RZ/T1 Group

Compare Match Timer (CMT)

R01AN2555EJ0140
Rev.1.40
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Introduction

This application note explains a sample program that uses the periodic counting operation of a compare match timer.

The major features of the sample program are listed below:

- Uses periodic counting operation of a compare match timer, CMT0, and flashes LED10 in 20Hz intervals.
- Uses periodic counting operation of a compare match timer, CMT1, and flashes LED8 in 10Hz intervals.

Target Devices

RZ/T1 Group

When applying the sample program covered in this application note to another microcomputer, modify the program according to the specifications for the target microcomputer and conduct an extensive evaluation of the modified program.

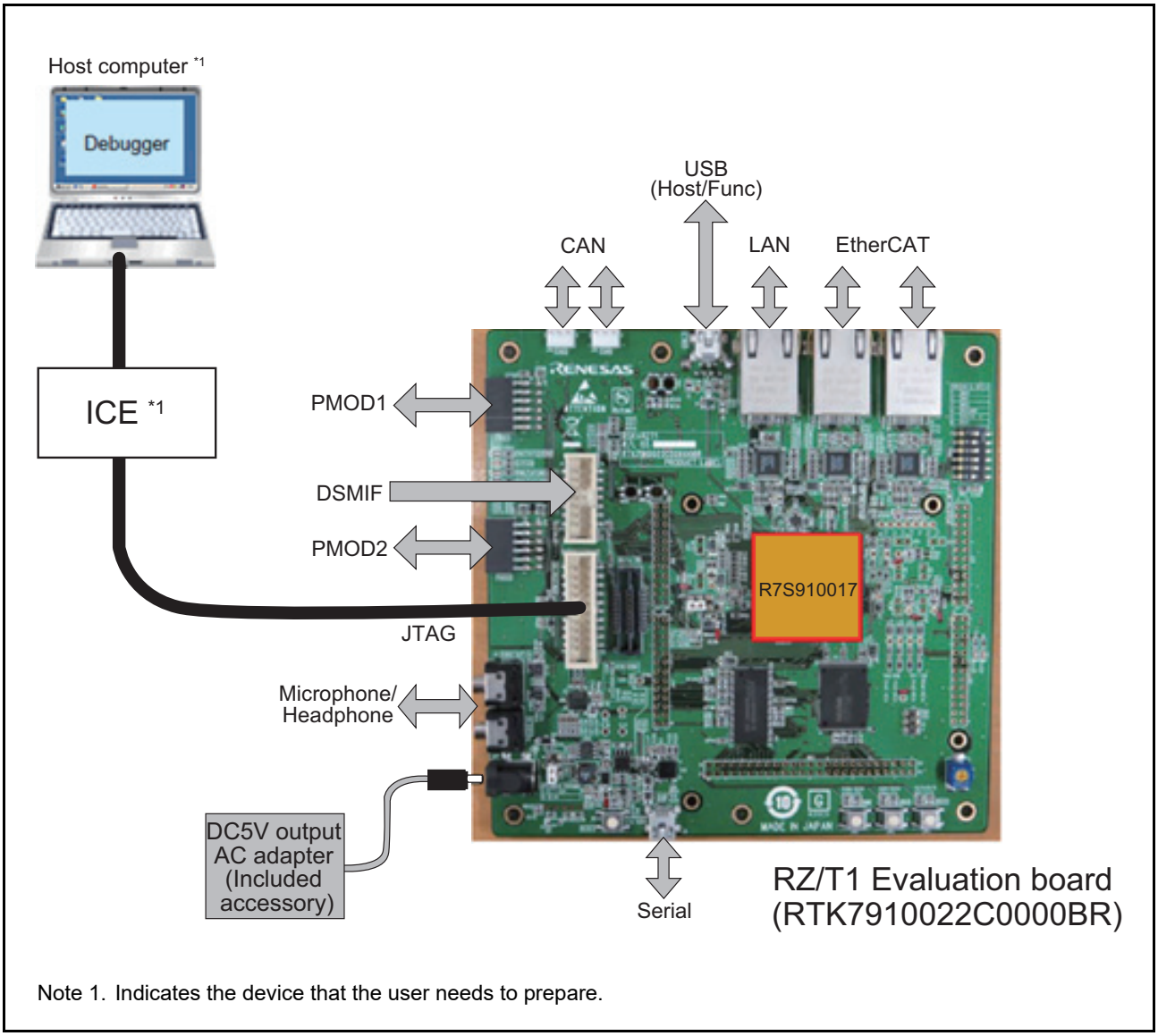
Table of Contents

1. Specifications

Table 1.1 lists the peripheral functions to be used and their applications. Figure 1.1 shows the operating environment when the sample code is being executed.

Table 1.1 Peripheral Functions and Applications

Peripheral Function	Application
Clock Generator (CPG)	Used as a CPU clock and low-speed on-chip oscillator
Interrupt controller (ICUA)	Used for compare match interrupt (CMI0 and CMI1)
Compare match timer (CMT)	Used for periodic counting operation of a compare match timer
Error control module (ECM)	Used to initialize ERROROUT# pin
General purpose I/O ports	Used to control a pin to light LED on and off



Note 1. Indicates the device that the user needs to prepare.

Figure 1.1 Operating Environment

2. Operating Environment

The sample program covered in this application note is for the environment below.

Table 2.1 Operating Environment

Item	Description
Microcomputer	RZ/T1 Group
Operating frequency	CPUCLK = 450 MHz
Operating voltage	3.3 V
Integrated Development Environment	Manufactured by IAR Systems Embedded Workbench® for Arm Version 8.20.2 Manufactured by Arm DS-5™ 5.26.2 Manufactured by RENESAS e2studio 6.1.0
Operating mode	SPI boot mode 16-bit bus boot mode
Board	RZ/T1 Evaluation Board (RTK7910022C00000BR)
Device (functions to be used on the board)	• NOR flash memory (connected to CS0 or CS1 space) Manufacturer: Macronix International Co.,Ltd. Model: MX29GL512FLT2I-10Q • SDRAM (connected to CS2 or CS3 space) Manufacturer: Integrated Silicon Solution Inc. Model: IS42S16320D-7TL • Serial flash memory Manufacturer: Macronix International Co.,Ltd. Model: MX25L51245G

3. Related Application Note

An additional application note related to this note is listed below for reference:

- RZ/T1 Group Initial Settings

4. Peripheral Functions

See the RZ/T1 Group User's Manual: Hardware for basic descriptions for clock generator (CPG), compare match timer (CMT), interrupt controller (ICUA), error control model (ECM) and general purpose I/O ports.

5. Hardware

5.1 Hardware Configuration Examples

Figure 5.1 shows a hardware configuration example.

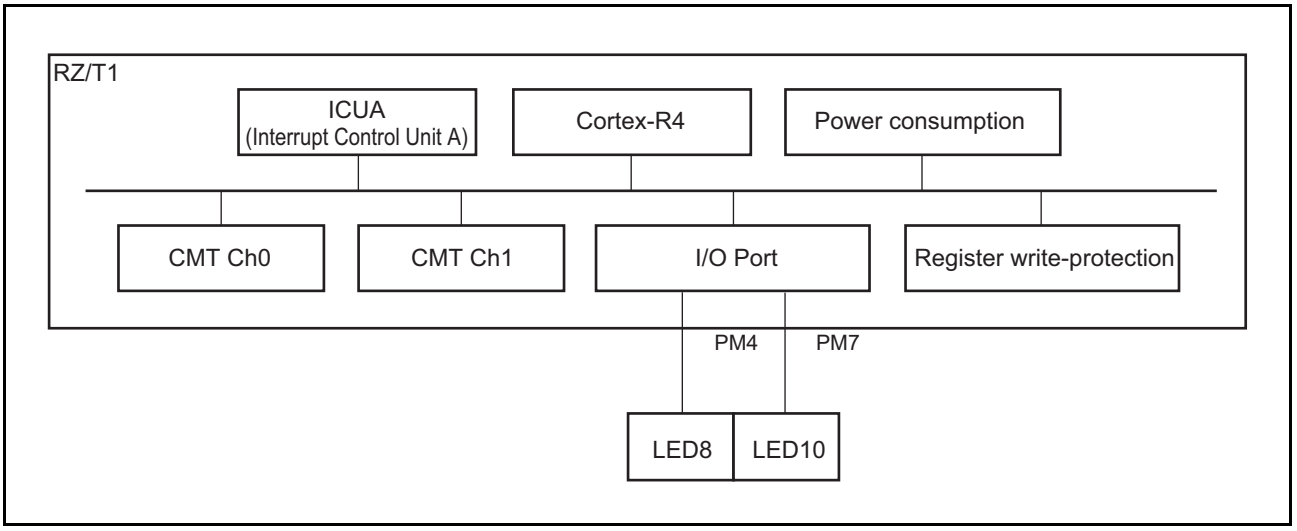


Figure 5.1 Hardware configuration example

5.2 Pins

Table 5.1 lists pins to be used and their functions

Table 5.1 Pins and Functions

Pin Name	Input/Output	Function
MD0	Input	Selects operating mode SPI boot mode if MD0="L", MD1="L" and MD2="L" 16-bit bus boot mode if MD0="L", MD1="H", and MD2="L"
MD1	Input	
MD2	Input	
PM7	Output	Lights LED10 on and off
PM4	Output	Lights LED8 on and off

6. Software

6.1 Operation Outline

This sample program performs the periodic counting operation of compare match timers (CMT0 and CMT1). After setup, a compare match timer interrupt, CMI0, will occur in ch0 to turn LED10 on and off in 20Hz intervals while another compare match timer interrupt, CMI1, will occur in ch1 to turn LED8 on and off at every 10Hz interval.

Table 6.1 shows a functional overview of this sample program. Figure 6.1 shows the timing chart.

Table 6.1 Operation Overview

Function	Overview
Channels	Channel 0 of Unit 0 (CMT0) Channel 1 of Unit 0 (CMT1)
Clock	Input clock of channel 0 (CMCNT0), PCLKD/512 Input clock of channel 1 (CMCNT1), PCLKD/512
Cycle count	Channel 0: 20Hz Channel 1: 10Hz
Interrupt	Channel 0: CMI0 enabled Channel 1: CMI1 enabled

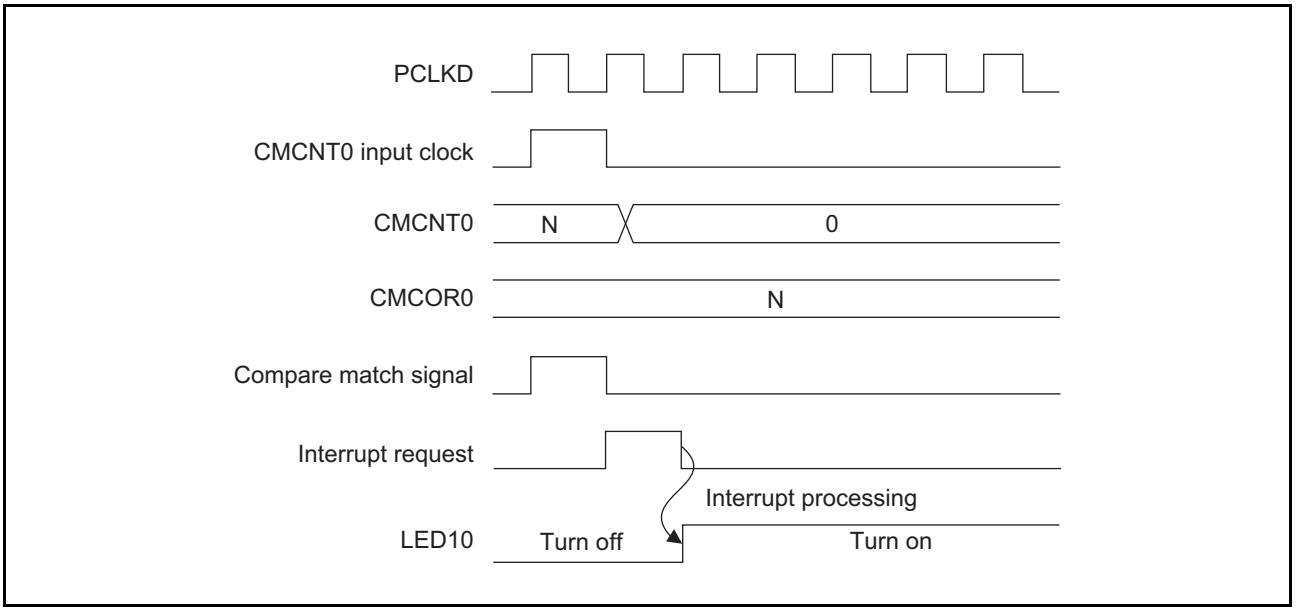


Figure 6.1 Timing chart (operation example of CMT0 case)

6.1.1 Project Setup

See the Application Note: RZ/T1 Group Initial Settings for project setup on the EWARM development environment.

6.2 Memory Map

See the Application Note: RZ/T1 Group Initial Settings for address space of RZ/T1 group and memory mapping under the RZ/T1 evaluation board.

6.2.1 Section Placement

See the Application Note: RZ/T1 Group Initial Settings for sections used by the sample program, the initial section placement at an initialized state of the sample program (load view) and section placement after scatter loading is used (execution view).

6.2.2 MPU Setup

See the Application Note: RZ/T1 Group Initial Settings for MPU setup.

6.2.3 Vector Table for Exception Handling

See the Application Note: RZ/T1 Group Initial Settings regarding the vector table for exception handling.

6.3 Interrupts

Table 6.2 lists interrupts used by the sample program.

Table 6.2 Interrupts

Interrupt (ID)	Priority	Description
Compare match interrupt for ch0 (CMI0)	15	Repeats on/off of LED10 every event interval of 20Hz
Compare match interrupt for ch1 (CMI1)	15	Repeats on/off of LED8 every event interval of 10Hz

6.4 Fixed-width Integer Types

Table 6.3 lists fixed-width integers for the sample program.

Table 6.3 Fixed-width integers

Symbol	Content
int8_t	8-bit signed integer (defined in the standard library)
int16_t	16-bit signed integer (defined in the standard library)
int32_t	32-bit signed integer (defined in the standard library)
int64_t	64-bit signed integer (defined in the standard library)
uint8_t	8-bit unsigned integer (defined in the standard library)
uint16_t	16-bit unsigned integer (defined in the standard library)
uint32_t	32-bit unsigned integer (defined in the standard library)
uint64_t	64-bit unsigned integer (defined in the standard library)

6.5 Constants/Error Codes

Table 6.4 shows the constants, and Table 6.5 shows the error codes used by the sample program.

Table 6.4 Constants

Constant	Value	Content
CMT_CH_TOTAL	(4)	Number of CMT channels
CMT_CH_0	(0)	Constant for specifying channel 0
CMT_CH_1	(1)	Constant for specifying channel 1
CMT_CH_2	(2)	Constant for specifying channel 2
CMT_CH_3	(3)	Constant for specifying channel 3
CMT_CKS_DIVISION_8	(0)	CMCNTn counter clock division constant for PCLKD/8
CMT_CKS_DIVISION_32	(1)	CMCNTn counter clock division constant for PCLKD/32
CMT_CKS_DIVISION_128	(2)	CMCNTn counter clock division constant for PCLKD/128
CMT_CKS_DIVISION_512	(3)	CMCNTn counter clock division constant for PCLKD/512

Table 6.5 Error codes

Error code	Value	Content
CMT_SUCCSESS	(0)	Return value indicating success of function execution
CMT_ERR	(-1)	Return value indicating failure of function execution

6.6 Global Variables

Table 6.6 shows the global variables.

Table 6.6 Global variables

Type	Variable	Content	Used by
static uint32_t	g_cmt_modes[]	Operating mode of channels of CMT	userdef_cmt_init userdef_cmt_create userdef_cmt_isr_cmi
static void	(* g_cmt_callbacks])(uint 32_t channel)	Callback function pointer called when a CMT interrupt occurs	userdef_cmt_init userdef_cmt_create userdef_cmt_isr_cmi

6.7 Functions

Table 6.7 shows a list of functions.

Table 6.7 Functions

Function	Page
main	13
cmt_standby	13
R_CMT_Init	14
R_CMT_CreatePeriodic	14
R_CMT_CreateOneShot	15
R_CMT_Stop	15
blink_led	16

6.8 Functions

Specifications of the functions used in the sample program are shown below.

6.8.1 main

main	
Synopsis	Main processing
Declaration	int main(void)
Description	Processing occurs in the following sequence: 1. Initializes general purpose I/O ports and ECM function 2. Releases disable states of CMT modules 3. Initializes CMT0 and CMT1 and sets their event interval 4. Enters main loop.
Arguments	None
Return values	None
Remarks	None

6.8.2 cmt_standby

Cmt_standby	
Synopsis	Disabled CMT module release processing
Declaration	static void cmt_standby (void)
Description	Releases disable states of CMT0, CMT1 and CMT2 modules.
Arguments	None
Return values	None
Remarks	None

6.8.3 R_CMT_Init

R_CMT_Init		
Synopsis	CMT channel initialization	
Header	r_cmt.h	
Declaration	int32_t R_CMT_Init(uint32_t channel, uint16_t cks)	
Description	Initializes a CMT channel specified by the argument. The argument ‘cks’ selects a clock input to the CMCNTn counter.	
Arguments	uint32_t channel	Specifies a CMT channel to be initialized. Range: 0 to 3
	uint16_t cks	Selects a clock to be entered in CMCNTn counter. CMT_CKS_DIVISION_8: PCLKD / 8 CMT_CKS_DIVISION_32: PCLKD / 32 CMT_CKS_DIVISION_128: PCLKD / 128 CMT_CKS_DIVISION_512: PCLKD / 512
Return values	CMT_SECCESS: Success CMT_ERR: Failure	
Remarks	None	

6.8.4 R_CMT_CreatePeriodic

R_CMT_CreatePeriodic		
Synopsis	Starts periodic events	
Header	r_cmt.h	
Declaration	int32_t R_CMT_CreatePeriodic(uint32_t channel, uint32_t frequency_hz, void (* callback)(uint32_t channel))	
Description	A compare match interrupt to a CMT channel will occur in the interval specified with the argument. A callback function specified by the ‘callback’ will be called when this interrupt occurs. Counting operation will continue even after occurrence of an interrupt. Call the periodic event stop function to cease the periodic events started by this function.	
Arguments	uint32_t channel	Specifies a CMT channel where periodic events will occur. Range: 0 to 3
	uint32_t frequency_hz	Specifies interval of events in units of Hz.
	void (* callback)(uint32_t channel)	Pointer to a callback function to be executed on occurrence of a compare match interrupt on the CMT channel.
Return values	Returns the result of periodic event setting. CMT_SECCESS: Success CMT_ERR: Failure	
Remarks	Before calling this function, initialize the CMT channel with the CMT channel initialization function.	

6.8.5 R_CMT_CreateOneShot

R_CMT_CreateOneShot		
Synopsis	One-shot event processing	
Header	r_cmt.h	
Declaration	int32_t R_CMT_CreateOneShot(uint32_t channel, uint32_t period_us, void (* callback)(uint32_t channel))	
Description	Causes a compare match interrupt on a CMT channel when the period specified with an argument elapses. The callback function specified with 'callback' argument will be called on occurrence of the interrupt. The counting operation will be stopped after issuance of the interrupt.	
Arguments	uint32_t channel	Specifies a CMT channel where periodic events will occur. Range: 0 to 3
	uint32_t period_us	Specifies interval of events in units of microseconds. (Unit: µSecond)
	void (* callback)(uint32_t channel)	Pointer to a callback function to be executed on occurrence of a compare match interrupt on the CMT channel.
Return values	Returns the result of one-shot event setting. CMT_SECCESS: Success CMT_ERR: Failure	
Remarks	Before calling this function, initialize the CMT channel with the CMT channel initialization function.	

6.8.6 R_CMT_Stop

R_CMT_Stop		
Synopsis	Shutdown of CMT operation	
Header	r_cmt.h	
Declaration	int32_t R_CMT_Stop(uint32_t channel)	
Description	Stops a CMT channel operation started by periodic or one-shot event processing.	
Arguments	uint32_t channel	Specifies a CMT channel to shut down. Range: 0 to 3
Return values	Returns the result of the shutdown operation. CMT_SECCESS: Success CMT_ERR: Failure	
Remarks	Before calling this function, initialize the CMT channel with the CMT channel initialization function.	

6.8.7 blink_led

blink_led		
Synopsis	LED Flashing	
Declaration	static void blink_led (uint32_t channel)	
Description	A callback function called when a compare match interrupt occurs. This function turns an LED on and off on the channel specified by an argument.	
Arguments	uint32_t channel	Specifies a CMT channel to shut down. Range: 0 to 3
Return values	None	
Remarks	None	

6.8.8 cmt0_isr

cmt0_isr	
Synopsis	CMI0 interrupt processing
Declaration	void cmt0_isr (void)
Description	Calls the callback function to reverse LED10 output.
Arguments	None
Return values	None
Remarks	None

6.8.9 cmt1_isr

cmt1_isr	
Synopsis	CMI1 interrupt processing
Declaration	void cmt1_isr (void)
Description	Calls the callback function to reverse LED8 output.
Arguments	None
Return values	None
Remarks	None

6.9 Flowcharts

6.9.1 Main Processing

Figure 6.2 shows a flowchart of the main processing

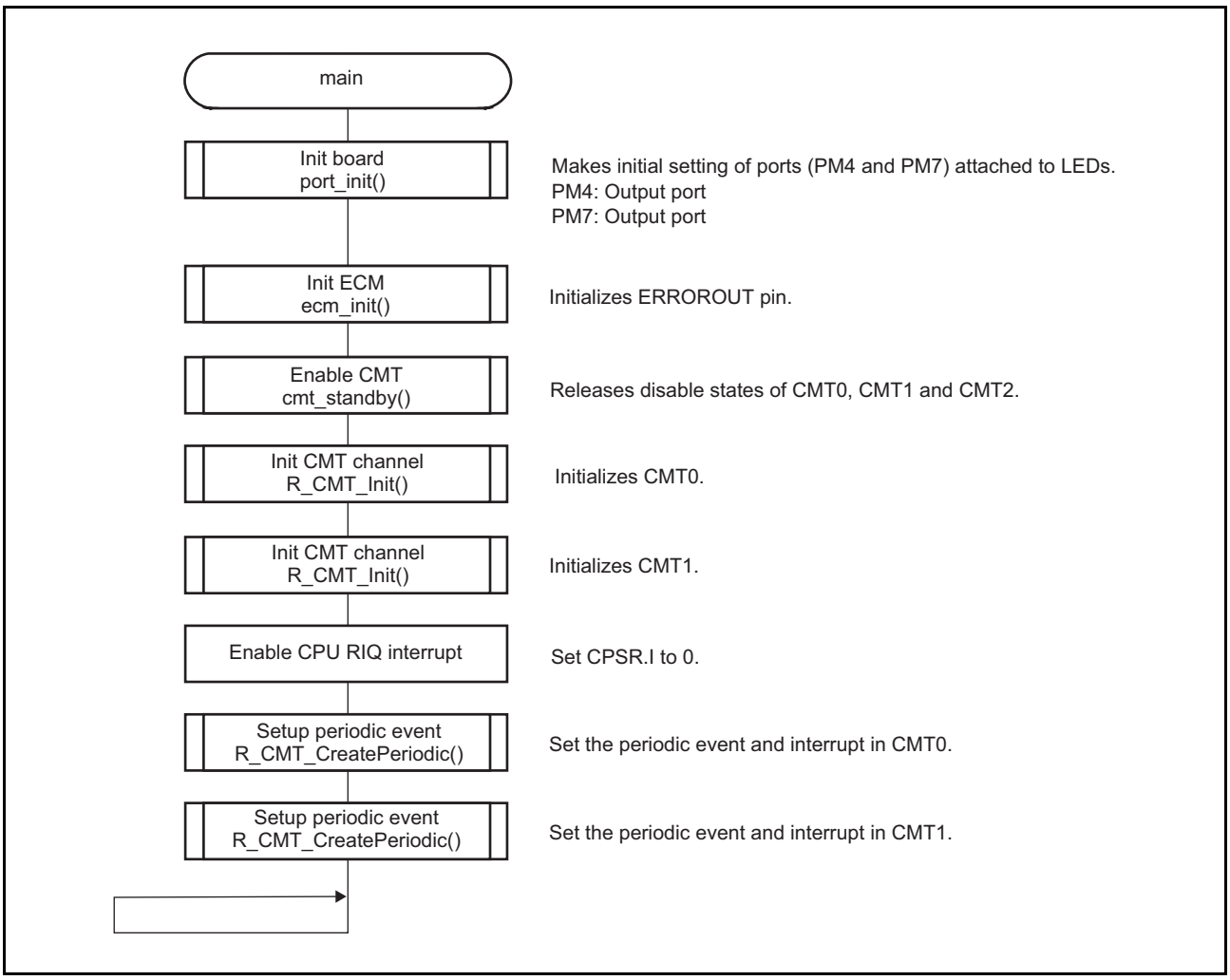


Figure 6.2 Main processing

6.9.2 CMT Module Shutdown Release

Figure 6.3 shows a flowchart of CMT module shutdown release processing.

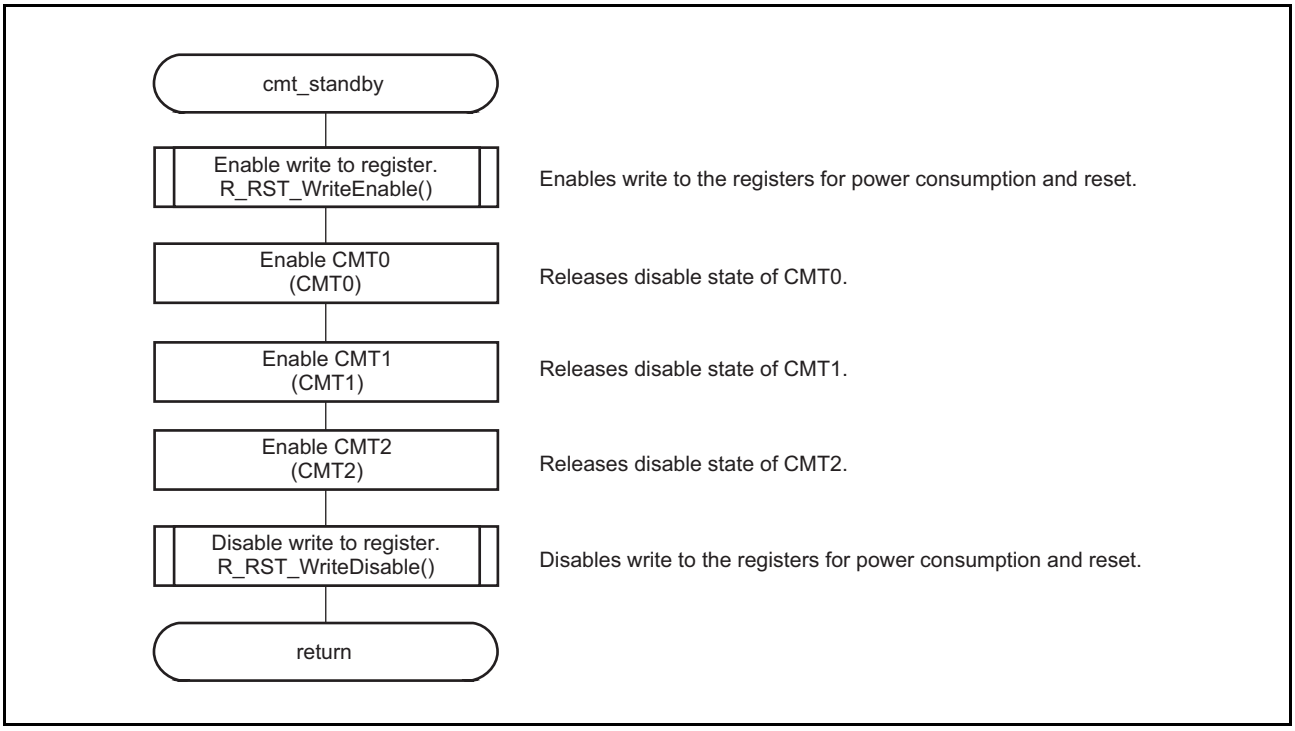


Figure 6.3 CMT module shutdown release

6.9.3 CMT Channel Initialization

Figure 6.4 shows a flowchart of CMT channel initialization.

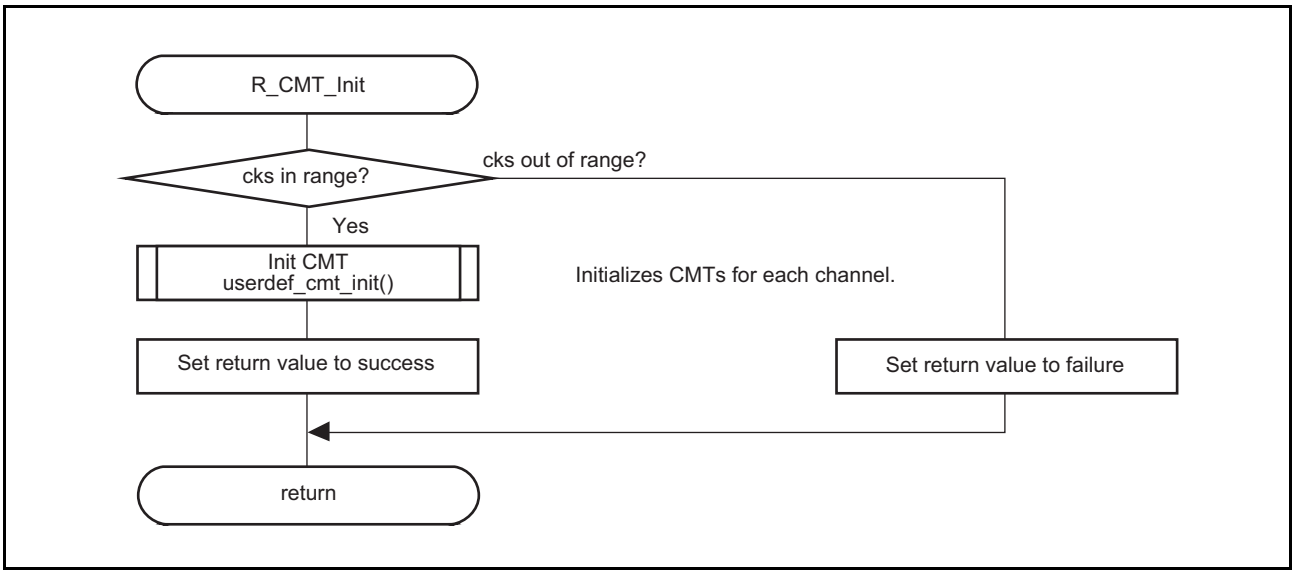


Figure 6.4 CMT channel initialization

6.9.4 Periodic Event Setting

Figure 6.5 shows a flowchart of periodic event setting.

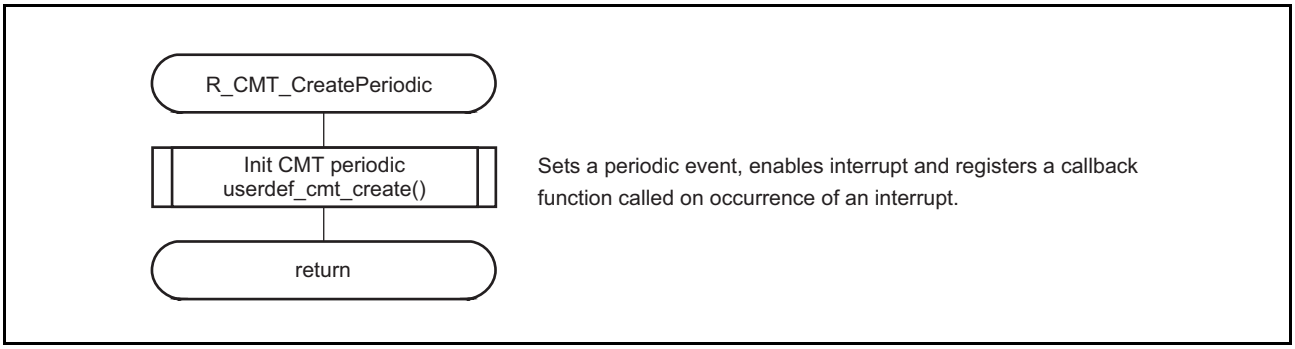


Figure 6.5 Periodic Event Setting

6.9.5 One-Shot Event Setting

Figure 6.6 shows a flowchart of one-shot event processing.

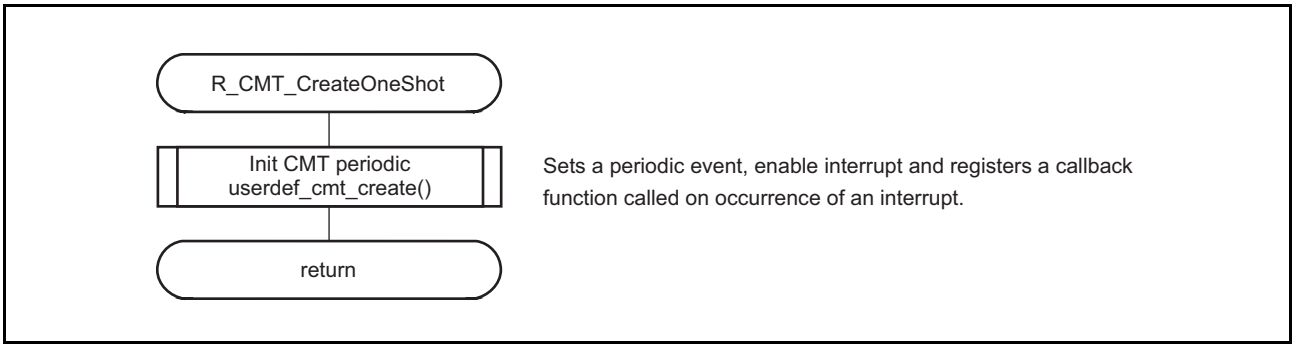


Figure 6.6 One-shot event setting

6.9.6 CMT Shutdown

Figure 6.7 shows a flowchart of CMT shutdown processing.

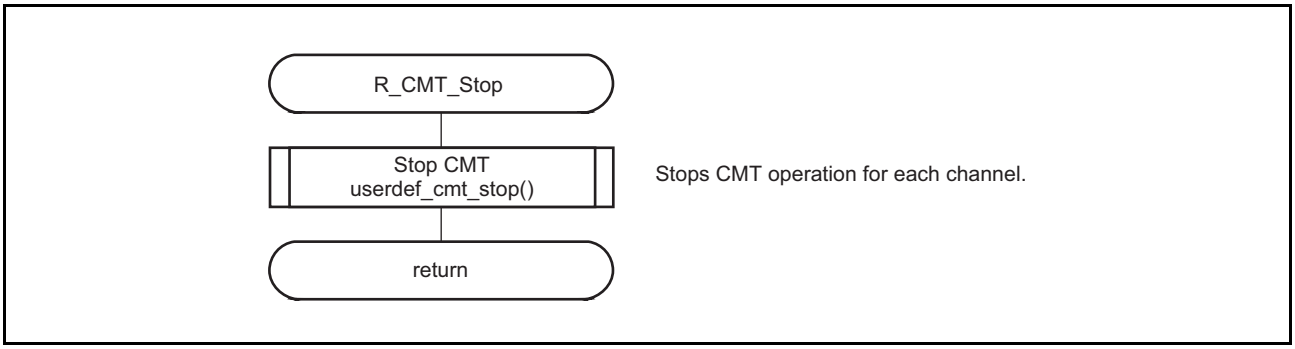


Figure 6.7 CMT shutdown

6.9.7 CMI0 Interrupt Processing

Figure 6.8 shows a flowchart of CMI0 interrupt processing.

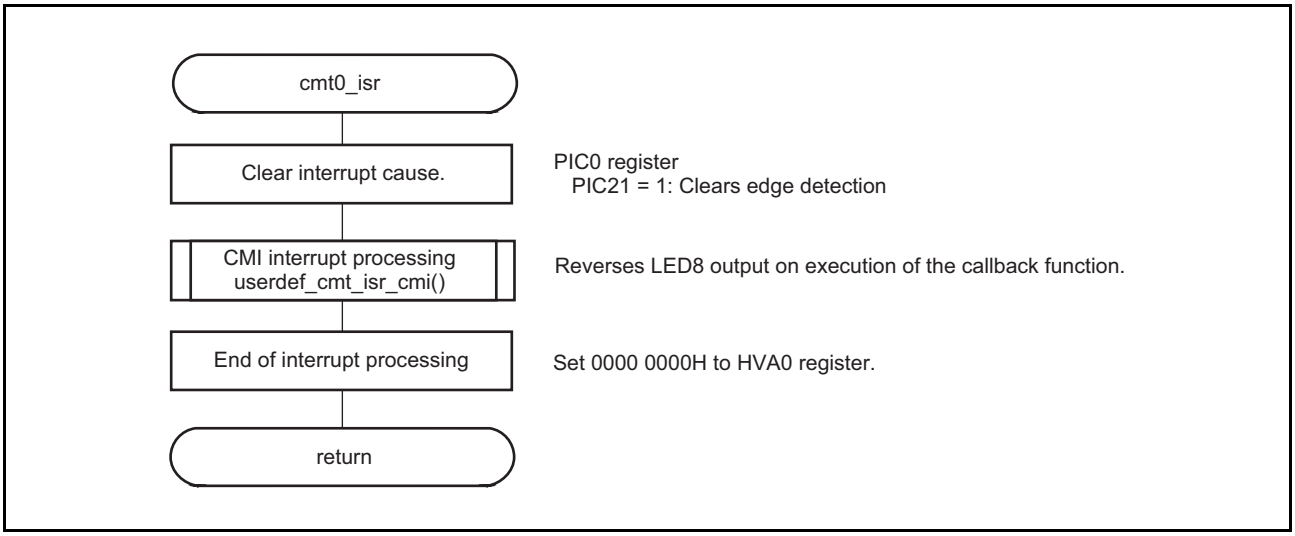


Figure 6.8 CMI0 Interrupt Processing

6.9.8 CMI1 Interrupt Processing

Figure 6.9 shows a flowchart of CMI1 interrupt processing.

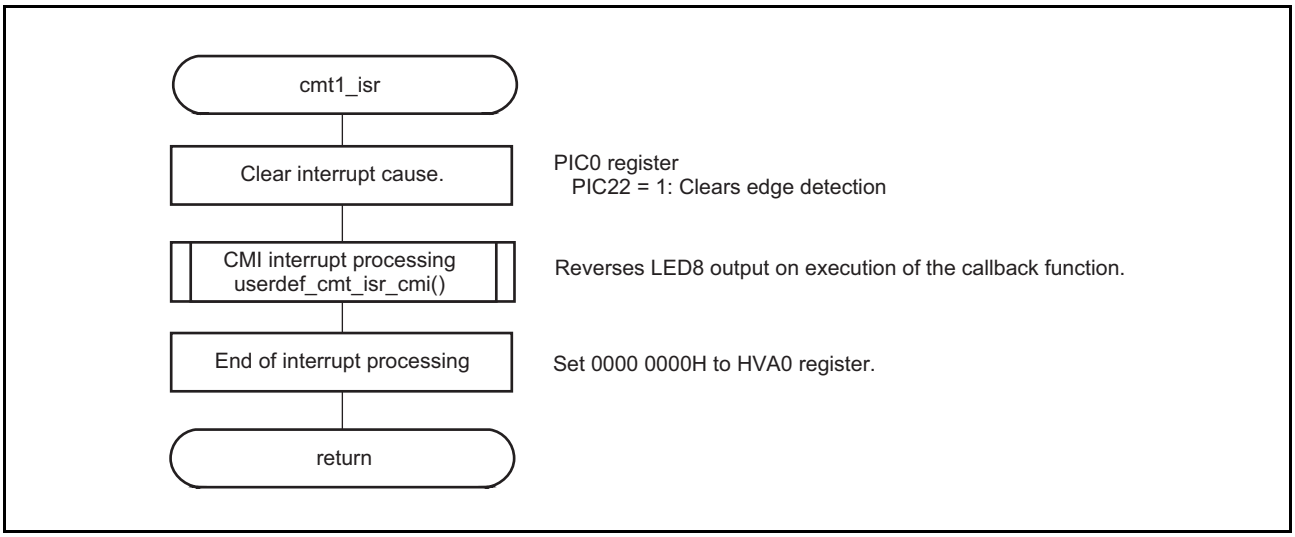


Figure 6.9 CMI1 Interrupt Processing

7. Sample Program

Download the sample program from the Renesas Electronics website.

8. Related Documents

- User’s Manual: Hardware
  RZ/T1 Group User’s Manual: Hardware
  (Download the latest version from the Renesas Electronics website.)

  RZ/T1 Evaluation Board: RTK7910022C00000BR User's Manual
  (Download the latest version from the Renesas Electronics website.)

- Technical Update / Technical News
  (Download the latest version from the Renesas Electronics website.)

- User's Manual: Development Environment
  IAR Embedded Workbench® for Arm
  (Download the latest version from the IAR website.)

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Renesas Electronics website

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Revision History	Application Note: Compare Match Timer (CMT)

Rev.	Date	Description	
		Page	Summary
0.20	Mar. 27, 2015	—	First Edition issued
1.00	Apr. 10, 2015	—	Only the revision number was changed to be posted on a website.
1.10	Aug. 18, 2015	2. Operating Environment	
		5	Table 2.1 Operating Environment: Integrated Development Environment, partially amended and added
		6. Software	
		10	6.2.4 Required Memory Size: Description and reference added
		10	Table 6.2: Table title and size description were partially amended
		11	Table 6.3 added
		11	Table 6.4 added
1.20	Dec. 04, 2015	2. Operating Environment	
		5	Table 2.1 Operating Environment: Integrated Development Environment, information partially amended
1.30	Apr. 05, 2017	2. Operating Environment	
		5	Table 2.1 Operating Environment: Integrated Development Environment, modified
		6. Software	
		—	6.2.4 Required Memory Size, deleted
1.40	Jun. 07, 2018	2. Operating Environment	
		5	Table 2.1 Operating Environment: The description on the integrated development environment, modified
		5. Hardware	
		8	Figure 5.1 Hardware configuration example: The name of module, modified
		6. Software	
		12	Table 6.7 Functions: The name of function, modified
		16	6.8.7 brink_led: The name of function, modified
		8. Related Documents	
		22	The name of IAR Embedded Workbench, modified

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. 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 Microprocessing unit or Microcontroller unit products 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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