RX63T Group

Effect of Using Double Data Registers in Single-Shunt Current Detection

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Introduction

This application note describes the effect of using double data registers when using the 12-bit A/D converter (S12ADB) provided by the RX63T Group microcontrollers.

Target Device

RX63T Group

Contents

1. Specifications

Figure 1.1 shows the usage example described in this application note. This application note assumes a motor control board that uses the single-shunt current detection method and describes an example of system setup that uses A/D detection timing synchronized with the PWM output. This example uses the extended operation performed when the 12-bit A/D converter (S12ADB) double trigger mode is selected and sets up two separate A/D detection timing factors that are synchronized with the PWM output. When these two set factors occur, an A/D conversion can be performed, and voltage detection is implemented with a single analog input pin by shifting the A/D detection timing for each of these factors independently.

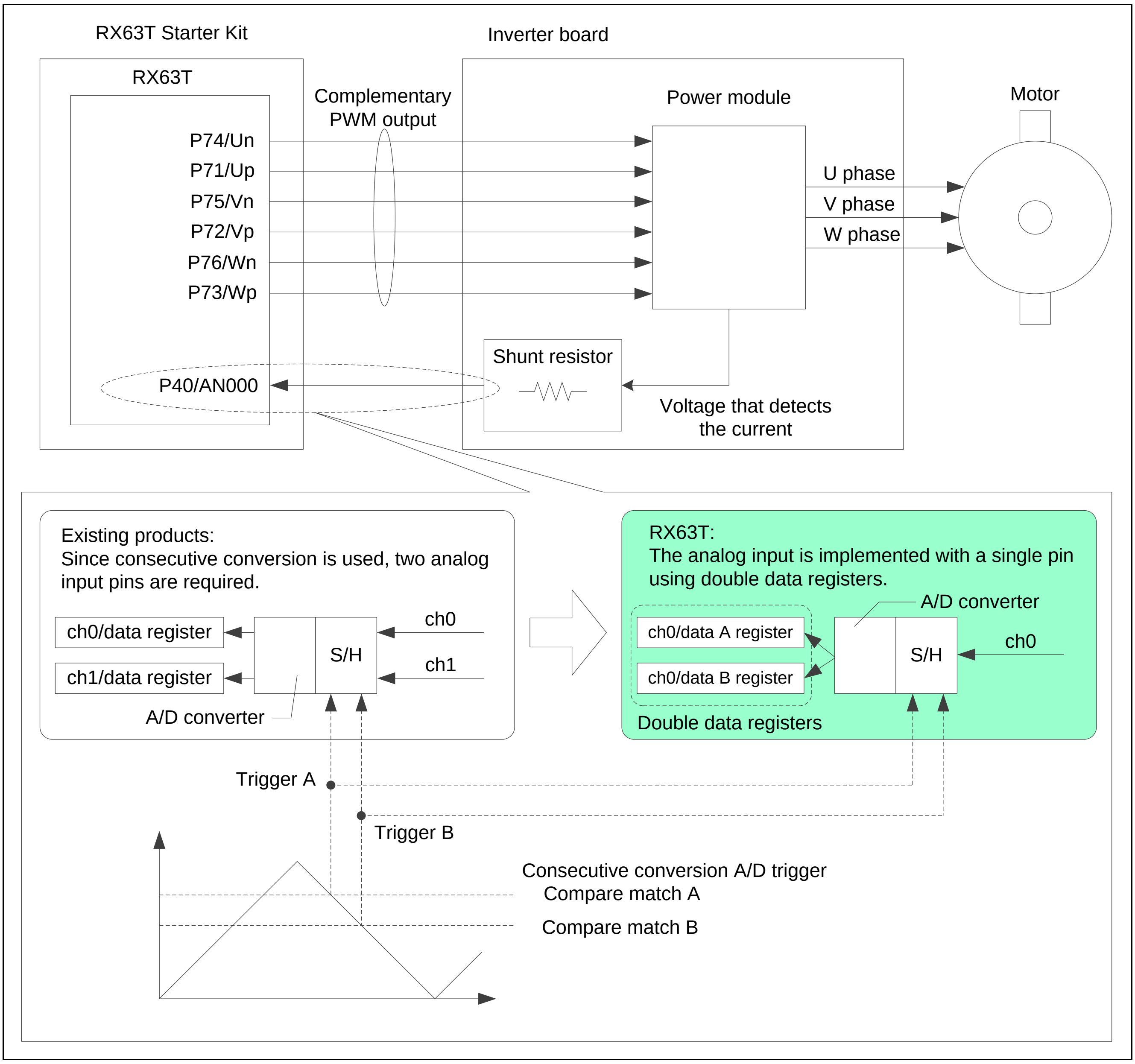

Figure 1.1 Usage Example

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	R5F563T6EDFM (RX63T Group)
Operating frequency	Main clock: 16.0 MHz PLL: 192 MHz (main clock divided by 1 and multiplied by 12) System clock (ICLK): 96 MHz (PLL divided by 2) Timer module clock (PCLKA): 96 MHz (PLL divided by 2) Peripheral module clock B (PCLKB): 48 MHz (PLL divided by 4) S12AD clock (PCLKD): 48 MHz (PLL divided by 4) Flash IF clock (FCLK): 48 MHz (PLL divided by 4)
Operating voltage	3.3 V
Integrated development environment	Renesas Electronics High-performance Embedded Workshop Version 4.09.01.007
C compiler	Renesas Electronics RX Standard Toolchain Version 1.2.1.0
	Compiler options (The integrated development environment default settings are used.)
iodefine.h version	2.00
Endian	Little endian
Operating mode	Single-chip mode
Processor mode	Supervisor mode
Sample code version	Version 1.00
Board used	Renesas Starter Kit+ for RX63T (Product No. R0K50563TS000BE)

3. Hardware

3.1 Pins Used

Table 3.1 lists the pins used and their functions.

Table 3.1 Pins Used and Their Functions

Pin Name	I/O	Function
P71/MTIOC3B	Output	PWM output 1 (Positive phase waveform)
P74/MTIOC3D	Output	PWM output 1’ (Reverse phase waveform)
P72/MTIOC4A	Output	PWM output 2 (Positive phase waveform)
P75/MTIOC4C	Output	PWM output 2’ (Reverse phase waveform)
P73/MTIOC4B	Output	PWM output 3 (Positive phase waveform)
P76/MTIOC4D	Output	PWM output 3’ (Reverse phase waveform)
P33/MTIOC3A	Output	Toggle output synchronized with the PWM output
P40/AN000	Input	Analog input pin

4. Software

4.1 Operation Overview

Multifunction timer unit 3 (MTU3) is set to complementary PWM mode. The 12-bit A/D converter (S12ADB) is activated in synchronization with this complementary PWM and the shunt current is monitored with the AN000 pin. Figure 4.1 shows an example of this operation. Applications should be set up so that A/D conversion completes before the carrier trough interrupt processing is performed.

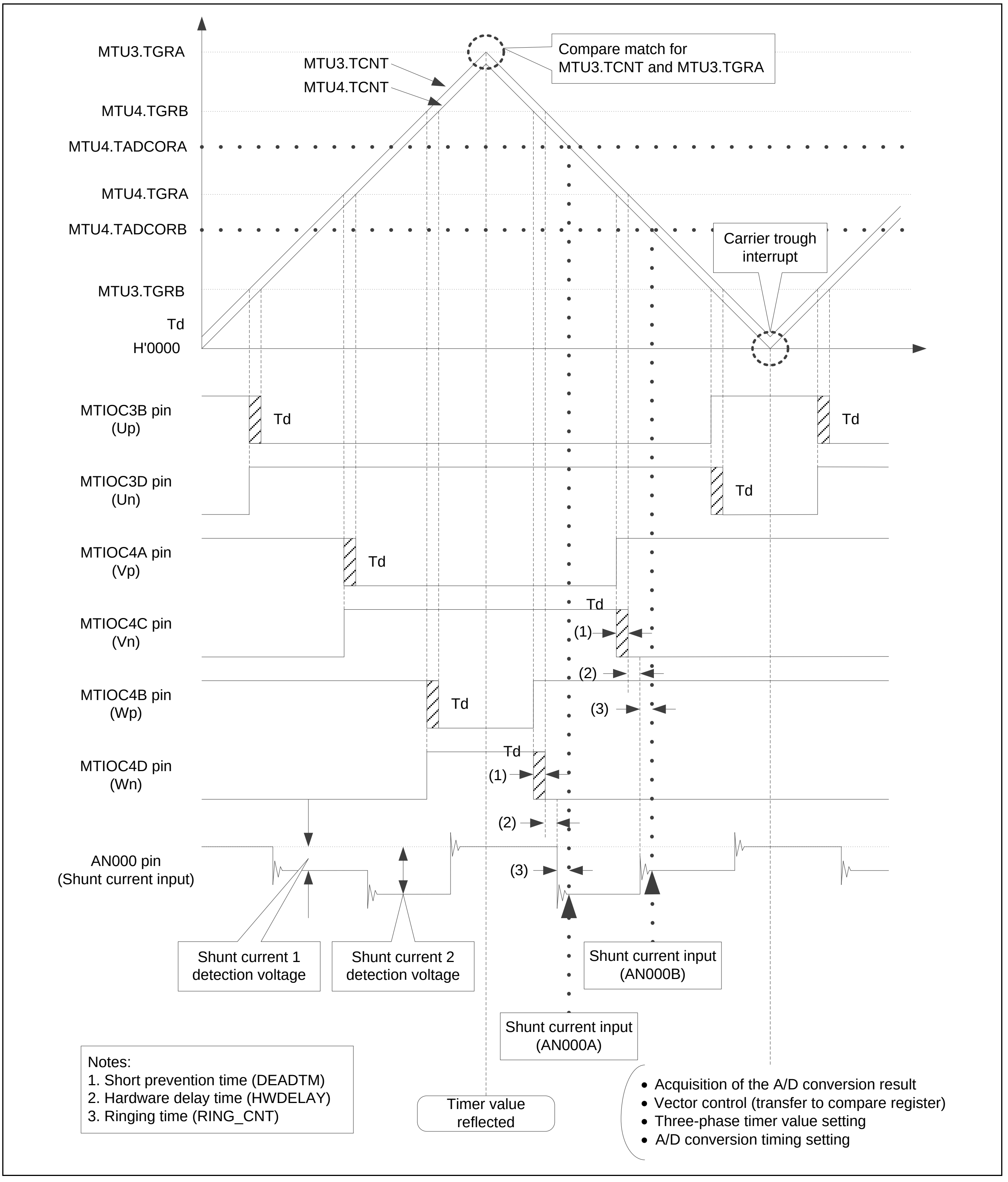

Figure 4.1 Sample Operation

4.2 File Composition

Table 4.1 lists the files used in the sample code. Note that of the files automatically generated by the integrated development environment, those whose contents are not changed are not shown here.

Table 4.1 Files Used in the Sample Code

File Name	Outline	Remarks
r_init_stop_module.h	RX63T Group Sample initialization program	See the application note that describes the RX63T initialization example for details.
r_init_stop_module.c		
r_init_clock.h		
r_init_clock.c		
r_init_non_existent_port.h		
r_init_non_existent_port.c		
intprg.c	Vector function definitions Comparator interrupt functions added	
main.c	Main processing, MTU3 initialization, S12ADB initialization, ICU initialization, TCIV4 interrupt handler	

4.3 Option-Setting Memory

Table 4.2 lists the option-setting memory configured in the sample code. When necessary, set a value suited to the user system.

Table 4.2 Option-Setting Memory Configured in the Sample Code

Symbol	Address	Setting Value	Contents
OFS0	FFFF FF8Fh to FFFF FF8Ch	FFFF FFFFh	After a reset, the IWDT is stopped. After a reset, the WDT is stopped.
OFS1	FFFF FF8Bh to FFFF FF88h	FFFF FFFFh	After a reset, voltage monitoring reset 0 is ignored.
MDES*[1]	FFFF FF83h to FFFF FF80h		(In single-chip mode)
		FFFF FFFFh	Little endian
		FFFF FFF8h	Big endian

Note: 1. The settings in this sample code set up little endian operation. See section 5.1, Endian, for details on switching the endian mode.

4.4 Constants

Table 4.3 lists the constants used in the sample code.

Table 4.3 Constants Used in the Sample Code

Constant Name	Setting Value	Contents
ADC_NUM	10	Number of A/D conversion result storage buffers
PWM_DEAD_TIME	01DFh	Dead time
CARRIER_1_2CYCLE	257Fh	One half the carrier period
PWM_DUTY3D	0B3Fh	PWM1 output timing
PWM_DUTY4C	12BFh	PWM2 output timing
PWM_DUTY4D	1A3Fh	PWM3 output timing
AD_START_A	5	A/D conversion start trigger timing generation constant
AD_START_B	15	A/D conversion start trigger timing generation constant
PWM_CHANGE_VAL	0010h	Constant used to control PWM output changes

4.5 VARIABLES

Figure 4.4 lists the static variables.

Table 4.4 static Variables

Type	Variable Name	Contents	Function Used
uint16_t	g_adc_dataA[ADC_NUM]	Storage for the result of the A/D conversion activated by trigger A	tciv4_interrupt
uint16_t	g_adc_dataB[ADC_NUM]	Storage for the result of the A/D conversion activated by trigger B	
uint16_t	g_du_val	Output timing setting for the PWM1 output (Sets MTU3.TGRD)	main, mtu_init, tciv4_interrupt
uint16_t	g_dv_val	Output timing setting for the PWM2 output (Sets MTU4.TGRC)	
uint16_t	g_dw_val	Output timing setting for the PWM3 output (Sets MTU4.TGRD)	

4.6 Functions

Table 4.5 lists the functions.

Table 4.5 Functions

Function Name	Outline
main	Main processing
icu_init	ICU initialization function
mtu_init	MTU3 initialization function
s12ad_init	S12AD initialization function
mpc_init	MPC initial settings function
pmr_init	PMR initial settings function
tciv4_interrupt	TCIV4 interrupt function

4.7 Function Specifications

The following tables list the sample code function specifications.

main

Outline Main processing

Header None

Declaration void main(void)

Description This function performs the following processing.

- Setup for transition to the module stop state
- Initialization for ports that do not exist (64-pin package products)
- Clock setup
  (System clock (ICLK), timer module clock (PCLKA), peripheral module clock (PCLKB), and S12AD clock (PCLKD))
- MTU3 initialization
- S12AD initialization
- MPC initialization
- PMR initialization
- ICU initialization
- Starting the MTU3 channel 3 and 4 counter

Arguments None

Return Value None

icu_init

Outline ICU initialization function

Header None

Declaration static void icu_init(void)

Description This function performs the following processing.

- Clearing the TCIV4 interrupt request flag
- Setting the TCIV4 interrupt priority level
- Enabling the TCIV4 interrupt

Arguments None

Return Value None

mtu_init	
Outline	MTU3 initialization function
Header	None
Declaration	static void mtu_init(void)
Description	This function performs the following processing. • Clearing the MTU3 module standby state • Stopping the MTU3 count output • Setting the MTU3 channel 3 and 4 counter clock • Setting the PWM period, the PWM1 to PWM3 duty ratio, the carrier period, and the dead time • Enabling the toggle output synchronized with the PWM period, setting the output level • Setting MTU3 channel 3 and 4 to complementary PWM mode • Enabling PWM waveform output • Enabling the MTU3 channel 4 overflow interrupt (This corresponds to the MTU4.TCNT underflow interrupt in complementary PWM mode.) • Setting the A/D conversion timing • Enabling the A/D conversion start requests (TRG4AN and TRG4BN) when MTU4.TCNT is incremented.
Arguments	None
Return Value	None

s12ad_init	
Outline	S12AD initialization function
Header	None
Declaration	static void s12ad_init(void)
Description	This function performs the following processing. • Clearing the S12AD module standby state • Setting trigger A to the MTU4.TCN and MTU4.TADCORA compare match • Setting trigger B to the MTU4.TCN and MTU4.TADCORB compare match • Setting the AN000 pin to be the A/D conversion target channel • Selecting double trigger mode and assigning the AN000 pin to the target channel. • Selecting A/D conversion start by the synchronous trigger (MTU3) • Setting up single cycle scan mode
Arguments	None
Return Value	None
Remarks	None

mpc_init	
Outline	MPC initial settings function
Header	None
Declaration	void mpc_gpt_init(void)
Description	The pins are set to the following functions using the MPC. • P76 → MTIOC4D • P75 → MTIOC4C • P74 → MTIOC3D • P73 → MTIOC4B • P72 → MTIOC4A • P71 → MTIOC3B • P33 → MTIOC3A • P40 → AN000
Arguments	None
Return Value	None
Remarks	None

pmr_init	
Outline	PMR initial settings function
Header	None
Declaration	void pmr_init(void)
Description	Initializes the PMR. • Ports P76, P75, P74, P73, P72, P71, and P33 are used as peripheral functions.
Arguments	None
Return Value	None
Remarks	The PMR bits corresponding to the analog input pins are used with the value 0 without change.

tciv4_interrupt	
Outline	TCIV4 interrupt function
Header	None
Declaration	void tciv4_interrupt(void)
Description	This function performs the following processing. • Clears the MTU3 channel 4 overflow flag. (In complementary PWM mode, this flag is set when the MTU4.TCNT register underflows.) • Updates the complementary PWM output timing. • Stores the A/D conversion result in RAM.
Arguments	None
Return Value	None
Remarks	None

4.8 Flowcharts

4.8.1 Main Processing

Figure 4.2 shows the main processing.

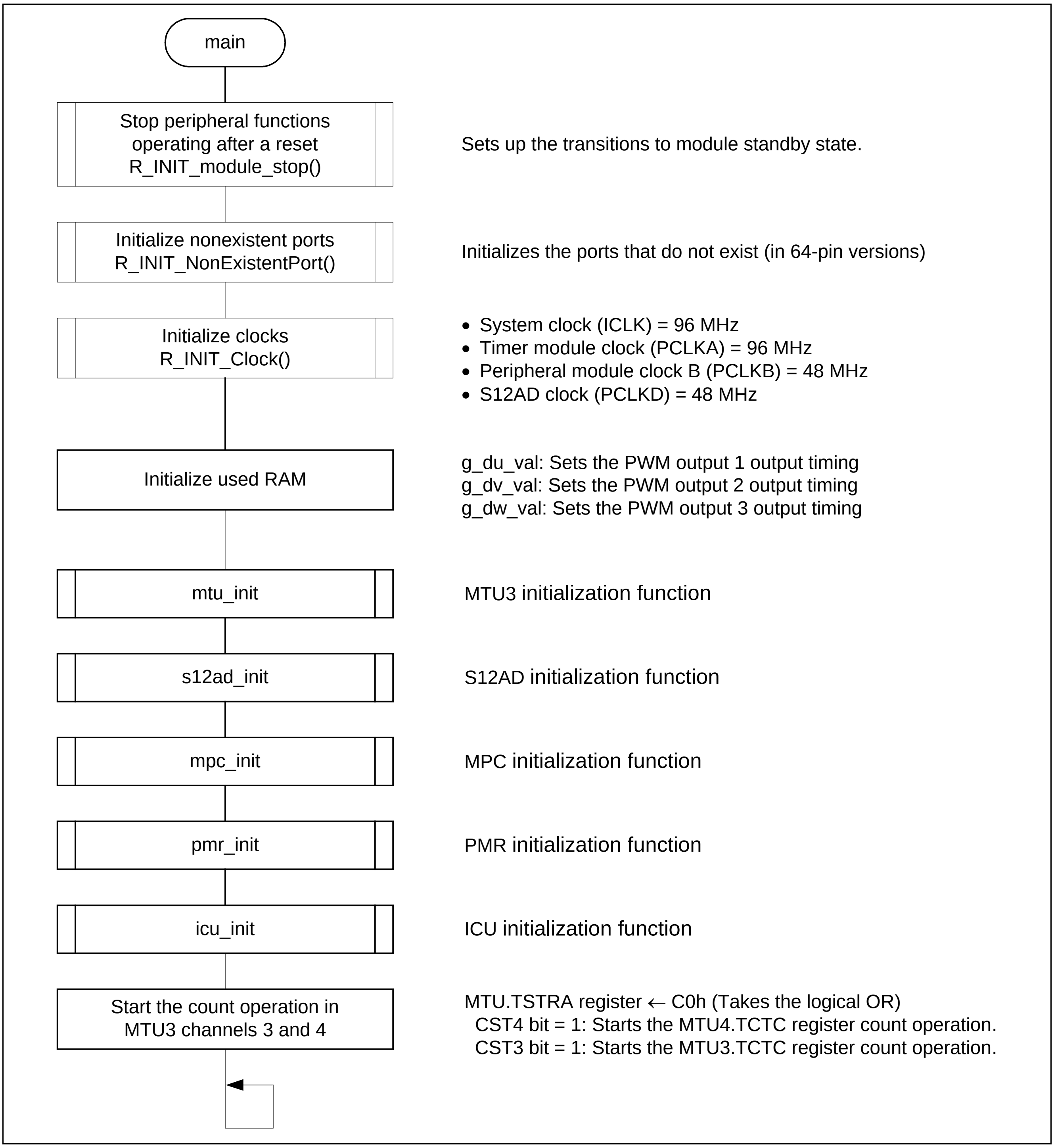

Figure 4.2 Main Processing

4.8.2 ICU Initialization Function

Figure 4.3 shows the flowchart for the ICU initialization function.

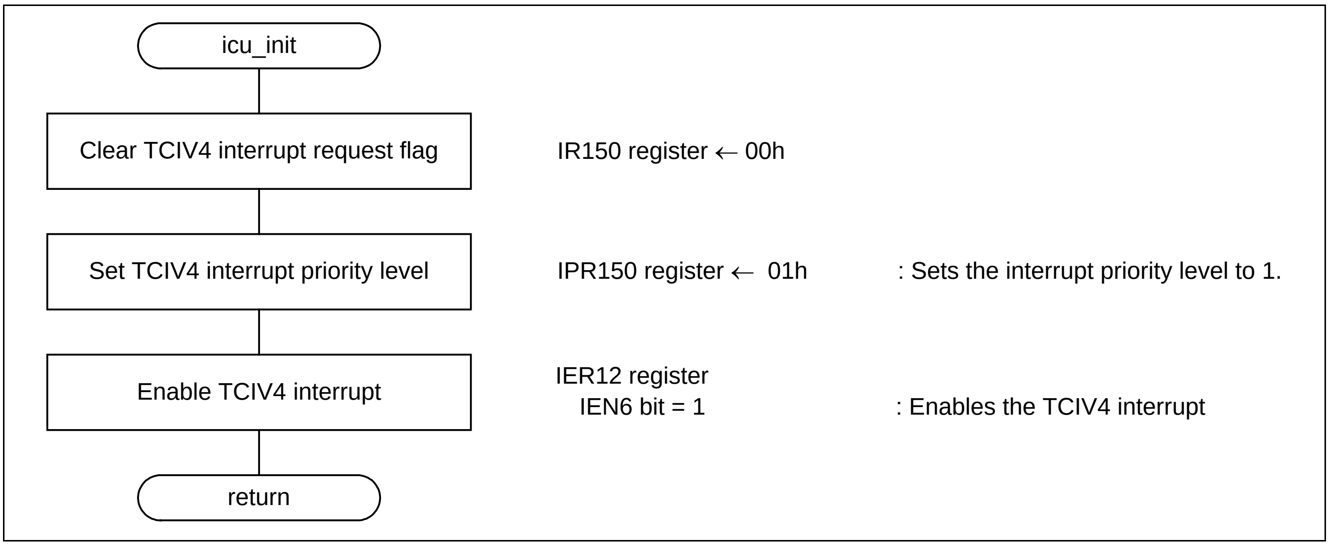

Figure 4.3 ICU Initialization Function

4.8.3 MTU3 Initialization Function

Figure 4.4 and figure 4.5 show the flowcharts for the MTU3 initialization function 1 and MTU3 initialization function 2.

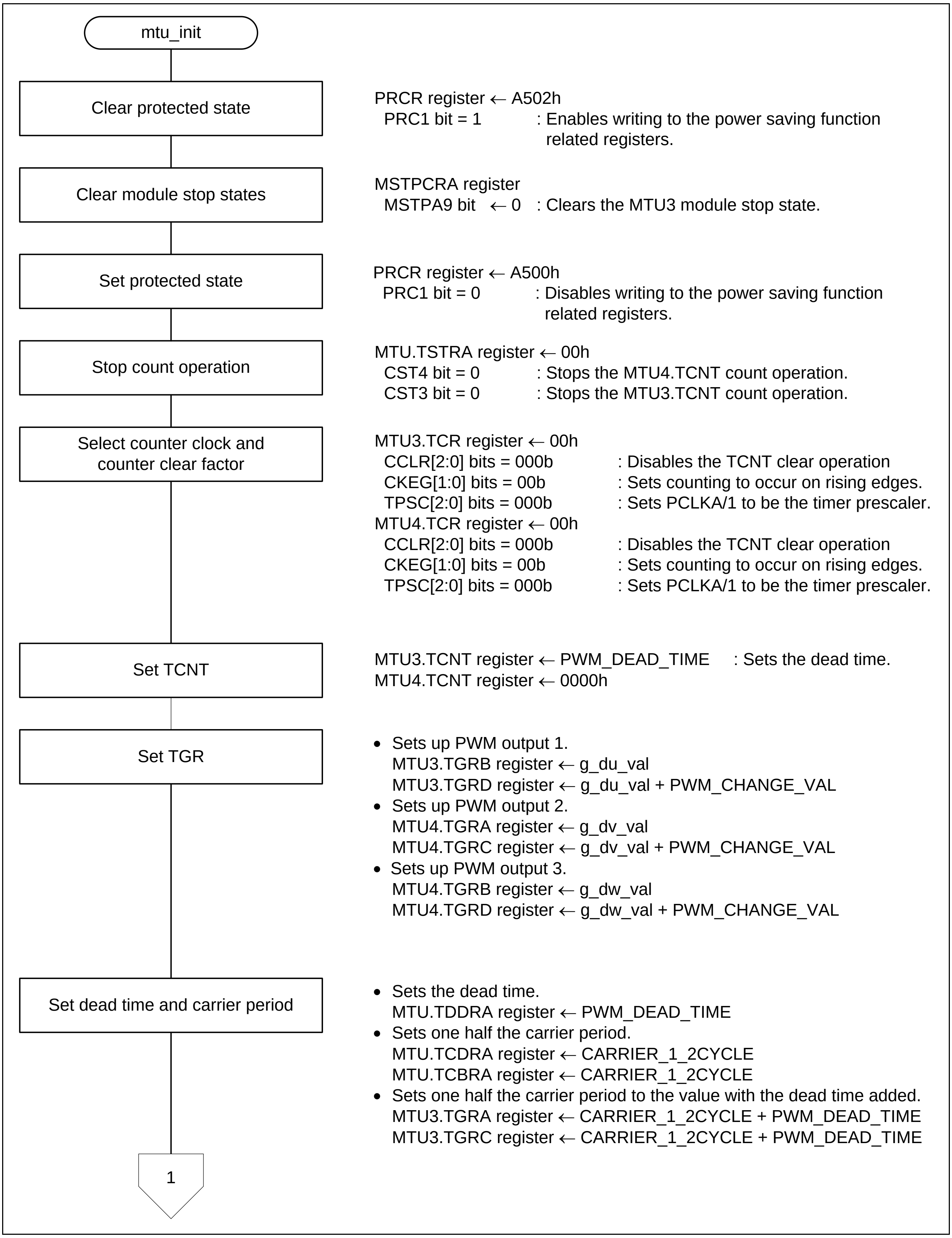

Figure 4.4 MTU3 Initialization Function 1

1

Enable PWM period output and set PWM output level

TOCR1A register ← 40h
- PSYE bit = 1 : Enable toggle output.
- TOCL bit = 0 : Enable writes to the TOCS, OLSN, and OLSP bits.
- TOCS bit = 0 : Enable setting TOCR1A.
- OLSN bit = 0 : Set the initial output to the high level, the active level to the low level, the increment compare match output to the high level, and the decrement compare match output to the low level.
- OLSP bit = 0 : Set the initial output to the high level, the active level to the low level, the increment compare match output to the low level, and the decrement compare match output to the high level.

Set up complementary PWM mode

MTU3.TMDR1 register ← 3Eh
- BFE bit = 0 : Sets MTU0.TGRE and MTU0.TGRF to normal operation.
- BFB bit = 1 : Sets the TGRB and TGRD registers to buffer operation.
- BFA bit = 1 : Sets the TGRA and TGRC registers to buffer operation.
- MD[3:0] bits = 1110b : Sets up complementary PWM mode 2 (transfer at the trough).

Enable waveform output

TOERA register ← FFh
- OE4D bit = 1 : Enables MTIOC4D pin output.
- OE4C bit = 1 : Enables MTIOC4C pin output.
- OE3D bit = 1 : Enables MTIOC3D pin output.
- OE4B bit = 1 : Enables MTIOC4B pin output.
- OE4A bit = 1 : Enables MTIOC4D pin output.
- OE3B bit = 1 : Enables MTIOC3B pin output.

Enable TCIV4 interrupt

MTU4.TIER register
- TGIEV bit = 1

Set A/D converter start request period

MTU4.TADCORA register ← CARRIER_1_2CYCLE - (PWM_DEAD_TIME × AD_START_A)
MTU4.TADCOBRA register ← CARRIER_1_2CYCLE - (PWM_DEAD_TIME × AD_START_A)
MTU4.TADCORB register ← CARRIER_1_2CYCLE - (PWM_DEAD_TIME × AD_START_B)
MTU4.TADCOBRB register ← CARRIER_1_2CYCLE - (PWM_DEAD_TIME × AD_START_B)

• Set period setting buffer register transfer timing
• Set A/D conversion start request

MTU4.TADCR register ← 80A0h
- BF[1:0] bits = 10b : Transfers the value from the period setting buffer register to the period setting register at the MTU4.TCNT trough.
- UT4AE bit = 1 : Enables the A/D conversion start request (TRG4AN) when MTU4.TCNT is incremented.
- UT4BE bit = 1 : Enables the A/D conversion start request (TRG4BN) when MTU4.TCNT is incremented.

return

Figure 4.5 MTU3 Initialization Function 2

4.8.4 S12AD Initialization Function

Figure 4.6 shows the flowchart for the S12AD initialization function.

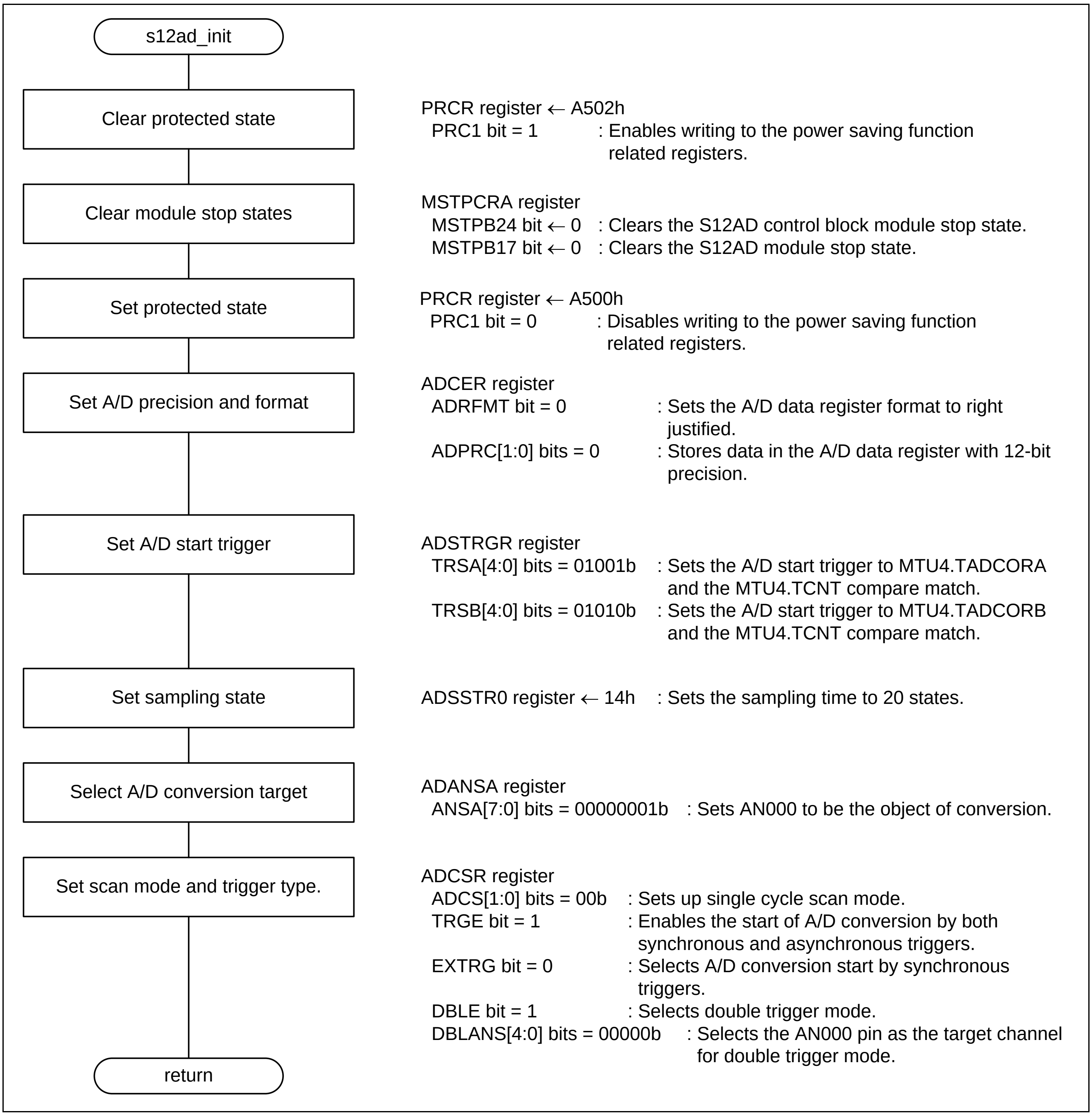

Figure 4.6 S12AD Initialization Function

4.8.5 MPC Initialization Function

Figure 4.7 shows the flowchart for the MPC initialization function.

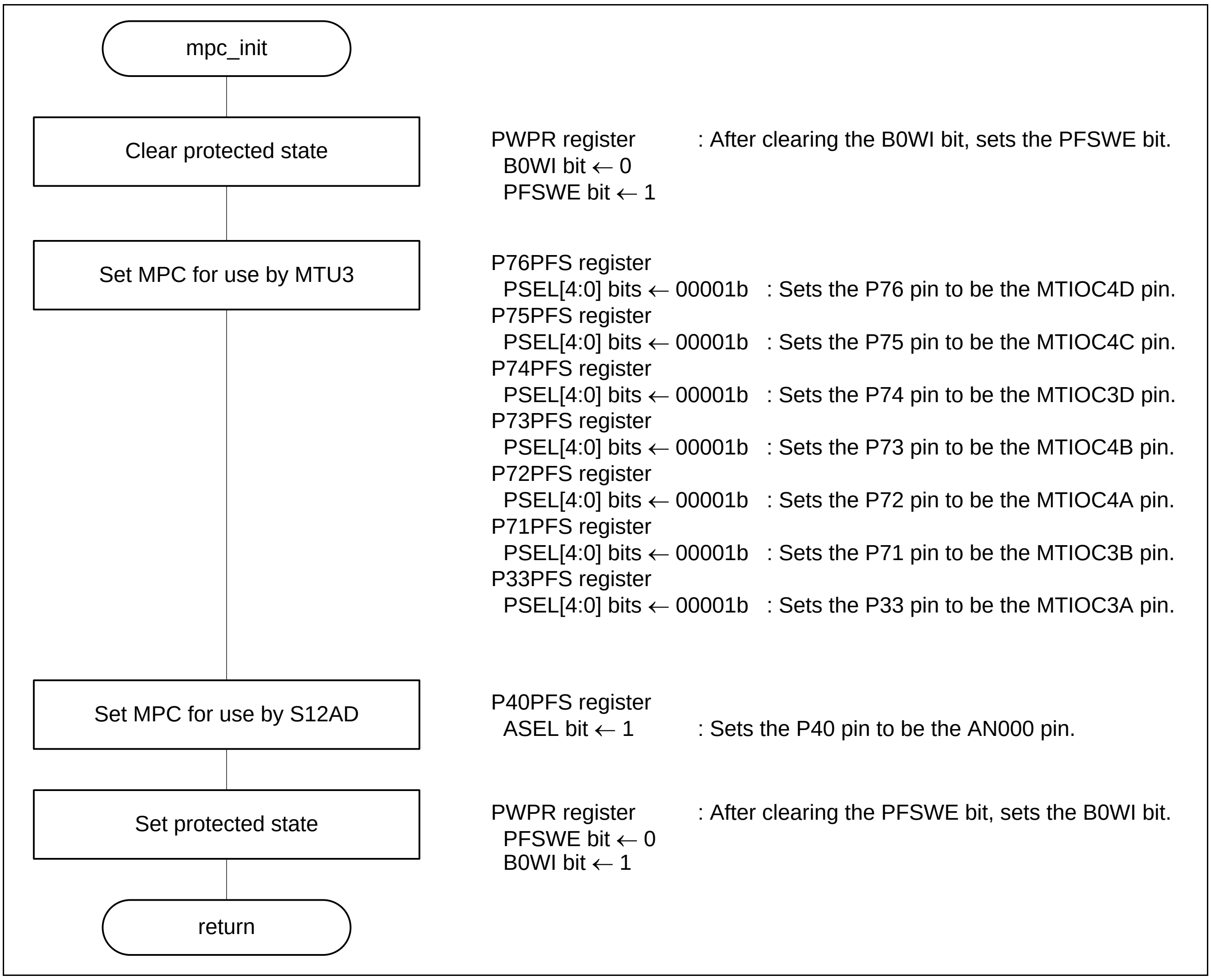

Figure 4.7 MPC Initialization Function

4.8.6 PMR Initialization Function

Figure 4.8 shows the flowchart for the PMR initialization function.

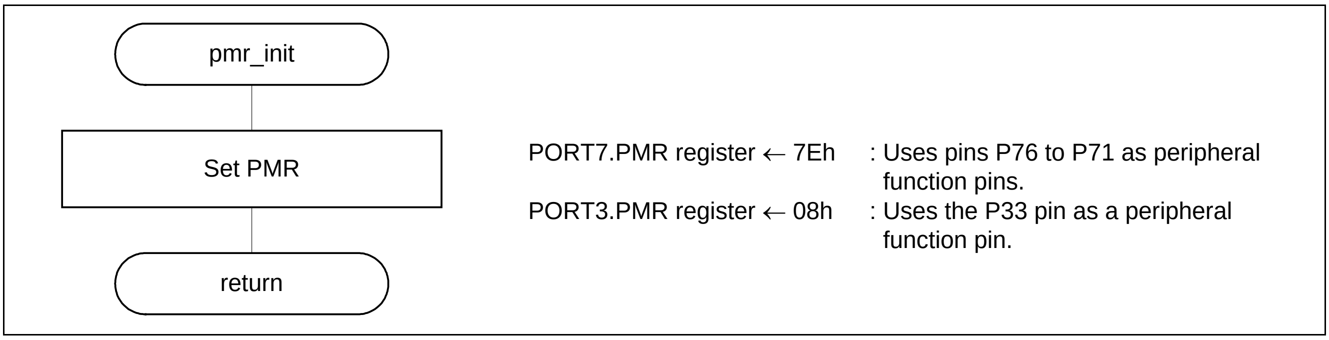

Figure 4.8 PMR Initialization Function

4.8.7 TCIV4 Interrupt Handler

Figure 4.9 shows the flowchart for the TCIV4 interrupt handler.

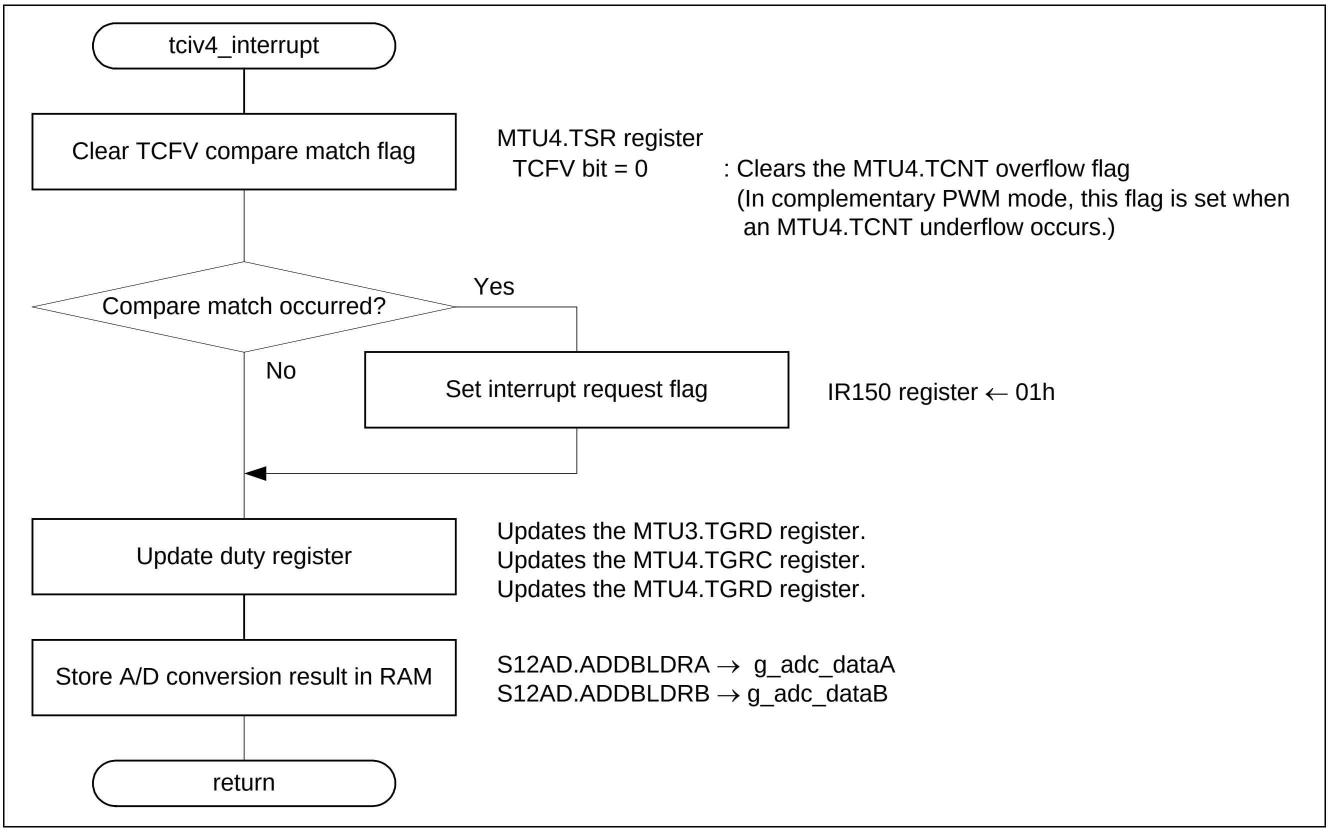

Figure 4.9 TCIV4 Interrupt Handler

5. Notes

5.1 Endian

The sample code provided with this application note supports both little endian and big endian operation.

5.1.1 When Using Little Endian

When operating in little endian mode, specify "little endian data" as the compiler option endian setting. The MDES setting shown in section 4.3, Operation-Setting Memory, is the value for little endian operation.

5.1.2 When Using Big Endian

When operating in big endian mode, specify "big endian data" as the compiler option endian setting. The MDES setting shown in section 4.3, Option-Setting Memory, is the value for big endian operation.

6. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

7. Reference Documents

User’s Manual: Hardware

RX63T Group User’s Manual: Hardware Rev.2.00
(The latest version can be downloaded from the Renesas Electronics website.)

Technical Update/Technical News

The content of the following technical data publication applies to this application note.

Document No.	Title
TN-RX*-A023A	Note on Using Multi-Function Timer Pulse Unit 3 (MTU3) Interrupts

(The latest version 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
(Including the documentation included with V.1.0.2)
(The latest version can be downloaded from the Renesas Electronics website.)

Application Note

RX63T Group Initialization Example Rev.1.00 (R01AN1252EJ0100)
(The latest version can be downloaded from the Renesas Electronics website.)

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Revision History

Rev.	Date	Description	
		Page	Summary
1.00	May. 14, 2014	—	First edition issued

General Precautions in the Handling of MPU/MCU Products

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1. Handling of Unused Pins
   Handle unused pins in accord 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.
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   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.
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