# RX210, RX21A, and RX220 Groups

## Efficient Allocation of the DTC Vector Table

R01AN1017EJ0101
Rev. 1.01
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## Abstract

This document describes how to efficiently allocate the DTC vector table of the data transfer controller (DTC) in the RX210, RX21A, and RX220 Groups.


## Products

- RX210, RX21A, and RX220 Groups

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

## Contents

## 1. Specifications

The pattern output from PORT1 to the LED is changed every 500 ms and the pattern output from PORTA is changed every 250 ms using the DTC.

This application note describes two methods to allocate the DTC vector table listed in Table 1.1.

Table 1.2 lists the Peripheral Functions and Their Applications, Figure 1.1 shows a Connection Example, Figure 1.2 shows the Memory Map when the DTC Vector Table is Allocated to the ROM Area (Sample Code 1), and Figure 1.3 shows Memory Map when the DTC Vector Table is Allocated to the RAM Area (Sample Code 2).

**Table 1.1 DTC Vector Table Allocations**

| Sample Code | Outline | Description |
|---|---|---|
| Sample code 1 | Allocate the DTC vector table to the ROM area | Set all DTC vectors (4 x 256 bytes used).<br>Add new section to allocate the DTC vector table. |
| Sample code 2 | Allocate the DTC vector table to the RAM area | Set required DTC vectors only.<br>Allocate DTC transfer data to blank areas.<br>Specify the absolute address of the DTC vector table with #pragma. |

**Table 1.2 Peripheral Functions and Their Applications**

| Peripheral Function | Application |
|---|---|
| DTC | Transfer output data to ports. |
| Channel 0 in the compare match timer (CMT0) | DTC activation source (the pattern output to the LED is changed every 500 ms). |
| Channel 3 in the compare match timer (CMT3) | DTC activation source (the pattern output from PORTA is changed every 250 ms). |

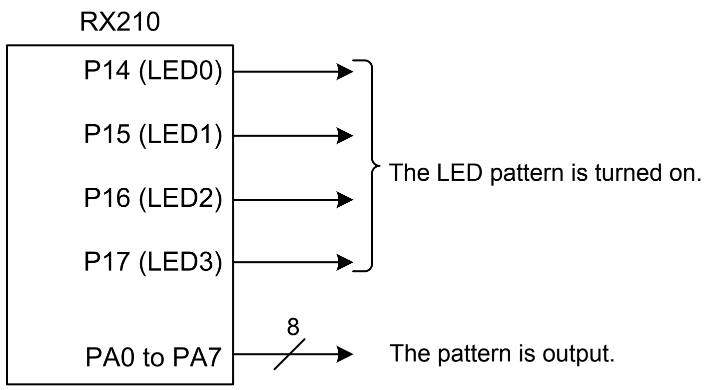



**Figure 1.1 Connection Example**

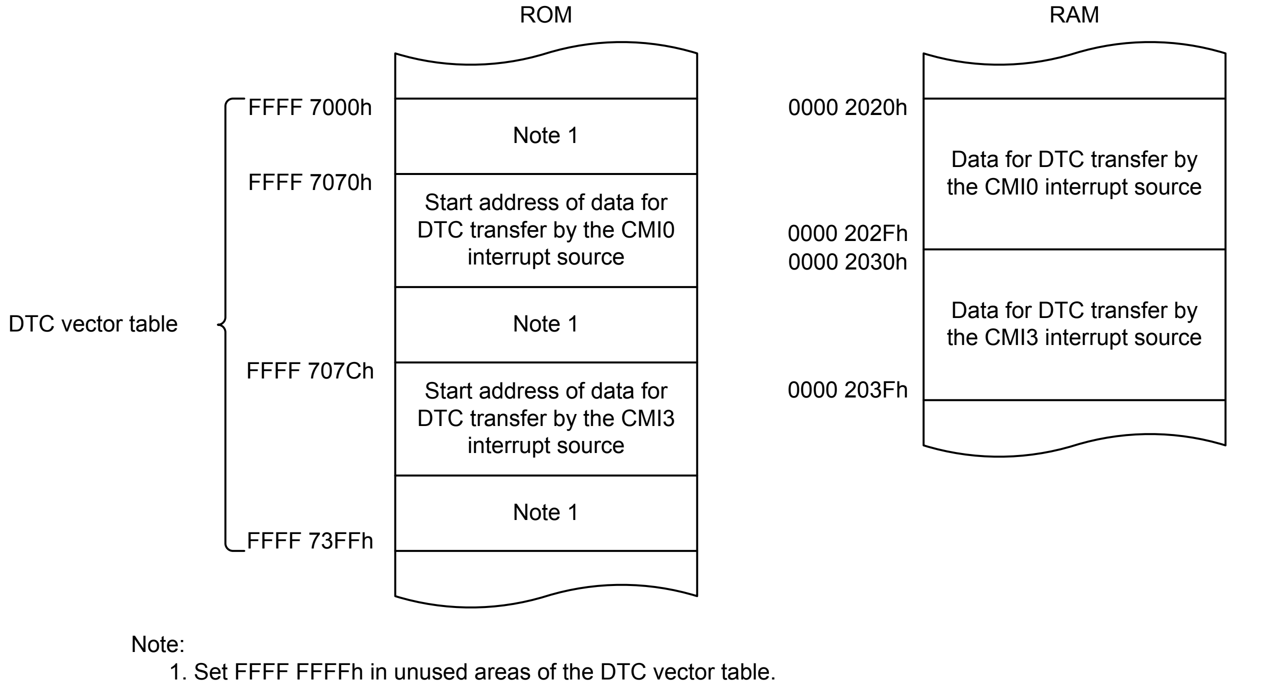
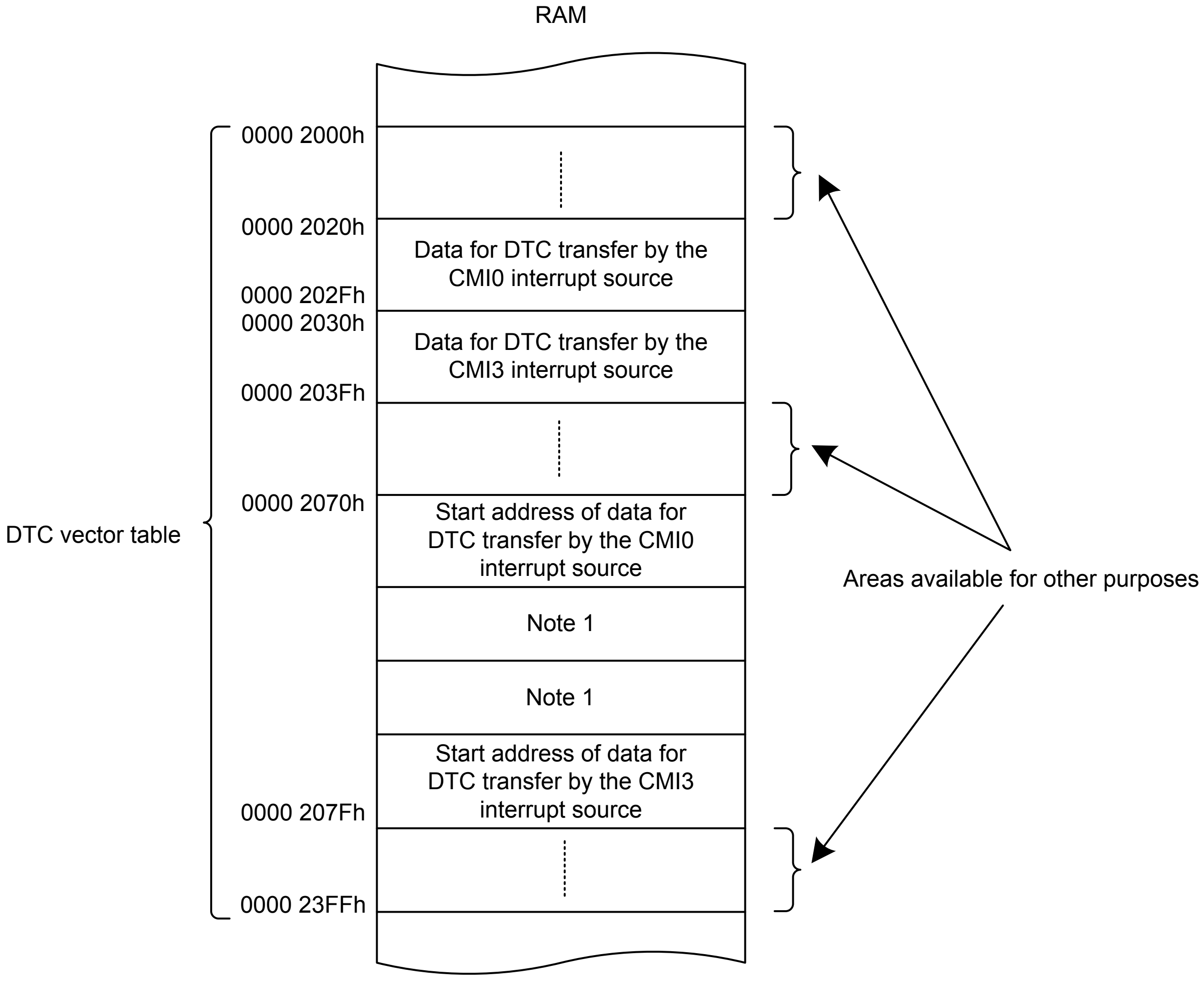



**Figure 1.2 Memory Map when the DTC Vector Table is Allocated to the ROM Area (Sample Code 1)**




Note:

1. Set FFFF FFFFh in this area since the CMI1 interrupt source and CMI2 interrupt source are not used.

**Figure 1.3 Memory Map when the DTC Vector Table is Allocated to the RAM Area (Sample Code 2)**

## 2. Operation Confirmation Conditions

The sample code accompanying this application note has been run and confirmed under the conditions below.

**Table 2.1 Operation Confirmation Conditions**

| Item | Contents |
|---|---|
| MCU used | R5F52108ADFP (RX210 Group) |
| Operating frequencies | - Main clock: 20 MHz<br>- PLL: 100 MHz (main clock divided by 2 and multiplied by 10)<br>- System clock (ICLK): 50 MHz (PLL divided by 2)<br>- Peripheral module clock B (PCLKB): 25 MHz (PLL divided by 4) |
| Operating voltage | 5.0 V |
| Integrated development environment | Renesas Electronics Corporation<br>High-performance Embedded Workshop Version 4.09.01 |
| C compiler | Renesas Electronics Corporation<br>C/C++ Compiler Package for RX Family V.1.02 Release 01 |
| | Compile options<br>-cpu=rx200 -output=obj="$(CONFIGDIR)\$(FILELEAF).obj" -debug –nologo<br>(The default setting is used in the integrated development environment.) |
| iodefine.h version | Version 1.2A |
| Endian | Little endian |
| Operating mode | Single-chip mode |
| Processor mode | Supervisor mode |
| Sample code version | Version 1.00 |
| Board used | Renesas Starter Kit for RX210 (product part no.: R0K505210C000BE) |

## 3. Reference Application Notes

For additional information associated with this document, refer to the following application notes.

- RX210 Group Initial Setting Rev. 2.00 (R01AN1002EJ)
- RX21A Group Initial Setting Rev. 1.10 (R01AN1486EJ)
- RX220 Group Initial Setting Rev. 1.10 (R01AN1494EJ)

The initial setting functions in the reference application notes are used in the sample code in this application note. The revision numbers of the reference application notes are current as of when this application note was made. However the latest version is always recommended. Visit the Renesas Electronics Corporation website to check and download the latest version.

# 4. Hardware

## 4.1 Pins Used

Table 4.1 lists the Pins Used and Their Functions.

**Table 4.1 Pins Used and Their Functions**

| Pin Name | I/O | Function |
|---|---|---|
| P14 | Output | Output data to turn on or turn off LED0 |
| P15 | Output | Output data to turn on or turn off LED1 |
| P16 | Output | Output data to turn on or turn off LED2 |
| P17 | Output | Output data to turn on or turn off LED3 |
| PA0 to PA7 | Output | Output a pattern |

## 5. Software

Allocate the data table of the LED output pattern and data table of the PORTA output pattern to the ROM area in advance.

When the CMT0 compare match interrupt (CMI0) request is generated, DTC transfer is activated and the LED output pattern is transferred to PORT1. Then the values in the data table are sequentially transferred every time the CMI0 interrupt request is generated.

Also when the CMT3 compare match interrupt (CMI3) request is generated, DTC transfer is activated and the PORTA output pattern is transferred to PORTA. Then the values in the data table are sequentially transferred every time the CMI3 interrupt request is generated.

Settings for the peripheral functions used are as follows:

CMT

- Count clock: PCLKB/512
- CMT0 compare match: In 500 ms intervals
- CMT3 compare match: In 250 ms intervals

DTC

- Activation source: Compare match interrupts for CMT0 and CMT3
- DTC address mode: Full-address mode

Setting for DTC transfer triggered by the CMI0 interrupt request

- Transfer mode: Repeat transfer mode
- Transfer source address addressing mode: SAR value is incremented after data transfer
- Transfer source address: ROM area (LED output data)
- Transfer destination address addressing mode: Address in the DAR register is fixed
- Transfer destination address: PORT1 (LED)
- Data transfer unit: 8 bits
- Number of transfers: 4 times
- Chain transfer: Disabled

Setting for DTC transfer triggered by CMI3 interrupt request

- Transfer mode: Repeat transfer mode
- Transfer source address addressing mode: SAR value is incremented after data transfer
- Transfer source address: ROM area (PORTA output data)
- Transfer destination address addressing mode: Address in the DAR register is fixed
- Transfer destination address: PORTA
- Data transfer unit: 8 bits
- Number of transfers: 8 times
- Chain transfer: Disabled

## 5.1 Operation Overview

(1) After initialization, when setting bits CMTSTR0.STR0 and CMTSTR1.STR3 to 1, CMT0 and CMT3 start counting.

(2) When the CMI3 interrupt request is generated, write the first byte of PORTA output data (01h) to the PORTA.PODR register using DTC transfer. Then every time the CMI3 interrupt request is generated, PORTA output data is sequentially transferred to the PORTA.PODR register using DTC transfer.

(3) When the CMI0 interrupt request is generated, write the first byte of LED output data (LED0 turned on) to the PORT1.PODR register using DTC transfer. Then every time the CMI0 interrupt request is generated, the LED output data is sequentially transferred to the PORT1.PODR register and output to the LED using DTC transfer.

(4) After DTC transfers with the CMI3 interrupt source have been performed for the specified number of times (8 times in the sample codes), when the CMI3 interrupt request is generated again, perform DTC transfer from the first byte of PORTA output data.

(5) After DTC transfers with the CMI0 interrupt source have been performed for the specified number of times (4 times in the sample codes), when the CMI0 interrupt request is generated again, perform DTC transfer from the first byte of LED output data.

Figure 5.1 shows the Operation Timing Diagram. (1) to (5) in the figure correspond to (1) to (5) in the description above.

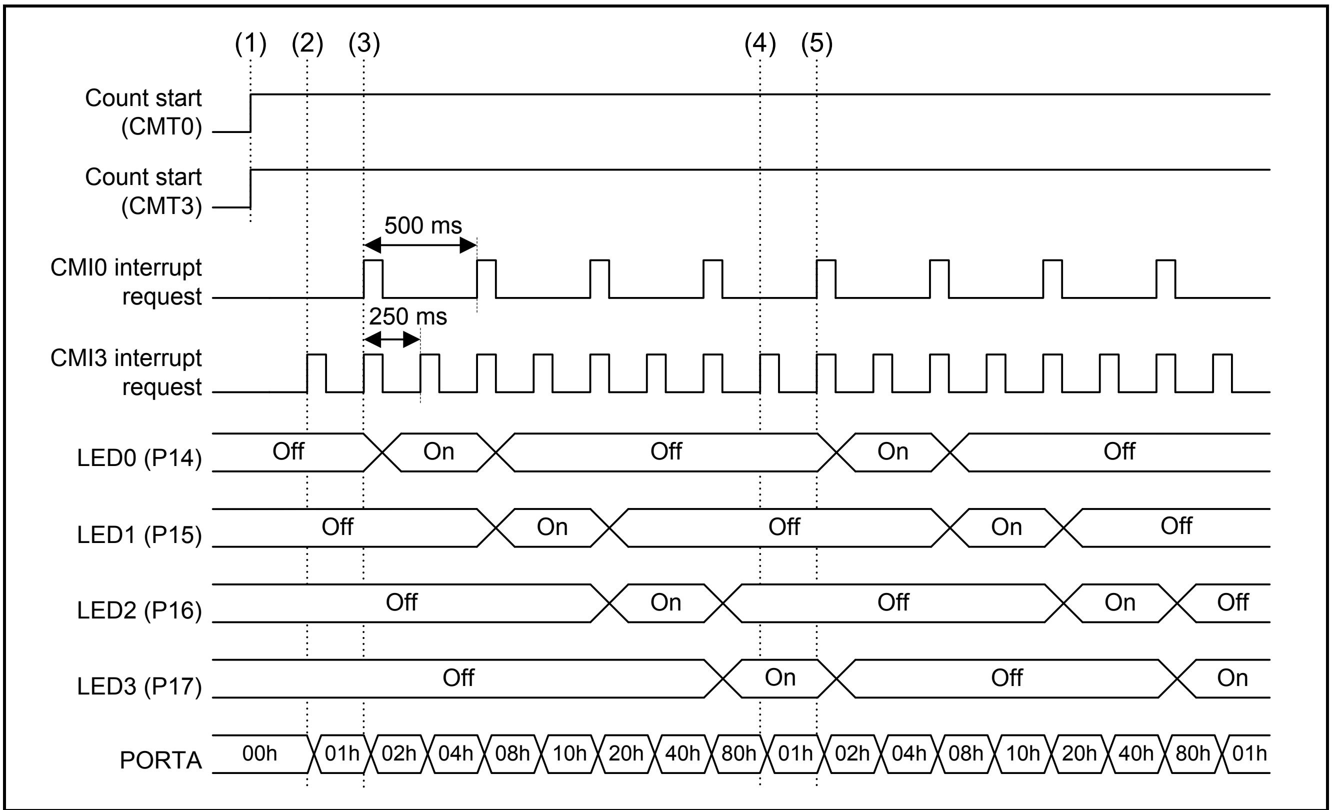



**Figure 5.1 Operation Timing Diagram**

Notes on embedding the sample codes

When embedding the sample codes from this application note in the actual system, note the following:

As DTC data transfer is performed in 8-bit units, when the DTC transfer is triggered by the CMI0 interrupt request and output data is written to the PORT1.PODR register for LED0 to LED3 (P14 to P17), P10 to P13 are also set to 0. Therefore do not use P10 to P13 as output ports.

## 5.2 Section Structure

Table 5.1 lists the Section Changed in Sample Code 1.

Refer to the latest RX Family C/C++ Compiler Package user's manual for adding, changing, or deleting sections.

**Table 5.1 Section Changed in Sample Code 1**

| Section Name | Change | Address | Description |
|---|---|---|---|
| DTC_SECTION | Addition | FFFF 7000h | DTC vector table (ROM area) |

## 5.3 File Composition

Table 5.2 lists the Files Used in Sample Code 1 and Table 5.3 lists the Files Used in Sample Code 2. Files generated by the integrated development environment are not included in this table.

**Table 5.2 Files Used in Sample Code 1**

| File Name | Outline | Remarks |
|---|---|---|
| main.c | Main processing | |
| r_init_stop_module.c | Stop processing for active peripheral functions after a reset | |
| r_init_stop_module.h | Header file for r_init_stop_module.c | |
| r_init_non_existent_port.c | Nonexistent port initialization | |
| r_init_non_existent_port.h | Header file for r_init_non_existent_port.c | |
| r_init_clock.c | Clock initialization | |
| r_init_clock.h | Header file for r_init_clock.c | |
| dtc_vecter_table.c | DTC vector table | |

**Table 5.3 Files Used in Sample Code 2**

| File Name | Outline | Remarks |
|---|---|---|
| main.c | Main processing | |
| r_init_stop_module.c | Stop processing for active peripheral functions after a reset | |
| r_init_stop_module.h | Header file for r_init_stop_module.c | |
| r_init_non_existent_port.c | Nonexistent port initialization | |
| r_init_non_existent_port.h | Header file for r_init_non_existent_port.c | |
| r_init_clock.c | Clock initialization | |
| r_init_clock.h | Header file for r_init_clock.c | |

## 5.4 Option-Setting Memory

Table 5.4 lists the Option-Setting Memory Configured in Sample Codes 1 and 2. When necessary, set values suited to the user system.

**Table 5.4 Option-Setting Memory Configured in Sample Codes 1 and 2**

| Symbol | Address | Setting Value | Contents |
|---|---|---|---|
| OFS0 | FFFF FF8Fh to FFFF FF8Ch | FFFF FFFFh | IWDT is stopped after reset<br>WDT is stopped after reset |
| OFS1 | FFFF FF8Bh to FFFF FF88h | FFFF FFFFh | Voltage monitoring 0 reset is disabled after reset<br>HOCO oscillation is disabled after reset |
| MDES | FFFF FF83h to FFFF FF80h | FFFF FFFFh | Little endian |

## 5.5 Constants

Table 5.5 lists the Constants Used in Sample Code 1 and Table 5.6 lists the Constants Used in Sample Code 2.

**Table 5.5 Constants Used in Sample Code 1**

| Constant Name | Setting Value | Contents |
|---|---|---|
| P_LED | PORT1.PODR.BYTE | LED output pin |
| LED_OFF | F0h | LED0 to LED3 all turned off |
| LED0_ON | E0h | LED0 turned on, LED1 to LED3 turned off |
| LED1_ON | D0h | LED1 turned on, LED0, LED2, and LED3 turned off |
| LED2_ON | B0h | LED2 turned on, LED0, LED1, and LED3 turned off |
| LED3_ON | 70h | LED3 turned on, LED0 to LED2 turned off |
| PD_LED | PORT1.PDR.BYTE | I/O select bit of the LED output pin |
| LED_OUTPUT | F0h | LED output setting |
| ADDR_CMT0_DTC_TBL | 0000 2020h | Start address of data for DTC transfer triggered by the CMI0 interrupt request |
| ADDR_CMT3_DTC_TBL | 0000 2030h | Start address of data for DTC transfer triggered by the CMI3 interrupt request |

**Table 5.6 Constants Used in Sample Code 2**

| Constant Name | Setting Value | Contents |
|---|---|---|
| P_LED | PORT1.PODR.BYTE | LED output pin |
| LED_OFF | F0h | LED0 to LED3 all turned off |
| LED0_ON | E0h | LED0 turned on, LED1 to LED3 turned off |
| LED1_ON | D0h | LED1 turned on, LED0, LED2, and LED3 turned off |
| LED2_ON | B0h | LED2 turned on, LED0, LED1, and LED3 turned off |
| LED3_ON | 70h | LED3 turned on, LED0 to LED2 turned off |
| PD_LED | PORT1.PDR.BYTE | I/O select bit of the LED output pin |
| LED_OUTPUT | F0h | LED output setting |
| ADDR_CMT0_DTC_TBL | 0000 2020h | Start address of data for DTC transfer triggered by the CMI0 interrupt request |
| ADDR_CMT3_DTC_TBL | 0000 2030h | Start address of data for DTC transfer triggered by the CMI3 interrupt request |
| ADDR_DTC_VECT_TOP | 0000 2000h | Start address of the DTC vector address |
| ADDR_CMT0_DTC_VECT | 0000 2070h | DTC vector address of CMT0 (CMI0) |
| ADDR_CMT1_DTC_VECT | 0000 2074h | DTC vector address of CMT1 (CMI1) |
| ADDR_CMT2_DTC_VECT | 0000 2078h | DTC vector address of CMT2 (CMI2) |
| ADDR_CMT3_DTC_VECT | 0000 207Ch | DTC vector address of CMT3 (CMI3) |

## 5.6 Structure/Union List

Figure 5.2 shows the Structure/Union Used in Sample Codes 1 and 2.

The bit field members are allocated from upper bits using the function of #pragma to specify the bit field sequence. Refer to the latest RX Family C/C++ Compiler Package user's manual for details

```
/* **** DTC Transfer information data **** */
#pragma bit_order left
#pragma unpack
struct st_dtc_full{
    union{
        unsigned long LONG;
        struct{
            unsigned long MRA_MD        :2;
            unsigned long MRA_SZ        :2;
            unsigned long MRA_SM        :2;
            unsigned long               :2;
            unsigned long MRB_CHNE      :1;
            unsigned long MRB_CHNS      :1;
            unsigned long MRB_DISEL     :1;
            unsigned long MRB_DTS       :1;
            unsigned long MRB_DM        :2;
            unsigned long               :2;
            unsigned long               :16;
        }BIT;
    }MR;
    void * SAR;
    void * DAR;
    struct{
        unsigned long CRA:16;
        unsigned long CRB:16;
    }CR;
};
#pragma bit_order
#pragma packoption
```

**Figure 5.2 Structure/Union Used in Sample Codes 1 and 2**

## 5.7 Variables

Table 5.7 lists the Global Variables for Sample Codes 1 and 2, Table 5.8 lists the const Variables for Sample Code 1, and Table 5.9 lists the const Variables for Sample Code 2.

**Table 5.7 Global Variables for Sample Codes 1 and 2**

| Type | Variable Name | Contents | Function Used |
|---|---|---|---|
| st_dtc_full | cmt0_dtc_tbl | DTC transfer data table when the CMI0 interrupt is requested | dtc_init |
| st_dtc_full | cmt3_dtc_tbl | DTC transfer data table when the CMI3 interrupt is requested | dtc_init |

**Table 5.8 const Variables for Sample Code 1**

| Type | Variable Name | Contents | Function Used |
|---|---|---|---|
| unsigned char | dtc_output_data0 | LED output data (transfer source of DTC transfer triggered by the CMI0 interrupt request) | dtc_init |
| unsigned char | dtc_output_data1 | PORTA output data (transfer source of DTC transfer triggered by the CMI3 interrupt request) | dtc_init |
| void* | Relocatable_Vectors | DTC vector table | dtc_init |

**Table 5.9 const Variables for Sample Code 2**

| Type | Variable Name | Contents | Function Used |
|---|---|---|---|
| unsigned char | dtc_output_data0 | LED output data (transfer source of DTC transfer triggered by the CMI0 interrupt request) | dtc_init |
| unsigned char | dtc_output_data1 | PORTA output data (transfer source of DTC transfer triggered by the CMI3 interrupt request) | dtc_init |

## 5.8 Functions

Table 5.10 lists the Functions for Sample Codes 1 and 2.

**Table 5.10 Functions for Sample Codes 1 and 2**

| Function Name | Outline |
|---|---|
| main | Main processing |
| port_init | Port initialization |
| R_INIT_StopModule | Stop processing for active peripheral functions after a reset |
| R_INIT_NonExistentPort | Nonexistent port initialization |
| R_INIT_Clock | Clock initialization |
| peripheral_init | Peripheral initialization |
| lpc_init | Low power consumption initialization |
| cmt_init | CMT initialization |
| dtc_init | DTC initialization |

## 5.9 Function Specifications

The following tables list the sample code function specifications.

| main | |
|---|---|
| **Outline** | Main processing |
| **Header** | None |
| **Declaration** | void main(void) |
| **Description** | After initialization, start the CMT count. |
| **Arguments** | None |
| **Return Value** | None |

| port_init | |
|---|---|
| **Outline** | Port initialization |
| **Header** | None |
| **Declaration** | void port_init(void) |
| **Description** | Initialize ports. |
| **Arguments** | None |
| **Return Value** | None |

| R_INIT_StopModule | |
|---|---|
| **Outline** | Stop processing for active peripheral functions after a reset |
| **Header** | r_init_stop_module.h |
| **Declaration** | void R_INIT_StopModule(void) |
| **Description** | Configure the setting to enter the module-stop state. |
| **Arguments** | None |
| **Return Value** | None |
| **Remarks** | Transition to the module-stop state is not performed in the sample code. For details on this function, refer to the Initial Setting application note for the product used. |

| R_INIT_NonExistentPort | |
|---|---|
| **Outline** | Nonexistent port initialization |
| **Header** | r_init_non_existent_port.h |
| **Declaration** | void R_INIT_NonExistentPort(void) |
| **Description** | Initialize port direction registers for ports that do not exist in products with less than 100 pins. |
| **Arguments** | None |
| **Return Value** | None |
| **Remarks** | The number of pins in the sample code is set for the 100-pin package (PIN_SIZE=100). After this function is called, when writing in byte units to the PDR registers or PODR registers which have nonexistent ports, set the corresponding bits for nonexistent ports as follows: set the I/O select bits in the PDR registers to 1 and set the output data store bits in the PODR registers to 0.<br>For details on this function, refer to the Initial Setting application note for the product used. |

| R_INIT_Clock | |
|---|---|
| **Outline** | Clock initialization |
| **Header** | r_init_clock.h |
| **Declaration** | void R_INIT_Clock(void) |
| **Description** | Initialize the clock. |
| **Arguments** | None |
| **Return Value** | None |
| **Remarks** | The sample code selects processing which uses PLL as the system clock without using the sub-clock.<br>For details on this function, refer to the Initial Setting application note for the product used. |

| peripheral_init | |
|---|---|
| **Outline** | Peripheral function initialization |
| **Header** | None |
| **Declaration** | void peripheral_init(void) |
| **Description** | Initialize peripheral functions used. |
| **Arguments** | None |
| **Return Value** | None |

| lpc_init | |
|---|---|
| **Outline** | Low power consumption initialization |
| **Header** | None |
| **Declaration** | void lpc_init(void) |
| **Description** | Cancel the module stop state for peripheral functions used. |
| **Arguments** | None |
| **Return Value** | None |

| cmt_init | |
|---|---|
| **Outline** | CMT initialization |
| **Header** | None |
| **Declaration** | void cmt_init(void) |
| **Description** | Configure the setting to use the CMT. |
| **Arguments** | None |
| **Return Value** | None |

| dtc_init | |
|---|---|
| **Outline** | DTC initialization |
| **Header** | None |
| **Declaration** | void dtc_init(void) |
| **Description** | Configure the setting to use the DTC. |
| **Arguments** | None |
| **Return Value** | None |

## 5.10 Flowcharts

### 5.10.1 Main Processing

Figure 5.3 shows the Main Processing.

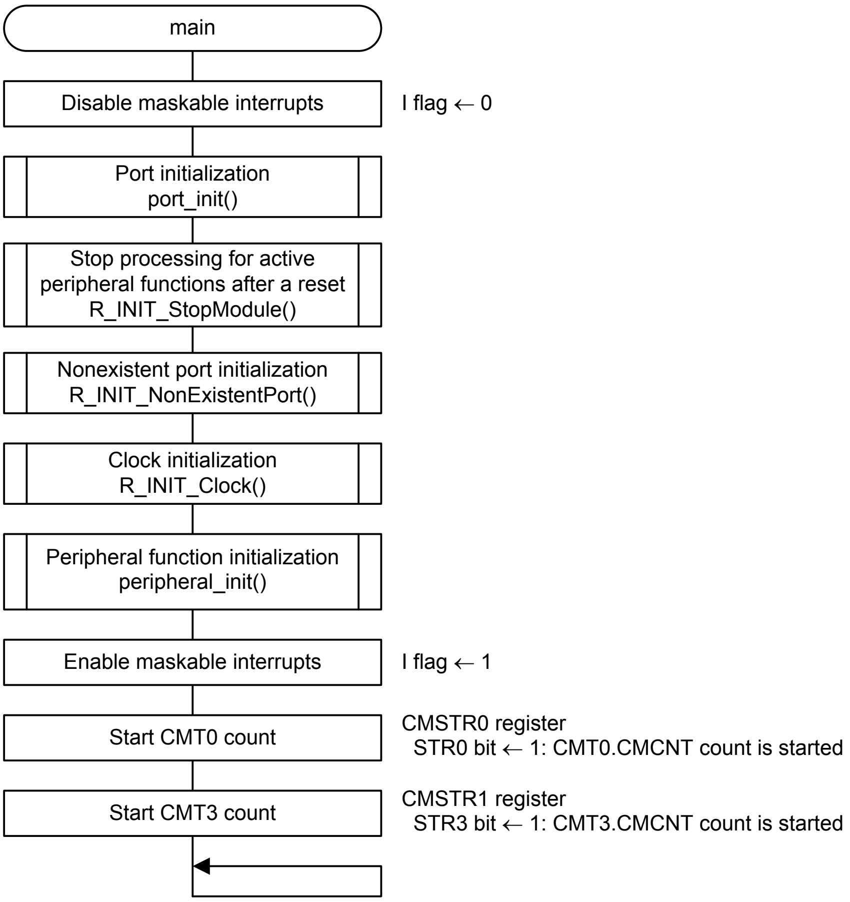



**Figure 5.3 Main Processing**

### 5.10.2 Port Initialization

Figure 5.4 shows the Port Initialization.

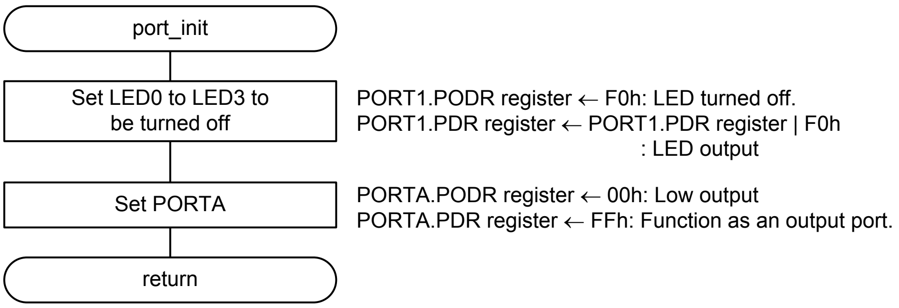



**Figure 5.4 Port Initialization**

### 5.10.3 Peripheral Function Initialization

Figure 5.5 shows Peripheral Function Initialization.

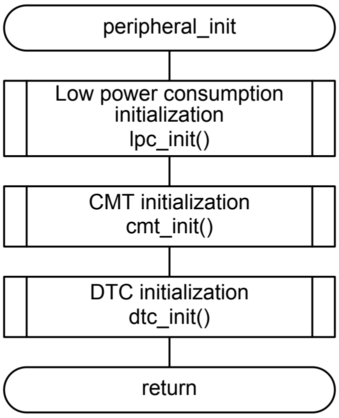



**Figure 5.5 Peripheral Function Initialization**

### 5.10.4 Low Power Consumption Initialization

Figure 5.6 shows the Low Power Consumption Initialization.

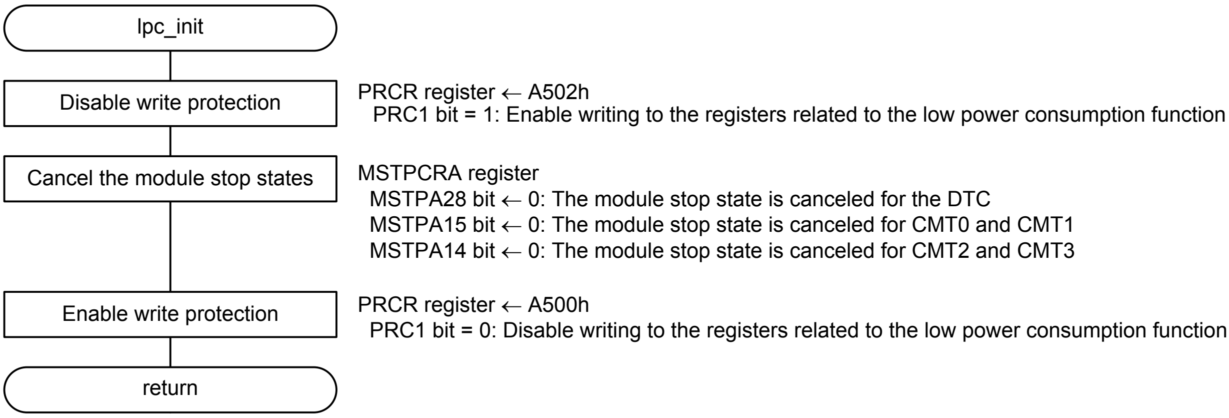



**Figure 5.6 Low Power Consumption Initialization**

### 5.10.5 CMT Initialization

Figure 5.7 shows the CMT Initialization.

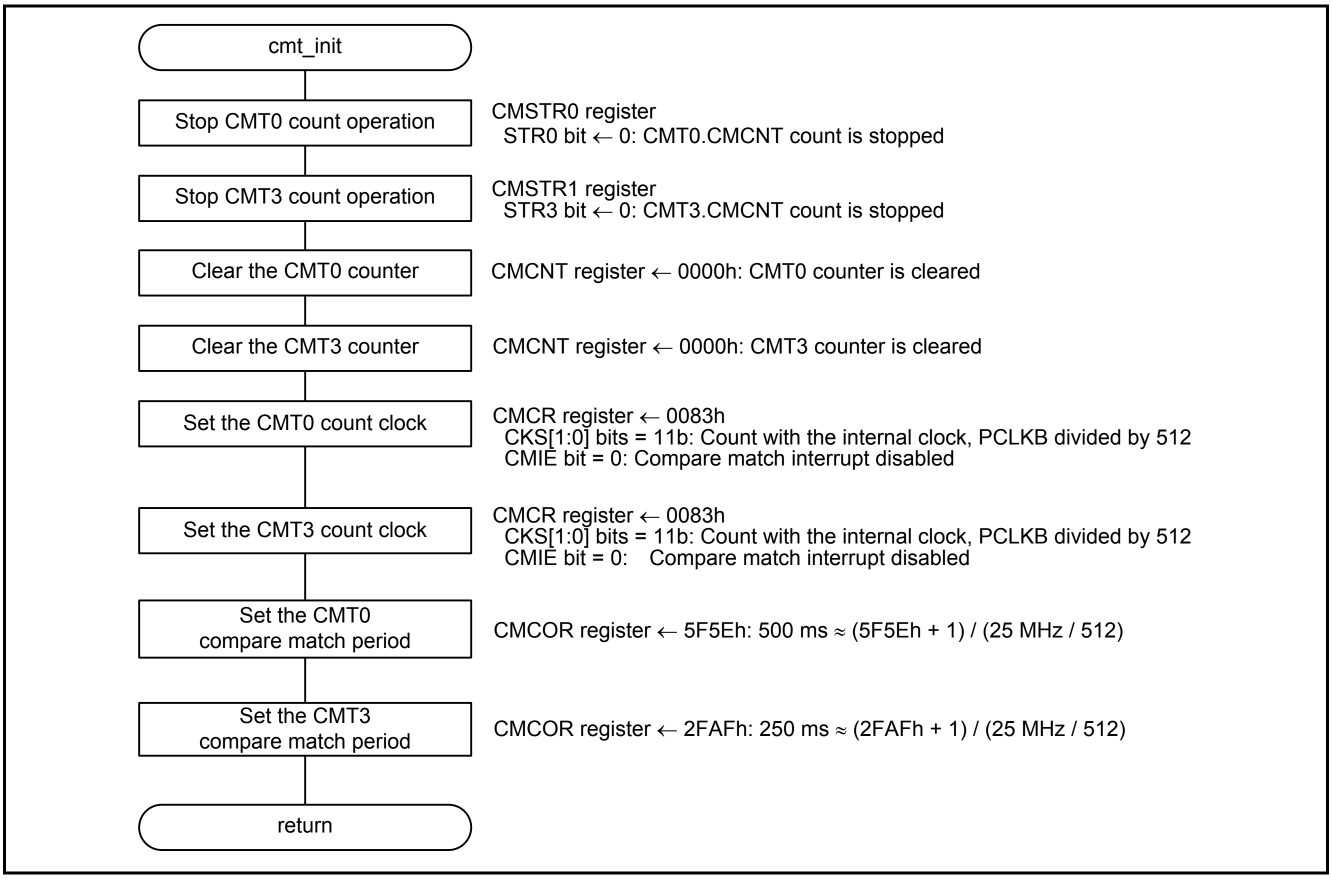



**Figure 5.7 CMT Initialization**

### 5.10.6 DTC Initialization

Figure 5.8 shows the DTC Initialization.

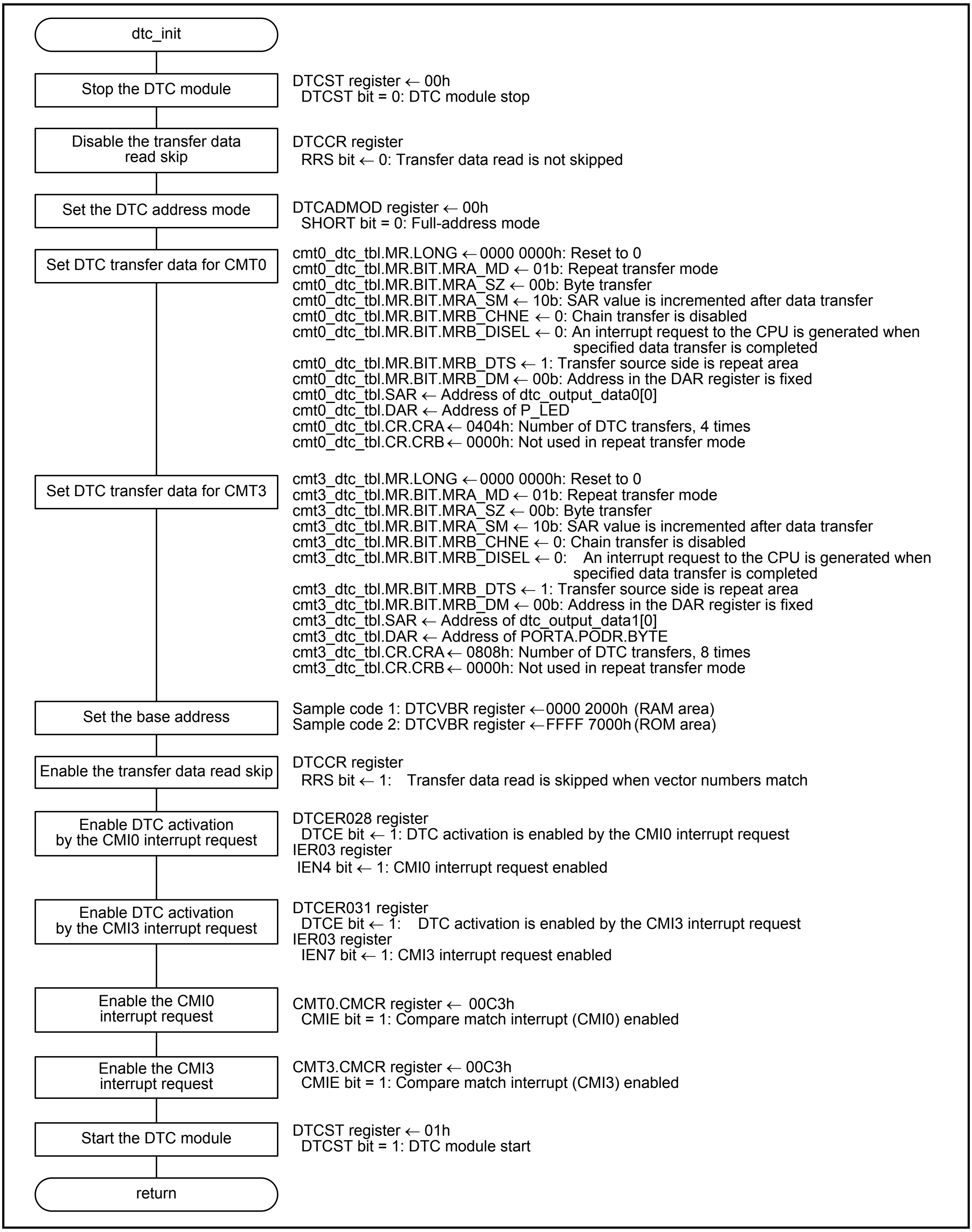



**Figure 5.8 DTC Initialization**

## 6. Applying This Application Note to the RX21A or RX220 Group

The sample code accompanying this application note has been confirmed to operate with the RX210 Group. To make the sample code operate with the RX21A or RX220 Group, use this application note in conjunction with the Initial Setting application note for each group.

For details on using this application note with the RX21A and RX220 Groups, refer to “5. Applying the RX210 Group Application Note to the RX21A Group” in the RX21A Group Initial Setting application note, and “4. Applying the RX210 Group Application Note to the RX220 Group” in the RX220 Group Initial Setting application note.

## 7. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

## 8. Reference Documents

User’s Manual: Hardware

RX210 Group User's Manual: Hardware Rev.1.50 (R01UH0037EJ)
RX21A Group User's Manual: Hardware Rev.1.00 (R01UH0251EJ)
RX220 Group User's Manual: Hardware Rev.1.10 (R01UH0292EJ)
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.

User’s Manual: Development Tools

RX Family C/C++ Compiler Package V.1.01 User’s Manual Rev.1.00 (R20UT0570EJ)
The latest version can be downloaded from the Renesas Electronics website.

## Website and Support

Renesas Electronics website

http://www.renesas.com

Inquiries

http://www.renesas.com/contact/

| REVISION HISTORY | RX210, RX21A, and RX220 Groups Application Note<br>Efficient Allocation of the DTC Vector Table |
|---|---|

| Rev. | Date | Description | |
|---|---|---|---|
| | | **Page** | **Summary** |
| 1.00 | Apr. 1, 2013 | — | First edition issued |
| 1.01 | July 1, 2014 | 1 | Products: Added the RX21A and RX220 Groups. |
| | | 6 | 2. Operation Confirmation Conditions:<br>- Changed the Contents of the MCU used.<br>- Changed the product part no. in the Contents of the Board used. |
| | | 6 | 3. Reference Application Notes: Added the Initial Setting application notes for the RX21A and RX220 Groups. |
| | | 15, 16 | Modified the description of reference application note in the following functions: R_INIT_StopModule, R_INIT_NonExistentPort, and R_INIT_Clock. |
| | | 21 | 6. Applying This Application Note to the RX21A or RX220 Group: Added. |
| | | 22 | 8. Reference Documents: Added the User's Manual: Hardware for the RX21A and RX220 Groups. |
| | | | |

## General Precautions in the Handling of MPU/MCU Products

The following usage notes are applicable to all MPU/MCU 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. 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 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. Unused pins should be handled as described under Handling of Unused Pins in the manual.

2. Processing at Power-on

   The state of the product is undefined at the moment 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 moment 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 moment 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 moment when power is supplied until the power reaches the level at which resetting has been specified.

3. Prohibition of Access to Reserved Addresses

   Access to reserved addresses is prohibited.

   — The reserved addresses are provided for the possible future expansion of functions. Do not access these addresses; the correct operation of LSI is not guaranteed if they are accessed.

4. Clock Signals

   After applying a reset, only release the reset line after the operating clock signal has become stable. When switching the clock signal during program execution, wait until the target clock signal has 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. Moreover, 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.

5. Differences between Products

   Before changing from one product to another, i.e. to a product with a different part number, confirm that the change will not lead to problems.

   — The characteristics of an MPU or MCU in the same group but having a different part number may differ in terms of the 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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