLOCK` command (CMD17)
- 3 blocks or more: `READ_MULTIPLE_BLOCK` command (CMD18)

**Reentrant**

This function is reentrant with respect to other channels.
Example

```c
#define TEST_BLOCK_CNT (4)
#define BLOCK_NUM   (512)

sdc_sd_access_t  sdc_sd_access;
uint32_t   g_test_r_buff[(TEST_BLOCK_CNT*BLOCK_NUM)/sizeof(uint32_t)];

sdc_sd_access.p_buff = (uint8_t *)&g_test_r_buff[0];
sdc_sd_access.lbn    = 0x10000000;
sdc_sd_access.cnt    = TEST_BLOCK_CNT;

if(R_SDC_SDMEM_ReadSoftwareTrans(SDC_SD_CARD0, &sdc_sd_access) != SDC_SD_SUCCESS)
    { /* Error */
    }
```

Special Notes

Before running this function, driver open processing must be performed by the R_SDC_SD_Open() function and initialization by the R_SDC_SD_Initialize() function.

We recommend repeating the read operation when this function terminates with a read error.

If the number of blocks to be transferred exceeds 65,535, break up the read into multiple function calls. This issue requires care when this functionality is called from upper layer application programs such as the FAT file system.

Note that the size of a block is 512 bytes.
3.8 R_SDC_SDMEM_ReadSoftwareTransSingleCmd()

This function performs read processing (CMD17 single software transfers).

**Format**

```c
sdc_sd_status_t R_SDC_SDMEM_ReadSoftwareTransSingleCmd(
    uint32_t card_no,
    sdc_sd_access_t *p_sdc_sd_access
)
```

**Parameters**

- `card_no`  
  SD Card number  
  The number of the SD Card used (numbering starts at 0)

- `*p_sdc_sd_access`  
  Access information structure
  - `*p_buff`: Read buffer pointer
    There are no address boundary restrictions. We recommend using an address that falls on a 4-byte boundary for faster processing.
  - `lbn`: Read start block number
  - `cnt`: Block count
    The maximum value that this argument may be set to is 65,535.
  - `mode`: Transfer mode (Does not need to be set and may not be changed)
  - `write_mode`: Write mode (Does not need to be set)

**Return Values**

- `SDC_SD_SUCCESS`: Successful operation
- Other than the above: Error termination (See the error code for details.)

**Properties**

A prototype declaration for this function appears in r_sdc_sd_rx_if.h.

**Description**

Reads the number of blocks of data specified by `cnt` in the argument `*p_sdc_sd_access` starting at the block specified by `lbn` in the argument `*p_sdc_sd_access` and stores that data in the buffer specified by `*p_buff` in the argument `*p_sdc_sd_access`.

Software transfer is used, regardless of the operating mode data transfer setting at command processing time.

If SD Card removal is detected at the start of this function's execution, processing is interrupted and processing is terminated and an error (SDC_SD_ERR_STOP) is returned.

If a forced stop request due to an R_SDC_SD_Control() function SDC_SD_SET_STOP (forced stop request) command is detected at the start of this function's execution, the forced stop is cleared and processing is terminated and an error (SDC_SD_ERR_STOP) is returned.

Only the CMD17 command is used for reading out block data.

**Reentrant**

This function is reentrant with respect to other channels.
Example

```c
#define TEST_BLOCK_CNT (4)
#define BLOCK_NUM   (512)

sdc_sd_access_t    sdc_sd_access;
uint32_t    g_test_r_buff[(TEST_BLOCK_CNT*BLOCK_NUM)/sizeof(uint32_t)];

sdc_sd_access.p_buff = (uint8_t *)&g_test_r_buff[0];
sdc_sd_access.lbn    = 0x10000000;
sdc_sd_access.cnt    = TEST_BLOCK_CNT;

if(R_SDC_SDMEM_ReadSoftwareTransSingleCmd(SDC_SD_CARD0, &sdc_sd_access) !=
  SDC_SD_SUCCESS)
{
    /* Error */
}
```

Special Notes

Before running this function, driver open processing must be performed by the R_SDC_SD_Open() function and initialization by the R_SDC_SD_Initialize() function.

We recommend repeating the read operation when this function terminates with a read error.

If the number of blocks to be transferred exceeds 65,535, break up the read into multiple function calls. This issue requires care when this functionality is called from upper layer application programs such as the FAT file system.

Note that the size of a block is 512 bytes.
3.9 R_SDC_SDMEM_Write()

This function performs write processing.

**Format**

```c
sdc_sd_status_t R_SDC_SDMEM_Write(
    uint32_t card_no,
    sdc_sd_access_t *p_sdc_sd_access
)
```

**Parameters**

- `card_no`: SD Card number
- `*p_sdc_sd_access`: Access information structure
  - `*p_buff`: Write buffer pointer
    - This must be set to an address on a 4-byte boundary.
  - `lbn`: Write start block number
  - `cnt`: Block count
    - The maximum value that this argument may be set to is 65,535.
  - `mode`: Transfer mode
    - (Does not need to be set and may not be changed)
  - `write_mode`: Write mode
    - Set this parameter to one of the macro definitions shown in Table 3.3, SD Card Driver Write Mode `write_mode`.

**Return Values**

- `SDC_SD_SUCCESS`: Successful operation
- Other than the above: Error termination (See the error code for details.)

**Properties**

A prototype declaration for this function appears in `r_sdc_sd_rx_if.h`.

**Description**

Writes the data from `p_buff` in the argument `p_sdc_sd_access` to an area with the number of blocks set by `cnt` in the argument `p_sdc_sd_access`. That area starts at the block specified by `lbn` in the argument `p_sdc_sd_access`.

If SD Card removal is detected at the start of this function’s execution, processing is interrupted and processing is terminated and an error (`SDC_SD_ERR_STOP`) is returned.

If a forced stop request due to an `R_SDC_SD_Control()` function `SDC_SD_SET_STOP` (forced stop request) command is detected at the start of this function’s execution, the forced stop is cleared and processing is terminated and an error (`SDC_SD_ERR_STOP`) is returned.

The following commands are used to write out the block data.

- Up to 2 blocks: WRITE_SINGLE_BLOCK command (CMD24)
- 3 blocks or more: WRITE_MULTIPLE_BLOCK command (CMD25)

**Table 3.3 SD Card Driver Write Mode (write_mode)**

<table>
<thead>
<tr>
<th>Type</th>
<th>Macro Definition</th>
<th>Value (Bits)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Write with pre-erase</td>
<td>SDC_SD_WRITE_WITH_PREERASE</td>
<td>0x00000000</td>
</tr>
<tr>
<td>Normal write</td>
<td>SDC_SD_WRITE_OVERWRITE</td>
<td>0x00000001</td>
</tr>
</tbody>
</table>
Reentrant
This function is reentrant with respect to other channels.

Example
#define TEST_BLOCK_CNT  (4)
#define BLOCK_NUM           (512)

sdc_sd_access_t   sdc_sd_access;
uint32_t   g_test_w_buff[(TEST_BLOCK_CNT*BLOCK_NUM)/sizeof(uint32_t)];

sdc_sd_access.p_buff = (uint8_t *)&g_test_w_buff[0];
sdc_sd_access.lbn     = 0x10000000;
sdc_sd_access.cnt     = TEST_BLOCK_CNT;
sdc_sd_access.write_mode = SDC_SD_WRITE_OVERWRITE;

if(R_SDC_SDMEM_Write(SDC_SD_CARD0, &sdc_sd_access) != SDC_SD_SUCCESS)
{
    /* Error */
}

Special Notes
Before running this function, driver open processing must be performed by the R_SDC_SD_Open() function and
initialization by the R_SDC_SD_Initialize() function.

We recommend repeating the write operation when this function terminates with a write error.

If an SD Card removal occurs during write processing when SDC_SD_WRITE_WITH_PREERASE is specified, there
is a higher probability that SD memory data will be lost than when SDC_SD_WRITE_OVERWRITE is specified.

This function disables the SD Card insertion/removal interrupt during the data transfer period for DMAC or DTC
transfers.

If the number of blocks to be transferred exceeds 65,535, break up the read into multiple function calls. This issue
requires care when this functionality is called from upper layer application programs such as the FAT file system.

Note that the size of a block is 512 bytes.
3.10 R_SDC_SDMEM_WriteSoftwareTrans()

This function performs write processing (software transfers).

**Format**

```c
sdc_sd_status_t R_SDC_SDMEM_WriteSoftwareTrans(
    uint32_t card_no,
    sdc_sd_access_t *p_sdc_sd_access
)
```

**Parameters**

- `card_no`: SD Card number
  - The number of the SD Card used (numbering starts at 0)
- `*p_sdc_sd_access`: Access information structure
  - `*p_buff`: Write buffer pointer
    - There are no address boundary restrictions. We recommend using an address that falls on a 4-byte boundary for faster processing.
  - `lbn`: Write start block number
  - `cnt`: Block count
    - The maximum value that this argument may be set to is 65,535.
  - `mode`: Transfer mode (Does not need to be set and may not be changed)
    - `write_mode`: Write mode
      - Set this parameter to one of the macro definitions shown in Table 3.4, SD Card Driver Write Mode (write_mode).

**Return Values**

- `SDC_SD_SUCCESS`: Successful operation
- Other than the above: Error termination (See the error code for details.)

**Properties**

A prototype declaration for this function appears in `r_sdc_sd_rx_if.h`.

**Description**

Writes the data from `p_buff` in the argument `p_sdc_sd_access` to an area with the number of blocks set by `cnt` in the argument `p_sdc_sd_access`. That area starts at the block specified by `lbn` in the argument `p_sdc_sd_access`.

Software transfer is used, regardless of the operating mode data transfer setting at command processing time.

If SD Card removal is detected at the start of this function's execution, processing is interrupted and processing is terminated and an error (SDC_SD_ERR_STOP) is returned.

If a forced stop request due to an `R_SDC_SD_Control()` function SDC_SD_SET_STOP (forced stop request) command is detected at the start of this function's execution, the forced stop is cleared and processing is terminated and an error (SDC_SD_ERR_STOP) is returned.

The following commands are used to write out the block data.

- Up to 2 blocks: WRITE_SINGLE_BLOCK command (CMD24)
- 3 blocks or more: WRITE_MULTIPLE_BLOCK command (CMD25)

**Table 3.4 SD Card Driver Write Mode (write_mode)**

<table>
<thead>
<tr>
<th>Type</th>
<th>Macro Definition</th>
<th>Value (Bits)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Write with pre-erase</td>
<td>SDC_SD_WRITE_WITH_PREERASE</td>
<td>0x00000000</td>
</tr>
<tr>
<td>Normal write</td>
<td>SDC_SD_WRITE_OVERWRITE</td>
<td>0x00000001</td>
</tr>
</tbody>
</table>
Reentrant
This function is reentrant with respect to other channels.

Example

```c
#define TEST_BLOCK_CNT (4)
#define BLOCK_NUM (512)

sdc_sd_access_t sdc_sd_access;
uint32_t    g_test_w_buff[(TEST_BLOCK_CNT*BLOCK_NUM)/sizeof(uint32_t)];

sdc_sd_access.p_buff = (uint8_t *)&g_test_w_buff[0];
sdc_sd_access.lbn   = 0x10000000;
sdc_sd_access.cnt   = TEST_BLOCK_CNT;
sdc_sd_access.write_mode = SDC_SD_WRITE_OVERWRITE;

if(R_SDC_SDMEM_WriteSoftwareTrans(SDC_SD_CARD0, &sdc_sd_access) != SDC_SD_SUCCESS)
{
    /* Error */
}
```

Special Notes
Before running this function, driver open processing must be performed by the R_SDC_SD_Open() function and initialization by the R_SDC_SD_Initialize() function.

We recommend repeating the write operation when this function terminates with a write error.

If an SD Card removal occurs during write processing when SDC_SD_WRITE_WITH_PREERASE is specified, there is a higher probability that SD memory data will be lost than when SDC_SD_WRITE_OVERWRITE is specified.

If the number of blocks to be transferred exceeds 65,535, break up the read into multiple function calls. This issue requires care when this functionality is called from upper layer application programs such as the FAT file system.

Note that the size of a block is 512 bytes.
3.11 R_SDC_SD_Control()

This function performs driver control processing.

**Format**

```c
sdc_sd_status_t R_SDC_SD_Control(
    uint32_t card_no,
    sdc_sd_cmd_t *p_sdc_sd_cmd
)
```

**Parameters**

- **card_no**: SD Card number
  - The number of the SD Card used (numbering starts at 0)
- **p_sdc_sd_cmd**: Control information structure
  - `cmd`: Command macro definition
  - `mode`: Mode
  - `*p_buff`: Transfer buffer pointer
  - `size`: Transfer size

**Return Values**

- **SDC_SD_SUCCESS**: Successful operation
- **Other than the above**: Error termination (See the error code for details.)

**Properties**

A prototype declaration for this function appears in `r_sdc_sd_rx_if.h`.

**Description**

This is an SD Card control utility.

Table 3.5, Commands, lists the commands that can be controlled. These commands are described individually starting on the following page.

**Table 3.5 Commands**

<table>
<thead>
<tr>
<th>Command macro Definition</th>
<th>Mode</th>
<th>Transfer Content</th>
<th>Transfer Size</th>
<th>Control Performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDC_SD_SET_STOP</td>
<td>Setting invalid</td>
<td>Setting invalid</td>
<td>Setting invalid</td>
<td>Transitions to the forced stop request state</td>
</tr>
<tr>
<td>(Forced stop request command)</td>
<td></td>
<td></td>
<td></td>
<td>When a forced stop request command due to this function call is issued during read or write processing, a transfer processing forced stop is requested.</td>
</tr>
</tbody>
</table>

**Reentrant**

This function is reentrant with respect to other channels.

**Example**

Examples are shown for each command on the following pages.

**Special Notes**

Before running this function, driver open processing must be performed by the `R_SDC_SD_Open()` function and initialization by the `R_SDC_SD_Initialize()` function.

Note that the error code cannot be acquired with the `R_SDC_SD_GetErrCode()` function.
(a) **SDC_SD_SET_STOP**

This function forcibly stops read/write processing.

### Return Values

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDC_SD_SUCCESS</td>
<td>Successful operation</td>
</tr>
</tbody>
</table>

### Description

This function requests a forced stop and transitions the SD Card driver to the forced stop state.

This function can be called from within an interrupt handler when an application program wants to stop processing.

**<For SD Memory>**

When there is a data transfer to or from the SD Card in progress, a CMD12 is issued to transition the SD Card to the transfer state (tran), the read/write processing for the transfer in progress is forcibly terminated, and an error is returned.

Note that if this function is executed during write processing, a CMD12 is issued and the SD Card may transition to the busy state. As a result, there are cases where an error is returned when a next read or write function is called. In such cases, we recommend performing the read or write processing again. If this occurs during a write, it will be necessary to wait until the SD Card is in the ready state.

Also, if a forced stop request is issued with a timing such that it occurs after a transfer has completed, the processing will return with the SD Card still in the forced stop request state. Therefore, an error end (SDC_SD_ERR_STOP) is returned when the R_SDC_SDMEM_Read() function or R_SDC_SDMEM_Write() function* is called.

### Example

```c
sdc_sd_cmd_t sdc_sd_cmd;

sdc_sd_cmd.cmd = SDC_SD_SET_STOP;
sdc_sd_cmd.mode = 0;
sdc_sd_cmd.p_buff = 0;
sdc_sd_cmd.size = 0;

if (R_SDC_SD_Control(SDC_SD_CARD0, &sdc_sd_cmd) != SDC_SD_SUCCESS)
{
    /* Error */
}
```

### Special Notes

When a forced stop is performed during write processing, the SD Card data is not guaranteed.

The following are the forced stop request checkpoints in library functions.

1. After read/write processing has started, before any commands are issued to the SD Card.
2. During software transfers, after the completion of transfer of a 512-byte block unit and before transfer of the next block.
3. Forced stop requests are always accepted during DMAC or DTC transfers.

Also, a forced stop request clear is performed in the following cases.

1. When forced stop processing is performed during execution of the R_SDC_SDMEM_Read() or R_SDC_SDMEM_Write()* function.
2. When the R_SDC_SDMEM_Read() or R_SDC_SDMEM_Write()* function is called in the forced stop state. In this case, the forced stop request is detected at the start of processing, the processing is stopped, and an error is returned.

Note: * The R_SDC_SDMEM_ReadSoftwareTrans(), R_SDC_SDMEM_ReadSoftwareTransSingleCmd(), and R_SDC_SDMEM_WriteSoftwareTrans() functions operate similarly.
3.12 R_SDC_SD_GetModeStatus()

This function acquires the transfer mode status.

Format

```c
sdc_sd_status_t R_SDC_SD_GetModeStatus(
    uint32_t card_no,
    uint8_t *p_mode
)
```

Parameters

- `card_no`
  - SD Card number
  - The number of the SD Card used (numbering starts at 0)
- `*p_mode`
  - Mode status information storage pointer (1 byte). See the macro definitions in Table 3.1, SD Card Driver Operating Mode (mode) for the values of this parameter.

Return Values

- `SDC_SD_SUCCESS` Successful operation
- `SDC_SD_ERR` General error

Properties

A prototype declaration for this function appears in r_sdc_sd_rx_if.h.

Description

This function acquires the transfer mode status and stores it in the mode status information storage pointer.

Reentrant

This function is reentrant with respect to other channels.

Example

```c
uint8_t * p_mode;

if(R_SDC_SD_GetModeStatus(SDC_SD_CARD0, p_mode) != SDC_SD_SUCCESS)
{
    /* Error */
}
```

Special Notes

Before running this function, driver open processing must be performed by the R_SDC_SD_Open() function and initialization by the R_SDC_SD_Initialize() function.

Note that the error code cannot be acquired with the R_SDC_SD_GetErrCode() function.
### 3.13 R_SDC_SD_GetCardStatus()

This function acquires the card status information.

#### Format

```c
sdc_sd_status_t R_SDC_SD_GetCardStatus(
    uint32_t card_no,
    sdc_sd_card_status_t *p_sdc_sd_card_status
)
```

#### Parameters

- `card_no`
  - SD Card number
  - The number of the SD Card used (numbering starts at 0)
- `p_sdc_sd_card_status`
  - Card status information structure pointer

- `card_sector_size`: User area block count
- `prot_sector_size`: Protected area block count
- `write_protect`: Write protect information (See Table 3.6, Write Protect Information (write_protect).)
- `media_type`: Media type (See Table 3.7, Media Type (media_type).)
- `csd_structure`: CSD information
  - 0: Standard Capacity card (SDSC)
  - 1: High Capacity card (SDHC, SDXC)
- `speed_mode`: Reserved
- `io_speed_mode`: Reserved

#### Return Values

- `SDC_SD_SUCCESS`: Successful operation
- `SDC_SD_ERR`: General error

#### Properties

A prototype declaration for this function appears in `r_sdc_sd_rx_if.h`.

#### Description

This function gets the card status information of the SD Card and stores it in a card status information structure.

#### Table 3.6 Write Protect Information (write_protect)

<table>
<thead>
<tr>
<th>Macro Definition</th>
<th>Value (Bits)</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDC_SD_WP_OFF</td>
<td>0x00</td>
<td>Write protect released state</td>
</tr>
<tr>
<td>SDC_SD_WP_HW</td>
<td>0x01</td>
<td>Hardware write protect state</td>
</tr>
<tr>
<td>SDC_SD_WP_TEMP</td>
<td>0x02</td>
<td>The TEMP_WRITE_PROTECT bit in the CSD register is set.</td>
</tr>
<tr>
<td>SDC_SD_WP_PERM</td>
<td>0x04</td>
<td>The PERM_WRITE_PROTECT bit in the CSD register is set.</td>
</tr>
<tr>
<td>SDC_SD_WP_ROM</td>
<td>0x10</td>
<td>SD ROM</td>
</tr>
</tbody>
</table>
Table 3.7 Media Type (media_type)

<table>
<thead>
<tr>
<th>Macro Definition</th>
<th>Value (Bits)</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDC_SD_MEDIA_UNKNOWN</td>
<td>0x00</td>
<td>Unknown</td>
</tr>
<tr>
<td>SDC_SD_MEDIA_SDMEM</td>
<td>0x20</td>
<td>SD Memory Card/SD memory</td>
</tr>
<tr>
<td>SDC_SD_MEDIA_SDIO</td>
<td>0x01</td>
<td>SDIO Card/SDIO</td>
</tr>
<tr>
<td>SDC_SD_MEDIA_COMBO</td>
<td>0x21</td>
<td>SD Combo card (Logical OR of SD memory and SDIO)</td>
</tr>
</tbody>
</table>

**Reentrant**
This function is reentrant with respect to other channels.

**Example**

```c
sdc_sd_card_status_t sdc_sd_card_status;

if (R_SDC_SD_GetCardStatus(SDC_SD_CARD0, &sdc_sd_card_status) != SDC_SD_SUCCESS)
{
    /* Error */
}
```

**Special Notes**
Before running this function, driver open processing must be performed by the R_SDC_SD_Open() function and initialization by the R_SDC_SD_Initialize() function.

Note that the error code cannot be acquired with the R_SDC_SD_GetErrCode() function.
3.14 R_SDC_SD_GetCardInfo()

This function acquires the SD Card register information.

Format

```c
sdc_sd_status_t R_SDC_SD_GetCardInfo(
    uint32_t card_no,
    sdc_sd_card_reg_t *p_sdc_sd_card_reg
)
```

Parameters

- **card_no**
  - SD Card number
  - The number of the SD Card used (numbering starts at 0)

- **p_sdc_sd_card_reg**
  - SD Card register information structure pointer
    - `sdio_ocr[1]`: SDIO OCR information
    - `ocr[1]`: SD memory OCR information
    - `cid[4]`: SD memory CID information
    - `csd[4]`: SD memory CSD information
    - `dsr[1]`: SD memory DSR information
    - `rca[2]`: SDIO and SD memory RCA information
    - `scr[2]`: SD memory SCR information
    - `sdstatus[4]`: SD memory SD status information

Return Values

- `SDC_SD_SUCCESS`: Successful operation
- `SDC_SD_ERR`: General error

Properties

A prototype declaration for this function appears in `r_sdc_sd_rx_if.h`.

Description

This function acquires the SD Card register information and stores it in the SD Card register information structure.

Reentrant

This function is reentrant with respect to other channels.

Example

```c
sdc_sd_card_reg_t sdc_sd_card_reg;
if (R_SDC_SD_GetCardInfo(SDC_SD_CARD0, &sdc_sd_card_reg) != SDC_SD_SUCCESS)
{
    /* Error */
}
```

Special Notes

Before running this function, driver open processing must be performed by the `R_SDC_SD_Open()` function and initialization by the `R_SDC_SD_Initialize()` function.

Note that the error code cannot be acquired with the `R_SDC_SD_GetErrCode()` function.
3.15  R_SDC_SDMEM_GetSpeed()

This function acquires the SD Card Speed Class information and the performance move information.

**Format**

```c
sdc_sd_status_t R_SDC_SDMEM_GetSpeed(
    uint32_t card_no,
    uint8_t *p_clss,
    uint8_t *p_move
);
```

**Parameters**

- `card_no`<br>SD Card number The number of the SD Card used (numbering starts at 0)
- `*p_clss`<br>Pointer to a Speed Class information structure (1 byte) (See Table 3.8, Speed Class Information.)
- `*p_move`<br>Pointer to a performance move information structure (1 byte) (See Table 3.9, Performance Move Information.)

**Return Values**

- `SDC_SD_SUCCESS` Successful operation
- `SDC_SD_ERR` General error

**Properties**

A prototype declaration for this function appears in `r_sdc_sd_rx_if.h`.

**Description**

Gets the Speed Class information and Performance Move information of the SD card.

**Table 3.8 Speed Class Information**

<table>
<thead>
<tr>
<th>Macro Definition</th>
<th>Value (Bits)</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>SDC_SD_SPEED_CLASS_0</td>
<td>0x00</td>
<td>Speed Class 0</td>
</tr>
<tr>
<td>SDC_SD_SPEED_CLASS_2</td>
<td>0x01</td>
<td>Speed Class 2</td>
</tr>
<tr>
<td>SDC_SD_SPEED_CLASS_4</td>
<td>0x02</td>
<td>Speed Class 4</td>
</tr>
<tr>
<td>SDC_SD_SPEED_CLASS_6</td>
<td>0x03</td>
<td>Speed Class 6</td>
</tr>
<tr>
<td>SDC_SD_SPEED_CLASS_10</td>
<td>0x04</td>
<td>Speed Class 10</td>
</tr>
<tr>
<td>(No corresponding definitions)</td>
<td>0x05 to 0xFF</td>
<td>Reserved</td>
</tr>
</tbody>
</table>

**Table 3.9 Performance Move Information**

<table>
<thead>
<tr>
<th>Value</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>0x00</td>
<td>Sequential write</td>
</tr>
<tr>
<td>0x01</td>
<td>1 MB/sec.</td>
</tr>
<tr>
<td>0x02</td>
<td>2 MB/sec.</td>
</tr>
<tr>
<td>...</td>
<td>...</td>
</tr>
<tr>
<td>0xFE</td>
<td>254 MB/sec.</td>
</tr>
<tr>
<td>0xFF</td>
<td>Infinity</td>
</tr>
</tbody>
</table>

**Note:** The values and definitions are the same as those in the SD Specifications Part 1 Physical Layer Simplified Specification.
**Reentrant**
This function is reentrant with respect to other channels.

**Example**
```c
uint8_t  cls;  
uint8_t  move;

if (R_SDC_SDMEM_GetSpeed(SDC_SD_CARD0, &cls, &move) != SDC_SD_SUCCESS)  
{
    /* Error */
}
```

**Special Notes**
Before running this function, driver open processing must be performed by the R_SDC_SD_Open() function and initialization by the R_SDC_SD_Initialize() function.

Note that the error code cannot be acquired with the R_SDC_SD_Get.ErrCode() function.
3.16  R_SDC_SD_CdInt()

This function sets up the SD Card insertion interrupt (including registering the insertion interrupt callback function).

Format

\[
\text{sdc_sd_status_t R_SDC_SD_CdInt(}
\begin{align*}
\text{uint32_t card_no,} \\
\text{int32_t enable,} \\
\text{sdc_sd_status_t (*callback)(int32_t)}
\end{align*}
\]

Parameters

\text{card_no} \\
SD Card number \\
The number of the SD Card used (numbering starts at 0)

\text{enable} \quad \text{Specifies enable/disable of the SD Card insertion interrupt.}

- When SDC_SD_CD_INT_ENABLE is specified, the SD Card insertion interrupt is enabled.
- When SDC_SD_CD_INT_DISABLE is specified, the SD Card insertion interrupt is disabled.

\text{(*callback)(int32_t): Callback function to be registered}

- If a null pointer is specified, no callback function is registered. If a callback function is to be used, execute this function to register the callback function before an SD Card is inserted.
- The SDHI_CD pin detection state is stored in the (int32_t).
  - 0: SDC_SD_CD_INSERT (A falling edge on the SDHI_CD pin was detected)
  - 1: SDC_SD_CD_REMOVE (A rising edge on the SDHI_CD pin was detected)

Return Values

\begin{align*}
\text{SDC_SD_SUCCESS} & \quad \text{Successful operation} \\
\text{SDC_SD_ERR} & \quad \text{General error}
\end{align*}

Properties

A prototype declaration for this function appears in r_sdc_sd_rx_if.h.

Description

This function sets up the SD Card insertion interrupt and registers a callback function.

The callback function registered by this function is called as a subroutine from the interrupt handler when an SD Card insertion interrupt occurs.

Note that the SD Card insertion state can be verified with the R_SDC_SD_GetCardDetection() function regardless of the enabled/disabled state of the SD Card insertion interrupt.

Reentrant

This function is reentrant with respect to other channels.
Example

/* Callback function */
sdc_sd_status_t r_sdc_sd_cd_callback(int32_t cd)
{
    if (cd & SDC_SD_CD_INSERT)
    {
        /* sdcard in */
    }
    else
    {
        /* sdcard out */
    }
    return SDC_SD_SUCCESS;
}

/* main */
void main(void)
{
    if (R_SDC_SD_CdInt(SDC_SD_CARD0, SDC_SD_CD_INT_ENABLE,
                       r_sdc_sd_cd_callback) != SDC_SD_SUCCESS)
    {
        /* Error */
    }
}

Special Notes
To enable card detection, set #define SDHI_CFG_CHx_CD_ACTIVE to 1 in the SDHI FIT module.
Before running this function, driver open processing must be performed by the R_SDC_SD_Open() function.
After this function has been executed, the SD Card insertion interrupt will be caused by an SD Card insertion.
Note that the error code cannot be acquired with the R_SDC_SD_GetErrCode() function.
3.17  R_SDC_SD_IntCallback()

This function registers an SD protocol status interrupt callback function.

Format

```c
sdc_sd_status_t R_SDC_SD_IntCallback(
    uint32_t card_no,
    sdc_sd_status_t (*callback)(int32_t)
)
```

Parameters

- `card_no`: SD Card number
  
  The number of the SD Card used (numbering starts at 0)

- `(*callback)(int32_t)`: Callback function to be registered
  
  If a null pointer is specified, no callback function is registered. If a callback function is to be used, register a callback function before the R_SDC_SD_Initialize() function is executed.
  
  The value 0 is always stored in (int32_t).

Return Values

- `SDC_SD_SUCCESS`: Successful operation
- `SDC_SD_ERR`: General error

Properties

A prototype declaration for this function appears in r_sdc_sd_rx_if.h.

Description

This function registers an SD protocol status interrupt callback function.

The callback function registered by this function is called as a subroutine from the interrupt handler when an interrupt occurs due to a change in the SD protocol status.

Reentrant

This function is reentrant with respect to other channels.

Example

```c
/* Callback function */
sdc_sd_status_t r_sdc_sd_callback(int32_t channel)
{
    /* User program */

    return SDC_SD_SUCCESS;
}

if (R_SDC_SD_IntCallback(SDC_SD_CARD0, r_sdc_sd_callback) != SDC_SD_SUCCESS)
{
    /* Error */
}
```

Special Notes

Before running this function, driver open processing must be performed by the R_SDC_SD_Open() function.

The task wait state clear operation and other processing is performed in the registered callback function.

The callback function registered by this function differs from the SD Card insertion interrupt callback function.

The callback function registered by this function is not called when an SD Card insertion interrupt occurs.

Note that the error code cannot be acquired with the R_SDC_SD_GetErrCode() function.
### 3.18 R_SDC_SD_GetErrCode()

This function acquires the driver error codes.

**Format**

```c
sdc_sd_status_t R_SDC_SD_GetErrCode(
    uint32_t card_no
)
```

**Parameters**

- `card_no`  
  SD Card number  
  The number of the SD Card used (numbering starts at 0)

**Return Values**

- `Error code`  
  See the error code documentation.

**Properties**

A prototype declaration for this function appears in `r_sdc_sd_rx_if.h`.

**Description**

This function returns the error codes that occur when the `R_SDC_SD_Initialize()`, `R_SDC_SDMEM_Read()`, and `R_SDC_SDMEM_Write()` function* are executed. Note that the error code is cleared when a library function is executed again.

Note: * The `R_SDC_SDMEM_ReadSoftwareTrans()`, `R_SDC_SDMEM_ReadSoftwareTransSingleCmd()`, and `R_SDC_SDMEM_WriteSoftwareTrans()` functions operate similarly.

**Reentrant**

This function is reentrant with respect to other channels.

**Example**

```c
sdc_sd_cfg_t sdc_sd_config;
sdc_sd_status_t error_code = SDC_SD_SUCCESS;

/* ==== Please add the processing to set the pins. ==== */

sdc_sd_config.mode = SDC_SD_CFG_DRIVER_MODE;
sdc_sd_config.voltage = SDC_SD_VOLT_3_3;
if (R_SDC_SD_Initialize(SDC_SD_CARD0, &sdc_sd_config) != SDC_SD_SUCCESS)
{
    /* Error */
    error_code = R_SDC_SD_GetErrCode(SDC_SD_CARD0);
}
```

**Special Notes**

Before running this function, driver open processing must be performed by the `R_SDC_SD_Open()` function.

Use this function when an application program needs to acquire the SD Card driver error code.
### 3.19 R_SDC_SD_GetBuffRegAddress()

This function acquires the address of the SD buffer register.

#### Format

```c
sdc_sd_status_t R_SDC_SD_GetBuffRegAddress(
    uint32_t card_no,
    uint32_t *p_reg_buff
)
```

#### Parameters

- `card_no`  
  - SD Card number  
  - The number of the SD Card used (numbering starts at 0)
- `*p_reg_buff`  
  - SD buffer register address pointer

#### Return Values

- `SDC_SD_SUCCESS`  
  - Successful operation
- `SDC_SD_ERR`  
  - General error

#### Properties

A prototype declaration for this function appears in `r_sdc_sd_rx_if.h`.

#### Description

This function acquires the address of the SD buffer register and stores it in a buffer. This function is used, for example, when specifying the data register address when using DMAC or DTC transfers.

#### Reentrant

This function is reentrant with respect to other channels.

#### Example

```c
uint32_t  reg_buff = 0;

if (R_SDC_SD_GetBuffRegAddress(SDC_SD_CARD0, &reg_buff) != SDC_SD_SUCCESS)
{
    /* Error */
}
```

#### Special Notes

Before running this function, driver open processing must be performed by the `R_SDC_SD_Open()` function. Note that the error code cannot be acquired with the `R_SDC_SD_GetErrCode()` function.
3.20 R_SDC_SD_1msInterval()

This function increments the SD Card driver's internal timer counter.

Format

```c
void R_SDC_SD_1msInterval(
    void
)
```

Parameters

None

Return Values

None

Properties

A prototype declaration for this function appears in r_sdc_sd_rx_if.h.

Description

The internal timer counter is incremented each time this function is called.

Reentrant

This function is not reentrant.

Example

```c
uint32_t  g_cmt_channel;

void r_cmt_callback(void * pdata)
{
    uint32_t channel;

    channel = *((uint32_t *)pdata);
    if (channel == g_cmt_channel)
    {
        R_SDC_SD_1msInterval();
    }
}

main()
{
    /* Create CMT timer */
    R_CMT_CreatePeriodic(1000, &r_cmt_callback, &g_cmt_channel);  /* 1ms */
}
```

Special Notes

The application must call this function once each millisecond. However, this is not required if the timer functionality has been replaced by the r_sdc_sd_int_wait() and r_sdc_sd_wait() functions in r_sdc_sd_config.c.

Note that the error code cannot be acquired with the R_SDC_SD_GetErrCode() function.
3.21 R_SDC_SD_SetDmacDtcTransFlg()

This function sets the DMAC/DTC transfer complete flag.

Format

```c
sdc_sd_status_t R_SDC_SD_SetDmacDtcTransFlg(
    uint32_t card_no,
    uint32_t flg
);
```

Parameters

- **card_no**: SD Card number
  - The number of the SD Card used (numbering starts at 0)

- **flg**: DMAC/DTC transfer complete flag
  - SDC_SD_SET_TRANS_STOP

Return Values

- **SDC_SD_SUCCESS**: Successful operation
- **SDC_SD_ERR**: General error (channel error)

Properties

A prototype declaration for this function appears in r_sdc_sd_rx_if.h.

Description

This function sets the DMAC/DTC transfer complete flag.

Table 3.10, DMAC Transfer/DTC Transfer Flag Processing Methods, lists the processing methods for handling the DMAC/DTC transfer complete flag.

Note that the DMAC/DTC transfer complete flag processing method differs depending on the transfer state.

For the DMAC, the application should set the SDC_SD_SET_TRANS_STOP in the interrupt handler called when a DMAC transfer completes and call this function.

For the DTC, no user processing is required to set SDC_SD_SET_TRANS_STOP in the SDHI SBFAI interrupt handler.

If an error occurs during a transfer, the user code must set SDC_SD_SET_TRANS_STOP, regardless of whether DMAC or DTC is used and then call this function.

<table>
<thead>
<tr>
<th>Data Transfer</th>
<th>On Successful Termination</th>
<th>On Error Termination</th>
</tr>
</thead>
<tbody>
<tr>
<td>DMAC transfer</td>
<td>Transfer in progress</td>
<td>Transfer in progress</td>
</tr>
<tr>
<td></td>
<td>The user code should execute R_SDC_SD_SetDmacDtcTransFlg() in the interrupt handler called when a DMAC transfer completes and set the transfer complete state.</td>
<td>The user code should execute R_SDC_SD_SetDmacDtcTransFlg() and set the transfer complete state.</td>
</tr>
<tr>
<td>DTC transfer</td>
<td>Transfer complete</td>
<td>As above</td>
</tr>
<tr>
<td></td>
<td>(Transfer complete processing is performed in the DTC handler)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>No user processing is required.</td>
<td></td>
</tr>
</tbody>
</table>

Reentrant

This function is reentrant with respect to other channels.
Example

<When the DMAC transfer completes successfully>

data_mca_callback:
{
    volatile dmaca_return_t ret_dmaca;
    dmaca_stat_t p_stat_dmaca;

    /* check DMA end */
    /*** DMACA transfer end check ***/
    ret_dmaca = R_DMACA_Control(DMACA_CH0, DMACA_CMD_STATUS_GET,
        (dmaca_stat_t*)&p_stat_dmaca);
    if (DMACA_SUCCESS != ret_dmaca)
    {
        return;
    }
    if (true == (p_stat_dmaca.dtif_stat))
    {
        ret_dmaca = R_DMACA_Control(DMACA_CH0, DMACA_CMD_DTIF_STATUS_CLR,
            (dmaca_stat_t*)&p_stat_dmaca);
        R_SDC_SD_SetDmacDtcTransFlg(SDC_SD_CARD0, SDC_SD_SET_TRANS_STOP);
    }
    if (true == (p_stat_dmaca.esif_stat))
    {
        ret_dmaca = R_DMACA_Control(DMACA_CH0, DMACA_CMD_ESIF_STATUS_CLR,
            (dmaca_stat_t*)&p_stat_dmaca);
    }
    return;
}

<When the DMAC transfer terminates with an error>

#define TEST_BLOCK_CNT (4)
#define BLOCK_NUM (512)

sdc_sd_access_t sdc_sd_access;
uint32_t g_test_r_buff[(TEST_BLOCK_CNT*BLOCK_NUM)/sizeof(uint32_t)];

test_data_clear(&g_def_buf[0], TEST_BLOCK_CNT);
sdc_sd_access.p_buff = (uint8_t *)&g_test_r_buff[0];
sdc_sd_access.lbn   = 0x10000000;
sdc_sd_access.cnt  = TEST_BLOCK_CNT;
sdc_sd_access.rw_mode= SDHI_PRE_DEF;

if(R_SDC_SDMEM_Read(SDC_SD_CARD0, &sdc_sd_access) != SDC_SD_SUCCESS)
{
    /* Error */
    R_SDC_SD_SetDmacDtcTransFlg(SDC_SD_CARD0, SDC_SD_SET_TRANS_STOP);
}

Special Notes
Before running this function, driver open processing must be performed by the R_SDC_SD_Open() function and
initialization by the R_SDC_SD_Initialize() function.

Note that the error code cannot be acquired with the R_SDC_SD_GetErrCode() function.
### 3.22 R_SDC_SD_SetLogHdlAddress()

This function sets the LONGQ FIT module handler address.

#### Format

```c
sdc_sd_status_t R_SDC_SD_SetLogHdlAddress(
    uint32_t user_long_que
)
```

#### Parameters

- **user_long_que**: LONGQ FIT module handler address

#### Return Values

- **SDC_SD_SUCCESS**: Successful operation

#### Properties

A prototype declaration for this function appears in `r_sdc_sd_rx_if.h`.

#### Description

This function sets the LONGQ FIT module handler address in the SD Card driver.

#### Reentrant

This function is reentrant with respect to other channels.

#### Example

```c
#define SDC_SD_USER_LONGQ_MAX    (8)
#define SDC_SD_USER_LONGQ_BUFSIZE   (SDC_SD_USER_LONGQ_MAX * 4)
#define SDC_SD_USER_LONGQ_IGN_OVERFLOW (1)

uint32_t     g_sdc_sd_user_longq_buf[SDC_SD_USER_LONGQ_BUFSIZE];
static longq_hdl_t  p_sdc_sd_user_long_que;
longq_err_t    err = LONGQ_SUCCESS;
uint32_t     user_long_que = 0;

err = R_LONGQ_Open(g_sdc_sd_user_longq_buf,
    SDC_SD_USER_LONGQ_BUFSIZE,
    SDC_SD_USER_LONGQ_IGN_OVERFLOW,
    &p_sdc_sd_user_long_que);
if (LONGQ_SUCCESS != err)
    { /* Error */
    }
user_long_que = (uint32_t)p_sdc_sd_user_long_que;
if (R_SDC_SD_SetLogHdlAddress(user_long_que) != SDC_SD_SUCCESS)
    { /* Error */
    }
```

#### Special Notes

This function performs the preparatory processing required to acquire an error log using the LONGQ FIT module. This processing should be performed before the `R_SDC_SD_Open()` function is called.

The LONGQ FIT module needs to be embedded in the application as a separate operation.

Note that the error code cannot be acquired with the `R_SDC_SD_GetErrCode()` function.
### 3.23 R_SDC_SD_Log()

This function acquires an error log.

**Format**

```c
uint32_t R_SDC_SD_Log(
    uint32_t flg,
    uint32_t fid,
    uint32_t line
)
```

**Parameters**

- `flg`  
  0x00000001 (Fixed value)
- `fid`  
  0x0000003f (Fixed value)
- `line`  
  0x00001fff (Fixed value)

**Return Values**

- 0  
  Successful operation

**Properties**

A prototype declaration for this function appears in `r_sdc_sd_rx_if.h`.

**Description**

This function acquires an error log.

To terminate error log acquisition, call this function.

**Reentrant**

This function is reentrant with respect to other channels.

**Example**

```c
#define USER_DRIVER_ID    (1)
#define USER_LOG_MAX      (63)
#define USER_LOG_ADR_MAX  (0x00001fff)

sdc_sd_cfg_t   sdc_sd_config;
/* ==== Please add the processing to set the pins. ==== */

sdc_sd_config.mode = SDC_SD_CFG_DRIVER_MODE;
sdc_sd_config.voltage = SDC_SD_VOLT_3_3;
if (R_SDC_SD_Initialize(SDC_SD_CARD0, &sdc_sd_config) != SDC_SD_SUCCESS)
{
    /* Error */
    R_SDC_SD_Log(USER_DRIVER_ID, USER_LOG_MAX, USER_LOG_ADR_MAX);
}
```

**Special Notes**

The LONGQ FIT module needs to be embedded in the application as a separate operation.

Note that the error code cannot be acquired with the `R_SDC_SD_GetErrCode()` function.
3.24 R_SDC_SD_GetVersion()

This function acquires the version information for the driver.

**Format**

```c
uint32_t R_SDC_SD_GetVersion(
    void
)
```

**Parameters**

None

**Return Values**

- **Upper 2 bytes**: Major version (decimal)
- **Lower 2 bytes**: Minor version (decimal)

**Properties**

A prototype declaration for this function appears in `r_sdc_sd_rx_if.h`.

**Description**

This function returns the driver version information.

**Reentrant**

This function is reentrant.

**Example**

```c
uint32_t version;
version = R_SDC_SD_GetVersion();
```

**Special Notes**

Note that the error code cannot be acquired with the `R_SDC_SD_GetErrCode()` function.
4. Pin Setting

To use the lower-layer SDHI FIT module, assign input/output signals of the peripheral function to pins with the multi-function pin controller (MPC).

When performing the pin setting in the e² studio, the Pin Setting feature of the Smart Configurator can be used. When using the Pin Setting feature, a source file is generated according to the option selected in the Pin Setting window in the Smart Configurator. Then pins are configured by calling the function defined in the source file. Refer to 4.1, SD Card Insertion and Power-On Timing, and 4.2, SD Card Removal and Power-Off Timing, and create appropriate program code to provide this processing.

1 For details of the pin setting function, refer to RX Family SDHI Module Using Firmware Integration Technology (R01AN3852EJ).
4.1 SD Card Insertion and Power-On Timing

Figure 4.1 and Table 4.1 show the control procedure. Perform the SD Card insertion procedure after successful operation of the R_SDC_SD_Open() function and when the supply of power voltage to the SD Card is in the halted state and the SDHI output pin is in the L output state.

After power-on reset

SD card pin initialization state
- SDHI input pin: SDHI input
- SDHI output pin: GPIO L output

Supply of power voltage to SD card halted state
- Power supply voltage control pin: GPIO L/H output
  (Values when supply of power voltage is in halted state)

Power voltage being supplied to SD card state
- Power supply voltage control pin: GPIO L/H output
  (Values when power voltage is being supplied)

After starting power supply voltage supply, provide a sufficient waiting time until it reaches operating voltage.

SD command issuance possible state
- SDHI input pin: SDHI input
- SDHI output pin: SDHI output

Notes:
1. This function is generated by setting the pins with Smart Configurator.
2. SDHI_CD pin and SDHI_WP pin
3. SDHI_CLK pin, SDHI_CMD pin, and SDHI_Dn pin
4. The waiting time is determined by the configuration of the SD card power supply circuit.

Figure 4.1 SD Card Insertion and Power-On Timing
<table>
<thead>
<tr>
<th>Processing</th>
<th>Target Pin</th>
<th>Pin Settings</th>
<th>Subsequent Pin State</th>
</tr>
</thead>
</table>
| Pin control 1 | SDHI input pin*1    | PMR setting: General I/O port  
PCR setting: Input pull-up resistor disabled*3  
PDR setting: Input  
MPC setting: SDHI  
PMR setting: Peripheral module | SDHI input  
(SD Card detection possible state) |
|             | SDHI output pin*2   | PMR setting: General I/O port  
DSCR setting: High-drive output  
PCR setting: Input pull-up resistor disabled*3  
PODR setting: L output  
PDR setting: Output  
MPC setting: Hi-z | GPIO L output |
| Pin control 2 | Power supply voltage control pin | PMR setting: General I/O  
PCR setting: Input pull-up resistor disabled*4  
PODR setting: L output/H output (output of value based on power voltage supplied/halted state)  
PDR setting: Output | GPIO L/H output  
(supply of power voltage halted state) |
| Pin control 3 | Power supply voltage control pin | PODR setting: L output/H output (output of value based on power voltage supply state) | GPIO L/H output  
(supply of power voltage halted state) |
| Pin control 4 | SDHI input pin*1    | MPC setting: SDHI  
PMR setting: Peripheral module | SDHI input  
(SD command issuance possible state) |
|             | SDHI output pin*2   | MPC setting: SDHI  
PMR setting: Peripheral module | SDHI output  
(SD command issuance possible state) |

Notes: 1. SDHI_CD pin and SDHI_WP pin  
2. SDHI_CLK pin, SDHI_CMD pin, and SDHI_Dn pin  
3. It is assumed that the pin will be pulled-up external to the microcontroller, so the microcontroller's integrated pull-up resistor is disabled.  
4. Review the setting to match the details of the system.
4.2 SD Card Removal and Power-Off Timing

Figure 4.2 and Table 4.2 show the control procedure. Perform the SD Card removal procedure after successful operation of the R_SDC_SD_End() function in the driver idle state and when the supply of power voltage to the SD Card is in the halted state. An equivalent procedure should be used to halt supply of the power voltage in cases where the SD Card is removed unexpectedly.

Card detected

R_SDC_SD_GetCardDetection()

Pin control 6
Add the following functions to the user program
r_sdc_sdmem_demo_power_off()

Card undetected (Processing exit)

R_SDC_SD_CLOSE()

Pin control 7
Add the following functions to the user program
R_SDHI_PinSetEnd()\(^{*1}\)

Driver uninitialized state

Driver idle state

R_SDC_SD_End()

Card detected

Pin control 5
Add the following functions to the user program
R_SDHI.PinSetTransfer()\(^{*1}\)

SD command issuance impossible state
SDHI input pin\(^{*2}\): SDHI input
SDHI output pin\(^{*3}\): GPIO L output

Supply of power voltage to SD card halted state
Power supply voltage control pin: GPIO L/H output
(Values when supply of power voltage is in halted state)
After stopping the supply voltage supply, provide a sufficient waiting time until it reaches the removable voltage of the SD card\(^{*4}\).

Card undetected (Card reinsertion)

A

Notes:
1. This function is generated by setting the pins with Smart Configurator.
2. SDHI_CD pin and SDHI_WP pin
3. SDHI_CLK pin, SDHI_CMD pin, and SDHI_Dn pin
4. The waiting time is determined by the configuration of the SD card power supply circuit.

Figure 4.2 SD Card Removal and Power-Off Timing
### Table 4.2 User Setting Method at SD Card Removal

<table>
<thead>
<tr>
<th>Processing</th>
<th>Target Pin</th>
<th>Pin Settings</th>
<th>Subsequent Pin State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pin control 5</td>
<td>SDHI input pin*¹</td>
<td>MPC setting: SDHI&lt;br&gt;PMR setting: Peripheral module</td>
<td>SDHI input</td>
</tr>
<tr>
<td></td>
<td>SDHI output pin*²</td>
<td>PMR setting: General I/O port&lt;br&gt;MPC setting: Hi-z</td>
<td>GPIO L output</td>
</tr>
<tr>
<td>Pin control 6</td>
<td>Power supply voltage control pin</td>
<td>PODR setting: L output/H output (output of value based on power voltage supply halted state)</td>
<td>GPIO L/H output (supply of power voltage halted state)</td>
</tr>
<tr>
<td>Pin control 7</td>
<td>SDHI input pin*¹</td>
<td>PMR setting: General I/O port&lt;br&gt;MPC setting: Hi-z</td>
<td>GPIO input</td>
</tr>
<tr>
<td></td>
<td>SDHI output pin*²</td>
<td>PMR setting: General I/O port&lt;br&gt;MPC setting: Hi-z</td>
<td>GPIO L output</td>
</tr>
</tbody>
</table>

**Notes:**
1. SDHI_CD pin and SDHI_WP pin
2. SDHI_CLK pin, SDHI_CMD pin, and SDHI_Dn pin
5. Demo Projects

5.1 Overview

The sample program is included and can be found in the FITDemos directory. This sample program performs the processing described in section 4.1, SD Card Insertion and Power-On Timing and 4.2, SD Card Removal and Power-Off Timing, as well as SD Card read and write processing.

5.2 State Transition Diagram

Figure 5.1 shows the state transition diagram for this driver.
### 5.3 Configuration Overview

The sample program configuration options are set in the file `r_sdc_sdmem_rx_demo_pin_config.h`. The table below lists the option names and set values when the RX64M RSK is used.

<table>
<thead>
<tr>
<th>Configuration options in <code>r_sdc_sdmem_rx_demo_pin_config.h</code></th>
<th>Function Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>#define SDC_SD_CFG_POWER_PORT_NONE</code></td>
<td>This definition is used when an SD Card is used. If SD Card power supply control is not required, enable this definition. If SD Card power supply control is required, disable this definition.</td>
</tr>
<tr>
<td><code>#define SDC_SD_CFG_POWER_HIGH_ACTIVE</code> (1)</td>
<td>This definition is used when an SD Card is used and furthermore SD Card power supply control is required. When set to 1, a high level is supplied to the port that controls the SD Card power supply circuit to enable the SD Card power supply circuit. When set to 0, a low level is supplied to the port that controls the SD Card power supply circuit to enable the SD Card power supply circuit.</td>
</tr>
<tr>
<td><code>#define SDC_SD_CFG_POWER_ON_WAIT</code> (100)</td>
<td>This definition is used when an SD Card is used. Set this definition to the wait time after power supply is started to the SD Card power supply circuit until the operating voltage is reached. A wait of 1 ms is provided for each count of the counter. Set this definition to a value appropriate for the system used.</td>
</tr>
<tr>
<td><code>#define SDC_SD_CFG_POWER_OFF_WAIT</code> (100)</td>
<td>This definition is used when an SD Card is used. Set this definition to the wait time after power supply to the SD Card power supply circuit is stopped until the voltage at which SD Card removal is possible is reached. A wait of 1 ms is provided for each count of the counter. Set this definition to a value appropriate for the system used.</td>
</tr>
<tr>
<td><code>#define R_SDC_SD_CFG_POWER_CARDx_PORT</code></td>
<td>Set these definitions to the port number for the power supply voltage control pin allocated for SD Card number (x). Surround each setting value with single quotation marks ' '.</td>
</tr>
<tr>
<td><code>#define R_SDC_SD_CFG_POWER_CARDx_BIT</code></td>
<td>Set these definitions to the bit number for the power supply voltage control pin allocated for SD Card number (x). Surround each setting value with single quotation marks ' '.</td>
</tr>
</tbody>
</table>

### 5.4 API Functions

The power supply voltage control pin control functions in the sample program are shown below. Add or modify functions as necessary.

**Table 5.1 Pin Control API Functions**

<table>
<thead>
<tr>
<th>Function</th>
<th>Function Outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>r_sdc_sdmem_demo_power_init()</td>
<td>Initializes the power supply voltage control pin settings</td>
</tr>
<tr>
<td>r_sdc_sdmem_demo_power_on()</td>
<td>Starts supply of power supply voltage</td>
</tr>
<tr>
<td>r_sdc_sdmem_demo_power_off()</td>
<td>Stops supply of power supply voltage</td>
</tr>
<tr>
<td>r_sdc_sdmem_demo_softwaredelay()</td>
<td>Performs delay</td>
</tr>
</tbody>
</table>
(1) r_sdc_sdmem_demo_power_init()

This function initializes the SDHI pin settings used by the SD Memory Card driver. It also initializes the setting of the power voltage control pin of the SD Card.

Format

```c
sdc_sd_status_t r_sdc_sdmem_demo_power_init(
    uint32_t card_no
)
```

Parameters

card_no

| SD Card number | The number of the SD Card used (numbering starts at 0) |

Return Values

| SDC_SD_SUCCESS | Successful operation |

Description

Initializes the setting of the power voltage control pin of the SD Card.

Special Notes:

The power supply voltage control pins are set as follows.

- The port mode register (PMR) is set to the general-purpose I/O port.
- Set the pull-up control register (PCR) to input pull-up resistance disabled.
- Pin output is set to the inactive state.
(2)  

r_sdc_sdmem_demo_power_on()

This function controls the power supply voltage control pin of the SD Card and starts power supply.

**Format**

    sdc_sd_status_t r_sdc_sdmem_demo_power_on(
        uint32_t card_no
    )

**Parameters**

- **card_no**
  
  SD Card number

  The number of the SD Card used (numbering starts at 0)

**Return Values**

- **SDC_SD_SUCCESS**
  
  Successful operation

- **SDC_SD_ERR**
  
  General error

**Description**

Controls the power supply voltage control pins of the SD Card, and starts the supply of power from the power supply. Then, after the time specified by `SDC_SD_CFG_POWER_ON_WAIT` in `r_sdc_sdmem_rx_demo_pin_config.h` has elapsed, returns the result.

**Special Notes:**

- Modify as necessary.

  After starting the supply of power supply voltage, executes the `r_sdc_sdmem_demo_softwaredelay()` function in order to wait until the operating voltage is reached. Set the wait time using `SDC_SD_CFG_POWER_ON_WAIT` in section 6.8.1, Compile Time Settings.

  Initialization using the `r_sdc_sdmem_demo_power_init()` function must be performed before executing this function.
(3)  r_sdc_sdmem_demo_power_off()

This function controls the power supply voltage control pins of the SD Card, and stops the supply of power from the power supply.

**Format**

```c
sdc_sd_status_t r_sdc_sdmem_demo_power_off(
    uint32_t card_no
)
```

**Parameters**

- `card_no`  
  SD Card number  
  The number of the SD Card used (numbering starts at 0)

**Return Values**

- `SDC_SD_SUCCESS`  
  Successful operation
- `SDC_SD_ERR`  
  General error

**Description**

Controls the power supply voltage control pins of the SD Card, and stops the supply of power from the power supply. Then, after the time specified by `SDC_SD_CFG_POWER_OFF_WAIT` in `r_sdc_sdmem_rx_demo_pin_config.h` has elapsed, returns the result.

**Special Notes:**

After stopping the supply of power supply voltage, executes the `r_sdc_sdmem_demo_softwaredelay()` function in order to wait until the removable voltage is reached. Set the wait time using `SDC_SD_CFG_POWER_OFF_WAIT` in section 6.8.1, Compile Time Settings.

Initialization using the `r_sdc_sdmem_demo_power_init()` function must be performed before executing this function.
(4)  \texttt{r_sdc_sdmem_demo_softwaredelay()}

This function is used when waiting for a particular time.

**Format**

```c
bool r_sdc_sdmem_demo_softwaredelay(
    uint32_t delay,
    sdhi_delay_units_t units
)
```

**Parameters**

- **delay**
  Timeout time (Units: set with the units)
- **units**
  - Microseconds: SDC_SD_DELAY_MICROSECS
  - Milliseconds: SDC_SD_DELAY_MILLISECS
  - Seconds: SDC_SD_DELAY_SECS

**Return Values**

- true  \textit{Successful operation}
- false  \textit{Parameter error}

**Description**

This function performs wait time processing.

True is returned when the timeout time specified in the argument delay has elapsed.

**Special Notes**

The wait time processing is listed in Table 5.2. Since this function only waits for the set time, it can be replaced with the operating system activating task delay processing (example: the \texttt{\mu}ITRON \texttt{dly_tsk()} function).

**Table 5.2 Wait Time Processing**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD Card power on power supply</td>
<td>The wait time until the operating voltage is reached after power supply is</td>
</tr>
<tr>
<td>voltage stabilization time</td>
<td>started to the SD Card power supply circuit &lt;100 ms\rangle \textit{Note:}</td>
</tr>
<tr>
<td></td>
<td>The wait time can be modified with</td>
</tr>
<tr>
<td></td>
<td>SDC_SD_CFG_POWER_ON_WAIT.</td>
</tr>
<tr>
<td>SD Card power off voltage</td>
<td>The wait time until the SD Card removable voltage is reached after supply</td>
</tr>
<tr>
<td>turn-off time</td>
<td>is stopped to the SD Card power supply circuit &lt;100 ms\rangle \textit{Note:}</td>
</tr>
<tr>
<td></td>
<td>The wait time can be modified with</td>
</tr>
<tr>
<td></td>
<td>SDC_SD_CFG_POWER_OFF_WAIT.</td>
</tr>
</tbody>
</table>
5.5 Replacing Wait Time Processing with Operating System Processing

The `r_sdc_sdmem_demo_softwaredelay()` function, which processes the delays that arise in the sample program, can be replaced by the task delay processing of the OS itself (for example, `dly_tsk()` in μITRON).

![Diagram](image)

**Figure 5.2** Wait Example Using Operating System Task Delay Processing

5.6 Downloading Demo Projects

Demo projects are not included in the RX Driver Package. When using the demo project, the FIT module needs to be downloaded. To download the FIT module, right click on this application note and select "Sample Code (download)" from the context menu in the *Smart Brower > Application Notes* tab.
6. Appendices

6.1 Operation Confirmation Environment

This section describes operation confirmation environment for this driver.

Table 6.1 Operation Confirmation Environment

<table>
<thead>
<tr>
<th>Item</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated development</td>
<td>Renesas Electronics e² studio V6.3.0</td>
</tr>
<tr>
<td>environment</td>
<td></td>
</tr>
<tr>
<td>C compiler</td>
<td>Renesas Electronics C/C++ Compiler Package for RX Family V2.08.00</td>
</tr>
<tr>
<td></td>
<td>Compiler option: The following option is added to the default settings of</td>
</tr>
<tr>
<td></td>
<td>the integrated development environment.</td>
</tr>
<tr>
<td></td>
<td>-lang = c99</td>
</tr>
<tr>
<td>Endian</td>
<td>Big endian/little endian</td>
</tr>
<tr>
<td>Version of the module</td>
<td>Ver.2.02</td>
</tr>
<tr>
<td>Board used</td>
<td>Renesas Starter Kit for RX64M (product No.:R0K50564MSxxxxBE)</td>
</tr>
<tr>
<td></td>
<td>Renesas Starter Kit for RX71M (product No.:R0K50571MSxxxxBE)</td>
</tr>
<tr>
<td></td>
<td>Renesas Starter Kit for RX231 (product No.:R0K505231SxxxxBE)</td>
</tr>
<tr>
<td></td>
<td>Renesas Starter Kit for RX65N (product No.:RTK500565NSxxxxBE)</td>
</tr>
<tr>
<td></td>
<td>Renesas Starter Kit for RX65N-2MB (product No.:RTK50565N2SxxxxBE)</td>
</tr>
</tbody>
</table>

Table 6.2 Confirmed Operation Environment (Rev. 3.00)

<table>
<thead>
<tr>
<th>Item</th>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Integrated development</td>
<td>Renesas Electronics e² studio Version 7.7.0</td>
</tr>
<tr>
<td>environment</td>
<td>IAR Embedded Workbench for Renesas RX 4.13.1</td>
</tr>
<tr>
<td>C compiler</td>
<td>Renesas Electronics C/C++ Compiler Package for RX Family V3.02.00</td>
</tr>
<tr>
<td></td>
<td>Compiler option: The following option is added to the default settings of</td>
</tr>
<tr>
<td></td>
<td>the integrated development environment.</td>
</tr>
<tr>
<td></td>
<td>-lang = c99</td>
</tr>
<tr>
<td></td>
<td>GCC for Renesas RX 8.3.0.201904</td>
</tr>
<tr>
<td></td>
<td>Compiler option: The following option is added to the default settings of</td>
</tr>
<tr>
<td></td>
<td>the integrated development environment.</td>
</tr>
<tr>
<td></td>
<td>-std=gnu99</td>
</tr>
<tr>
<td></td>
<td>IAR C/C++ Compiler for Renesas RX version 4.13.1</td>
</tr>
<tr>
<td></td>
<td>Compiler option: The default settings of the integrated development</td>
</tr>
<tr>
<td></td>
<td>environment.</td>
</tr>
<tr>
<td>Endian</td>
<td>Big endian/little endian</td>
</tr>
<tr>
<td>Revision of the module</td>
<td>Rev.3.00</td>
</tr>
<tr>
<td>Board used</td>
<td>Renesas Starter Kit+ for RX72M (product No.: RTK5572Mxxxxxxxxxxxx)</td>
</tr>
</tbody>
</table>
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 e² studio:
  Application note "Adding Firmware Integration Technology Modules to Projects (R01AN1723)"

When using this 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_sdc_sd_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.

6.3 SD Memory: Notes on Power Consumption Settings (XPS Setting when an ACMD41 Command is Issued) in SDXC Card Default Speed Mode

This SD Memory Card driver issues an ACMD41 command with the command argument XPC set to 0 during SDXC card initialization. As a result, regardless of the VDD power supply capacity of the external power supply circuit, the SD Memory Card will operate with a maximum power consumption of 0.36 W (maximum current drain 100 mA, 3.6 V) in Default Speed mode for SDXC cards as well as SDSC and SDHC cards.
6.4 Replacing Wait Processing with Operating System Processing

The handling of status interrupts generated by this SD Card driver can be replaced with operating system processing. The table below lists the details of the related functions.

### Table 6.2 Target Microcontroller Interface Functions

<table>
<thead>
<tr>
<th>Function</th>
<th>Functional Overview</th>
</tr>
</thead>
<tbody>
<tr>
<td>r_sdc_sd_int_wait()</td>
<td>Status interrupt wait processing</td>
</tr>
<tr>
<td>r_sdc_sd_int_mem_wait()</td>
<td>Status interrupt wait processing (SD memory control)</td>
</tr>
<tr>
<td>r_sdc_sd_int_err_mem_wait()</td>
<td>Status interrupt wait processing (SD memory error control)</td>
</tr>
<tr>
<td>r_sdc_sd_wait()</td>
<td>Wait time processing</td>
</tr>
</tbody>
</table>

(1) r_sdc_sd_int_wait()

This function is used when waiting for a status interrupt.

**Format**

```c
dsc_sd_status_t r_sdc_sd_int_wait(
    uint32_t card_no,
    int32_t time
)
```

**Parameters**

- **card_no**
  - SD Card number
  - The number of the SD Card used (numbering starts at 0)
- **time**
  - Timeout time (units ms)

**Return Values**

- **SDC_SD_SUCCESS**
  - Successful operation (Interrupt request generation)
- **SDC_SD_ERR**
  - General error

**Description**

This function performs the interrupt wait processing used for protocol communication with the SD Card.

When an interrupt request is verified, this function returns SDC_SD_SUCCESS.

If no interrupt is detected within the interrupt wait time given by the argument time, it returns SDC_SD_ERR.

The interrupt wait processing is already included as processing that uses interrupts.

This function calls SD status register 1 and 2 acquisition processing (the r_sdc_sd_get_intstatus() function) internally to determine whether or not an interrupt has occurred.

**Note:** * The r_sdc_sd_int_mem_wait() and r_sdc_sd_int_err_mem_wait() functions operate similarly.
Special Notes
The response reception wait time during communication with the SD Card and the data transfer completion wait time can be allocated to other processing.

Figure 6.1 shows a usage example in which the operating system invoking task delay processing (in this example, the µITRON dly_tsk() function) is used. Note, however, that users must code the required calls to the r_sdc_sd_int_wait() function themselves.

![Flowchart](image.png)

Figure 6.1 SD Protocol Status Verification Example Using Operating System Task Delay Processing
Figure 6.2 shows a usage example in which the operating system event flag set wait processing is used. If this functionality is used, the user must replace the `r_sdc_sd_int_wait()` function SD status register 1 and 2 acquisition processing (the `r_sdc_sd_get_intstatus()` function) with event flag set wait processing and furthermore add wakeup processing to the SD protocol status interrupt callback function.

![Diagram](image)

**Figure 6.2** SD Protocol Status Verification Example Using Operating System Wait Task Processing

Task execution rights are released with, for example, the µITRON `twai_flg()` function and perform wakeup operations either with a callback function or by timeout.
(2) r_sdc_sd_wait()

This function is used when waiting for a particular time.

**Format**

```c
sdc_sd_status_t r_sdc_sd_wait(
    uint32_t card_no,
    int32_t time
)
```

**Parameters**

- **card_no**: SD Card number
  - The number of the SD Card used (numbering starts at 0)
- **time**: Timeout time (units ms)

**Return Values**

- **SDC_SD_SUCCESS**: Successful operation (Interrupt request generation)
- **SDC_SD_ERR**: General error

**Description**

This function performs wait time processing.

SDC_SD_SUCCESS is returned when the timeout time specified in the argument time has elapsed.

**Special Notes**

Table 6.5 lists the wait time processing not associated with status verification. Since this function only provides a wait for a specified time, it can be replaced with the operating system task delay processing (example: the µITRON dly_tsk() function).

**Table 6.3 Wait Time Processing not Associated with Status Verification**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>The 74 clock cycle wait during SD Card initialization</td>
<td>Card identification mode: A wait of 74 clock cycles &lt;3 ms&gt; for initialization (A minimum of 2 ms and a maximum of 3 ms must be assured)</td>
</tr>
<tr>
<td>Ready state transition detection during SD Card initialization</td>
<td>Card identification mode: Wait for the ready state &lt;5 ms&gt; (maximum: 1 second) For SD memory, an ACMD41 command is issued at 5 ms intervals, repeated a maximum of 200 times.</td>
</tr>
<tr>
<td>Wait time after a CMD9 command has been issued to the SD memory</td>
<td>Data transfer mode: response wait time &lt;3 ms&gt; after a CMD9 command has been issued to the SD memory Wait time after issuing a CMD9 command to the SD memory (A minimum of 2 ms and a maximum of 3 ms must be assured)</td>
</tr>
</tbody>
</table>
Figure 6.3 Wait Example Using Operating System Task Delay Processing

```
r_sdc_sd_wait()
```

Task delay processing
(Example: μITRON dly_tsk())

```
SDC_SD_SUCCESS
```
7. Reference Documents

User's Manual: Hardware
The latest versions can be downloaded from the Renesas Electronics website.

Technical Update/Technical News
The latest information can be downloaded from the Renesas Electronics website.

RX Family C/C++ Compiler CC-RX User's Manual (R20UT3248)
The latest version can be downloaded from the Renesas Electronics website.

Related Technical Updates
This module reflects the content of the following technical updates.

- TN-RX*-A195A/E
- TN-RX*-A196A/E
- TN-RX*-A197A/E

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<table>
<thead>
<tr>
<th>Rev.</th>
<th>Date</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.01</td>
<td>Feb 28, 2018</td>
<td>First edition issued. SD Mode SD Memory Card Driver Software RTM0RX0000DSDD0 Ver.2.00 User's Manual (R01UW0135) changed to the application note.</td>
</tr>
<tr>
<td>2.02</td>
<td>Jun 29, 2018</td>
<td>Corresponded to SD Specifications Part1 Physical Layer Simplified Specification.</td>
</tr>
</tbody>
</table>
| 3.00 | Feb. 10, 2020 | Supported the following compilers.  
- GCC for Renesas RX  
- IAR C/C++ Compiler for Renesas RX  
Fix type mismatch with "r_sdhi_rx".  
Add "WAIT_LOOP" to the code. |
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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