RX220 Group

A/D Conversion in Group Scan Mode with Double Trigger Mode

R01AN1714EJ0100
Rev. 1.00
Dec. 16, 2013

Abstract

This document describes A/D conversion using double trigger mode in the RX220 Group.

Products

- RX220 Group 100-pin package with a ROM size between 64 KB and 256 KB
- RX220 Group 64-pin package with a ROM size between 32 KB and 256 KB
- RX220 Group 48-pin package with a ROM size between 32 KB and 256 KB

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

In the sample code, A/D conversion is performed when the A/D conversion request from multi-function timer pulse unit 2a (MTU2a) is accepted. Group scan mode is used in the 12-bit A/D converter (S12ADb) to obtain A/D conversion values for groups A and B at different timings. Also double trigger mode is used to perform A/D conversion on one channel at different two timings and store the converted values in different registers (A/D data duplication register).

Table 1.1 lists the Peripheral Functions and Their Applications and Figure 1.1 shows the Operation Overview.

Table 1.1 Peripheral Functions and Their Applications

Peripheral Function	Application
S12ADb	A/D conversion
MTU2a	Generates the A/D conversion request and outputs a complementary PWM waveform.

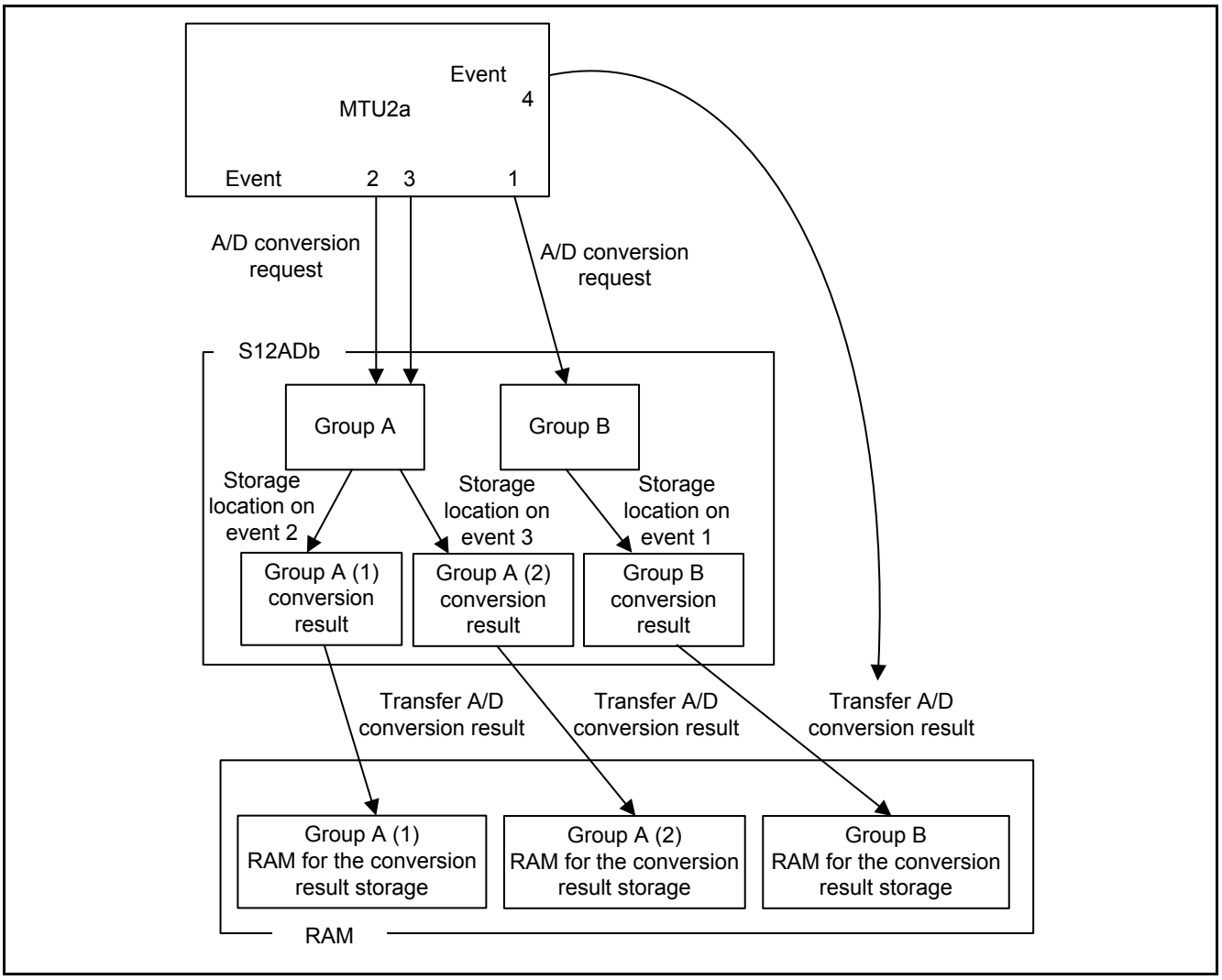

Figure 1.1 Operation Overview

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	R5F52206BDFP (RX220 Group)
Operating frequencies	- Main clock: 20 MHz - Sub-clock: 32.768 kHz - System clock (ICLK): 20 MHz (main clock divided by 1) - Peripheral module clock B (PCLKB): 20 MHz (main clock divided by 1)
Operating voltage	5.0 V
Integrated development environment	Renesas Electronics Corporation High-performance Embedded Workshop Version 4.09.01
C compiler	Renesas Electronics Corporation C/C++ Compiler Package for RX Family V.1.02 Release 01
	Compile options -cpu=rx200 -output=obj="$(CONFIGDIR)\$(FILELEAF).obj" -debug -nologo (The default setting is used in the integrated development environment.)
iodefine.h version	Version 1.0A
Endian	Little endian
Operating mode	Single-chip mode
Processor mode	Supervisor mode
Sample code version	Version 1.00
Board used	Renesas Starter Kit for RX220 (R0K505220S000BE)

3. Reference Application Note

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

- RX220 Group Initial Setting Rev.1.00 (R01AN1494EJ0100_RX220)

The initial setting functions in the reference application note are used in the sample code in this application note. The revision number of the reference application note is the one 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/MTIOC3A	Output	Toggle output synchronized with the PWM period
P17/MTIOC3B	Output	PWM output 1
P16/MTIOC3D	Output	PWM output 1' (a negative phase waveform that is in a non-overlapping relationship with PWM output 1)
PE2/MTIOC4A	Output	PWM output 2
PE1/MTIOC4C	Output	PWM output 2' (a negative phase waveform that is in a non-overlapping relationship with PWM output 2)
PE3/MTIOC4B	Output	PWM output 3
PE4/MTIOC4D	Output	PWM output 3' (a negative phase waveform that is in a non-overlapping relationship with PWM output 3)
P40/AN000	Input	A/D conversion of group A
P41/AN001	Input	A/D conversion of group B

5. Software

5.1 Operation Overview

The sample code performs A/D conversion using the MTU2a and S12ADb.

The MTU2a outputs a complementary PWM waveform with a 5 kHz carrier frequency and a 4 μs dead time. PWM 1, PWM 2, and PWM 3 outputs are the same signals.

The S12ADb performs A/D conversions in different timings for groups A and B using group scan mode.

Double trigger mode is used for group A and A/D conversion of AN000 is started on the compare match timing of MTU4.TCNT with MTU4.TADCORA or MTU4.TADCORB. For group B, A/D conversion of AN001 is started on the timing of the MTU4.TCNT underflow. The conversion result of each group is stored in the RAM by the compare match interrupt on the compare match timing between TGRA3 and MTU3.TCNT.

Figure 5.1 shows the Timing of MTUa Operation and A/D Conversion.

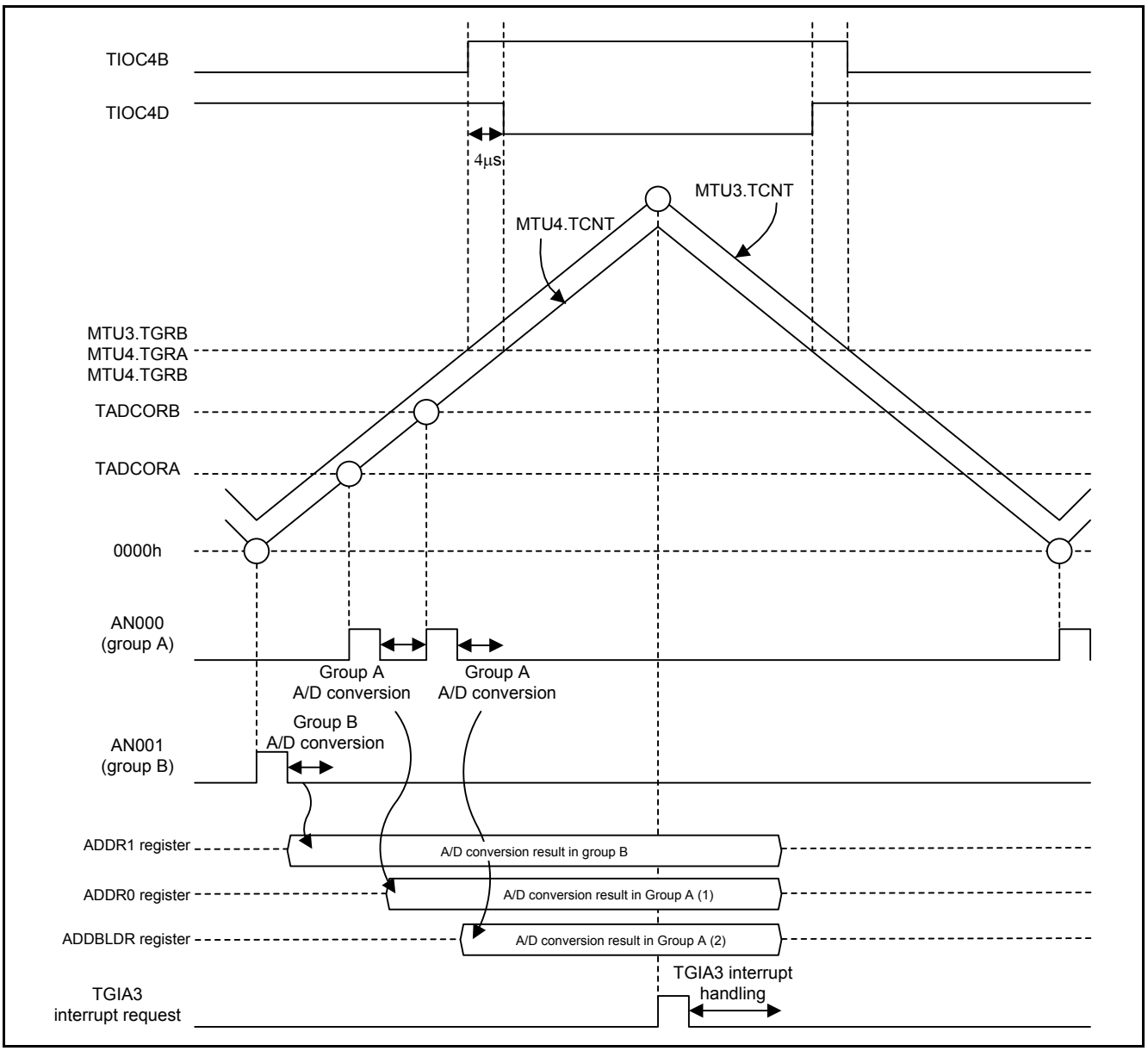

Figure 5.1 Timing of MTUa Operation and A/D Conversion

5.2 File Composition

Table 5.1 lists the Files Used in the Sample Code. Files generated by the integrated development environment are not included in this table.

Table 5.1 Files Used in the Sample Code

File Name	Outline	Remarks
main.c	Main processing including the MTU23_TGIA3 interrupt	
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	
intprg.c	Interrupt handling	MTU23_TGIA3 interrupt generated as default is deleted.

5.3 Option-Setting Memory

Table 5.2 lists the Option-Setting Memory Configured in the Sample Code. When necessary, set a value suited to the user system.

Table 5.2 Option-Setting Memory Configured in the Sample Code

Symbol	Address	Setting Value	Contents
OFS0	FFFF FF8Fh to FFFF FF8Ch	FFFF FFFFh	The IWDT is stopped after a reset.
OFS1	FFFF FF8Bh to FFFF FF88h	FFFF FFFFh	The voltage monitor 0 reset is disabled after a reset. HOCO oscillation is disabled after a reset.
MDES	FFFF FF83h to FFFF FF80h	FFFF FFFFh	Little endian

5.4 Constants

Table 5.3 lists the Constants Used in the Sample Code.

Table 5.3 Constants Used in the Sample Code

Constant Name	Setting Value	Contents
DEAD_TIME	20	Dead time (4 µs)
CYCLE	1000	Time for 1 carrier (200 µs)
C_CYCLE	CYCLE/2(500)	Time for 1/2 carrier (100 µs)
PUL_CYCLE	C_CYCLE+DEAD_TIME(520)	Time for 1/2 carrier + dead time

5.5 Variables

Table 5.4 lists the Global Variables.

Table 5.4 Global Variables

Type	Variable Name	Contents	Function Used
unsigned short	buf_an000a	Stores the A/D conversion result for group A on the compare match timing of MTU4.TCNT with TADCORA	TGIA3_INT
unsigned short	buf_an000b	Stores the A/D conversion result for group A on the compare match timing of MTU4.TCNT with TADCORB	TGIA3_INT
unsigned short	buf_an001	Stores the A/D conversion result for group B on the timing of the MTU4.TCNT underflow.	TGIA3_INT

5.6 Functions

Table 5.5 lists the Functions.

Table 5.5 Functions

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 function initialization
ad_init	S12ADb initialization
mtu_init	MTU2 initialization
Excep_MTU23_TGIA3	TGIA3 interrupt processing

5.7 Function Specifications

The following tables list the sample code function specifications.

main	
Outline	Main processing
Header	None
Declaration	void main(void)
Description	Performs initialization for ports, clocks, and peripheral functions.
Arguments	None
Return Value	None

port_init	
Outline	Port initialization
Header	None
Declaration	void port_init(void)
Description	Initializes 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	Configures 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. Refer to the RX220 Group Initial Setting Rev. 1.00 application note for details on this function.

R_INIT_NonExistentPort	
Outline	Nonexistent port initialization
Header	r_init_non_existent_port.h
Declaration	void R_INIT_NonExistentPort(void)
Description	Initializes 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. Refer to the RX220 Group Initial Setting Rev. 1.00 application note for details on this function.

R_INIT_Clock	
Outline	Clock initialization
Header	r_init_clock.h
Declaration	void R_INIT_Clock(void)
Description	Initializes the clock.
Arguments	None
Return Value	None
Remarks	The sample code selects processing which uses the main clock as the system clock without using the sub-clock. Refer to the RX220 Group Initial Setting Rev. 1.00 application note for details on this function.

peripheral_init	
Outline	Peripheral function initialization
Header	None
Declaration	void peripheral_init(void)
Description	Initializes peripheral functions used.
Arguments	None
Return Value	None

ad_init	
Outline	S12ADb initialization
Header	None
Declaration	void ad_init(void)
Description	Initializes S12ADb including settings for group scan mode and double trigger mode.
Arguments	None
Return Value	None

mtu_init	
Outline	MTU2 initialization
Header	None
Declaration	void mtu_init(void)
Description	Initializes MTU2 including settings for complementary PWM mode
Arguments	None
Return Value	None

Excep_MTU23_TGIA3	
Outline	TGIA3 interrupt handling
Header	None
Declaration	void Excep_MTU23_TGIA3(void)
Description	Obtains the A/D conversion result.
Arguments	None
Return Value	None

5.8 Flowcharts

5.8.1 Main Processing

Figure 5.2 shows the Main Processing.

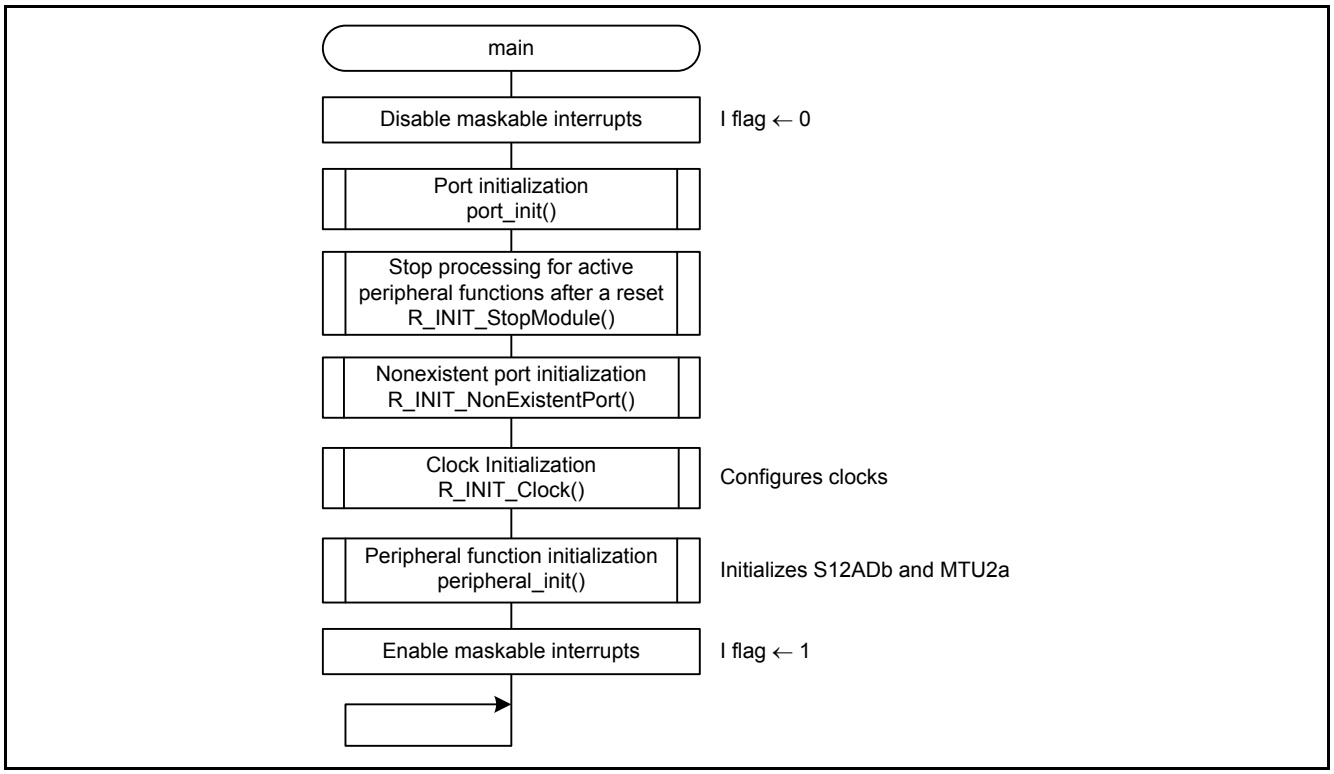

Figure 5.2 Main Processing

5.8.2 Port Initialization

Figure 5.3 shows the Port Initialization.

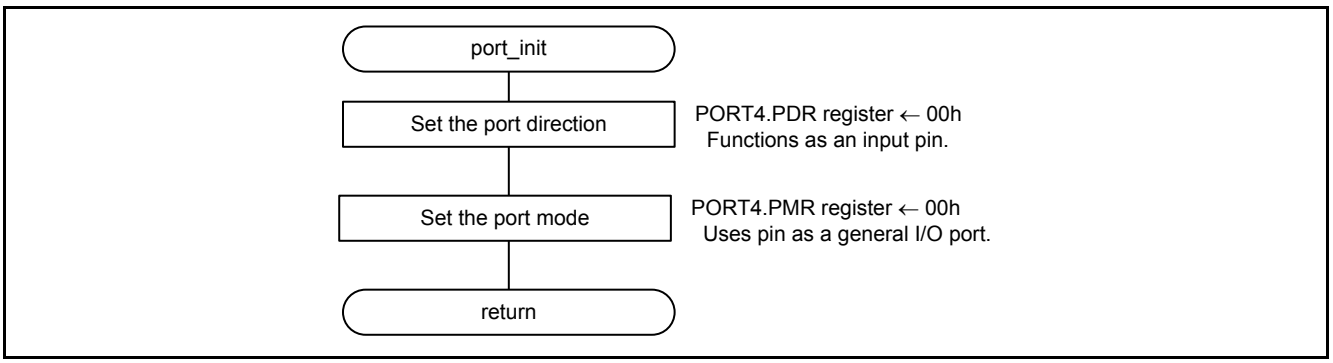

Figure 5.3 Port Initialization

5.8.3 Peripheral Function Initialization

Figure 5.4 shows the Peripheral Function Initialization.

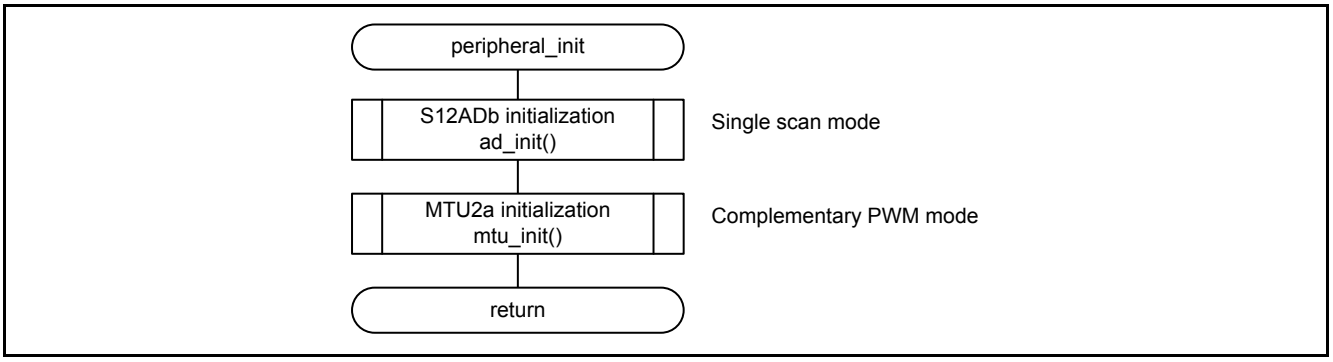

Figure 5.4 Peripheral Function Initialization

5.8.4 S12ADb Initialization

Figure 5.5 shows the S12ADb Initialization.

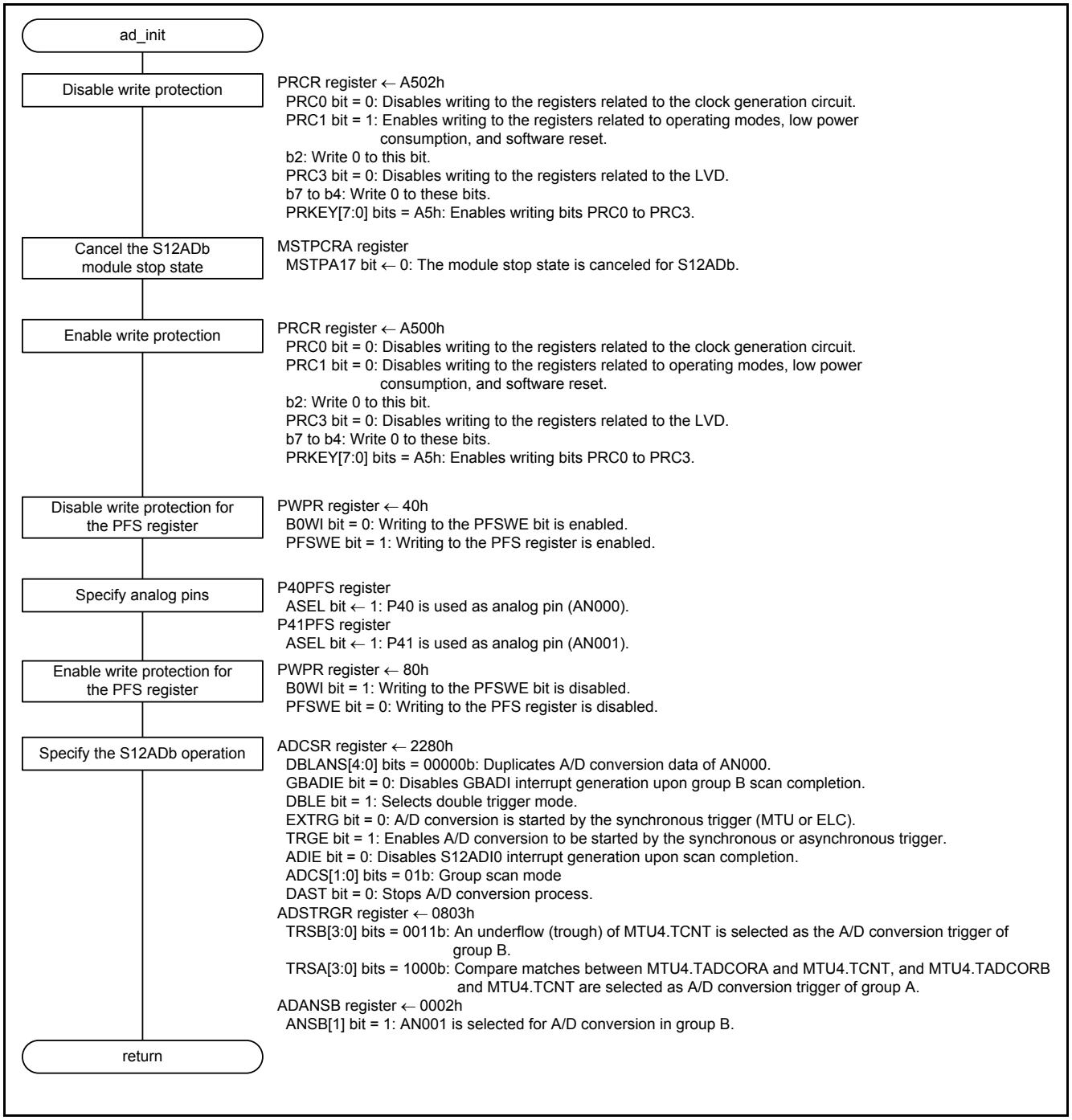

Figure 5.5 S12ADb Initialization

5.8.5 MTU2 Initialization

Figure 5.6 to Figure 5.8 show the MTU2 Initialization.

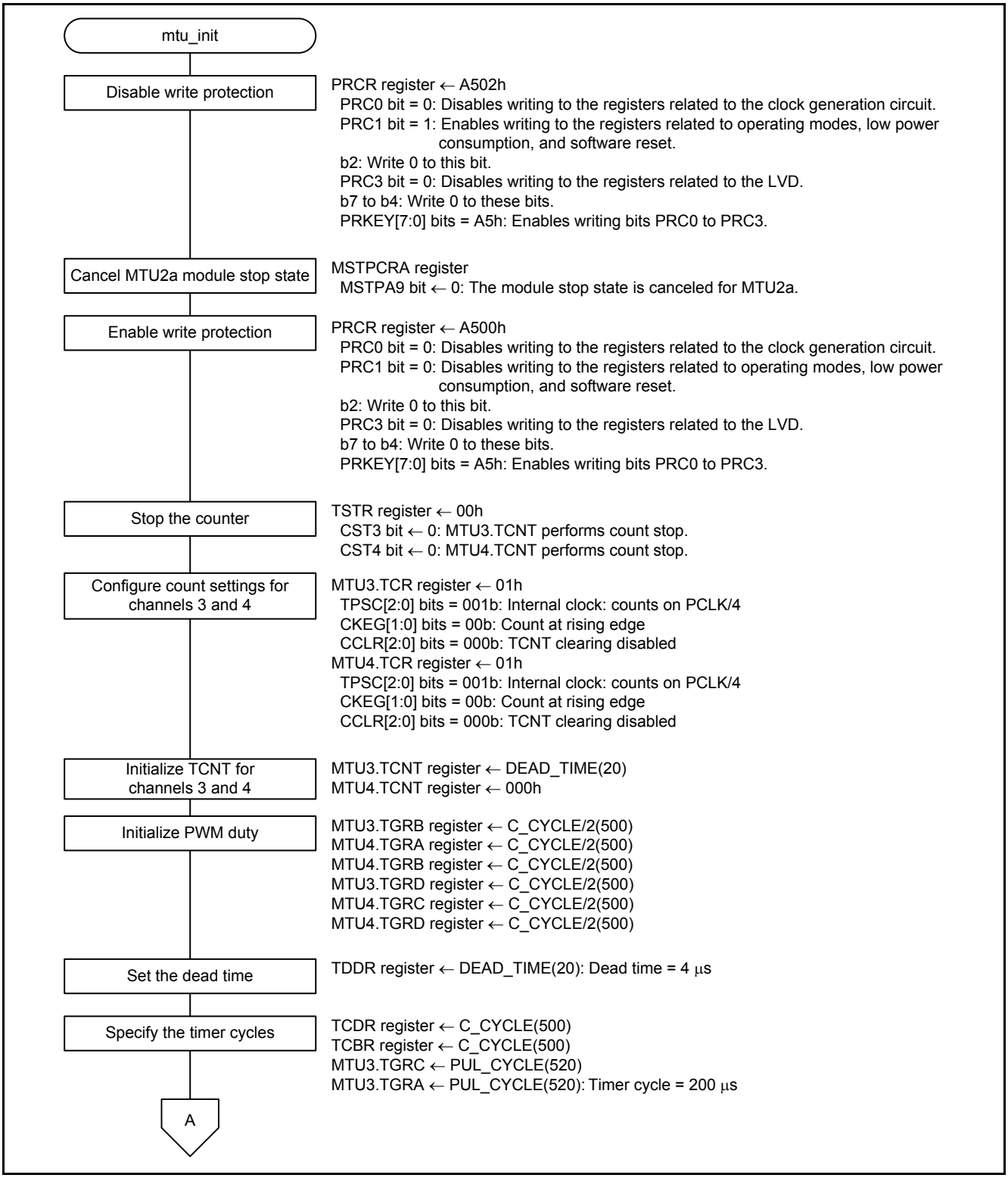

Figure 5.6 MTU2 Initialization (1/3)

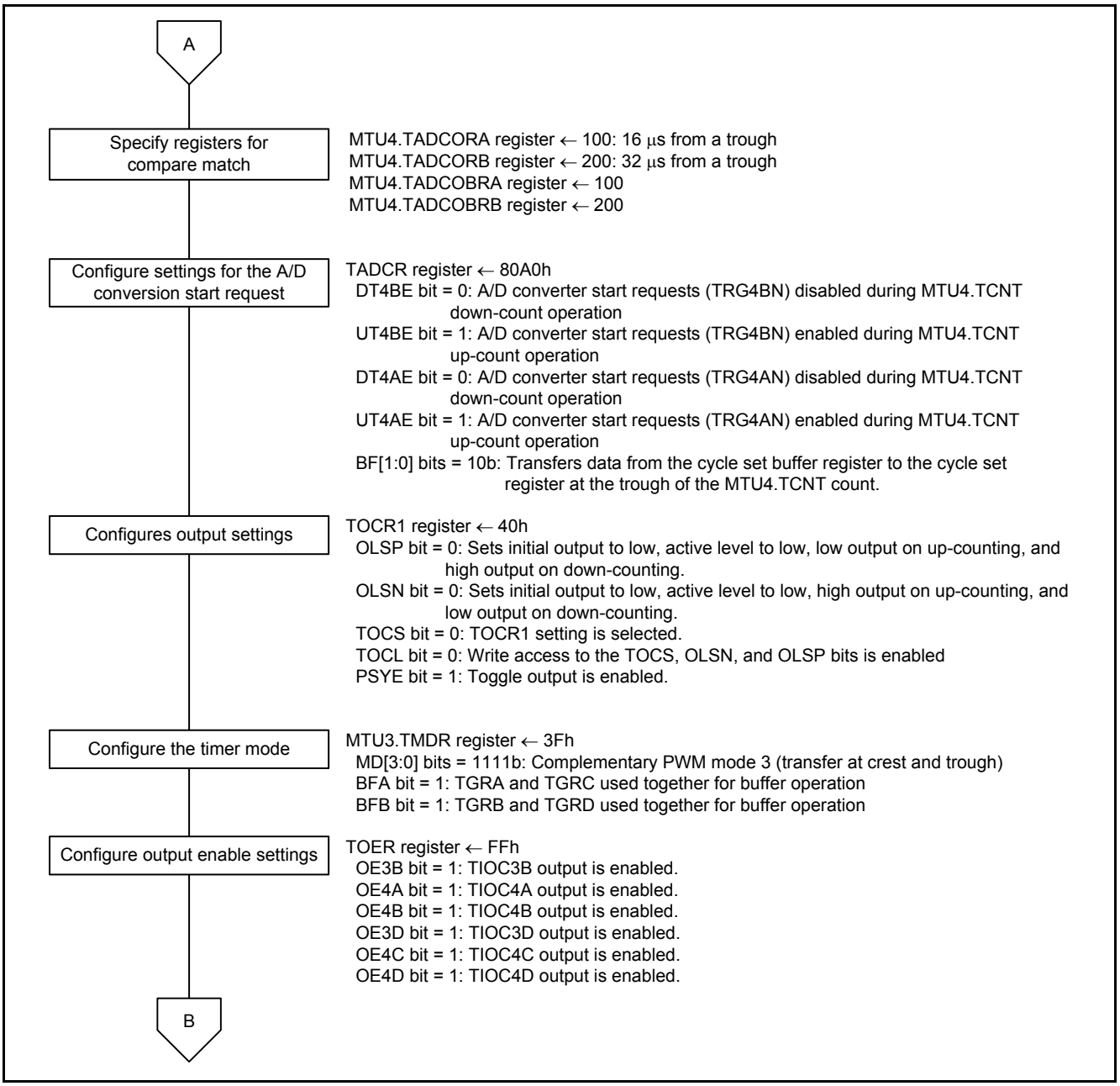

Figure 5.7 MTU2 Initialization (2/3)

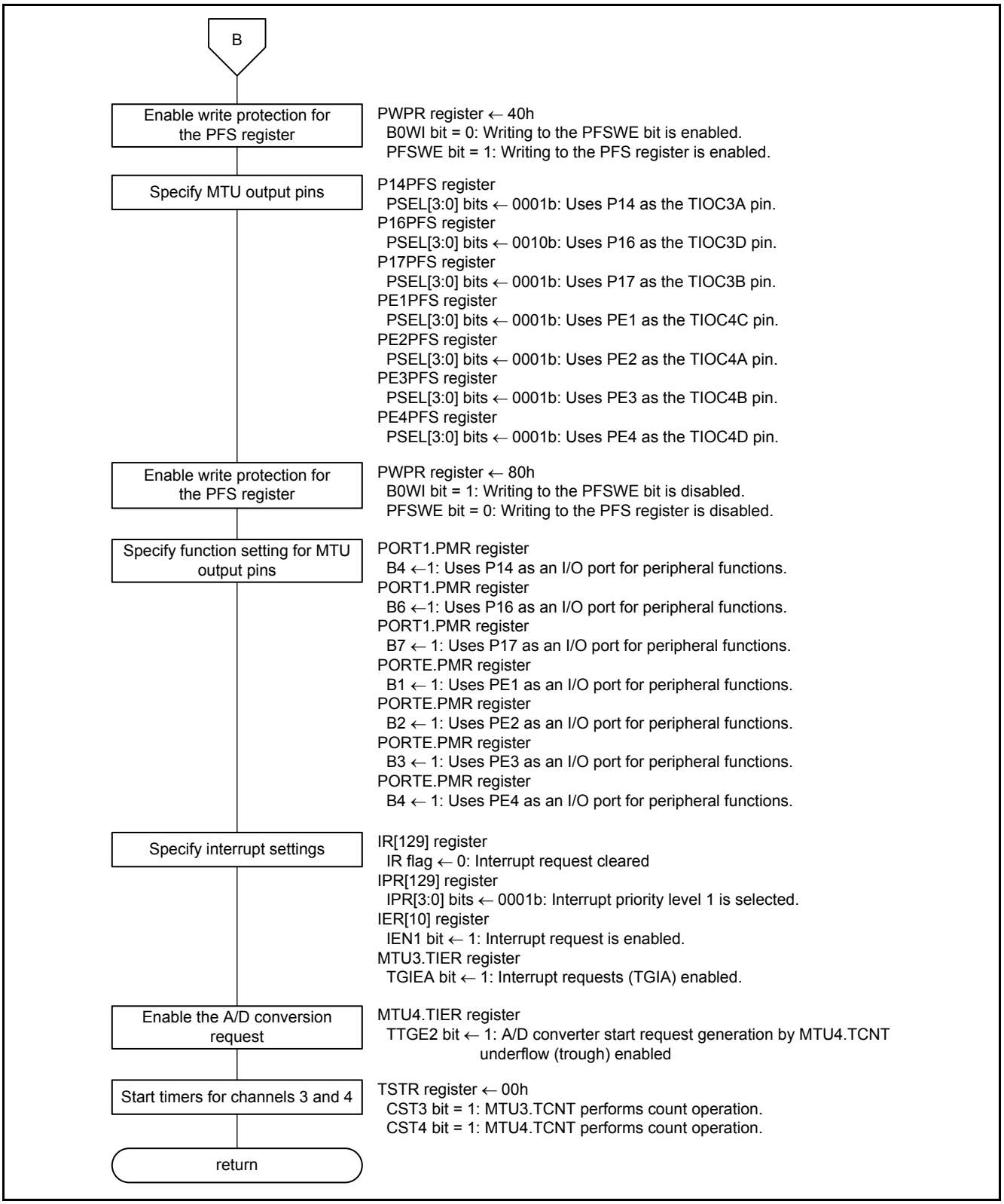

Figure 5.8 MTU2 Initialization (3/3)

5.8.6 TGIA3 Interrupt Handling

Figure 5.9 shows the TGIA3 Interrupt Handling.

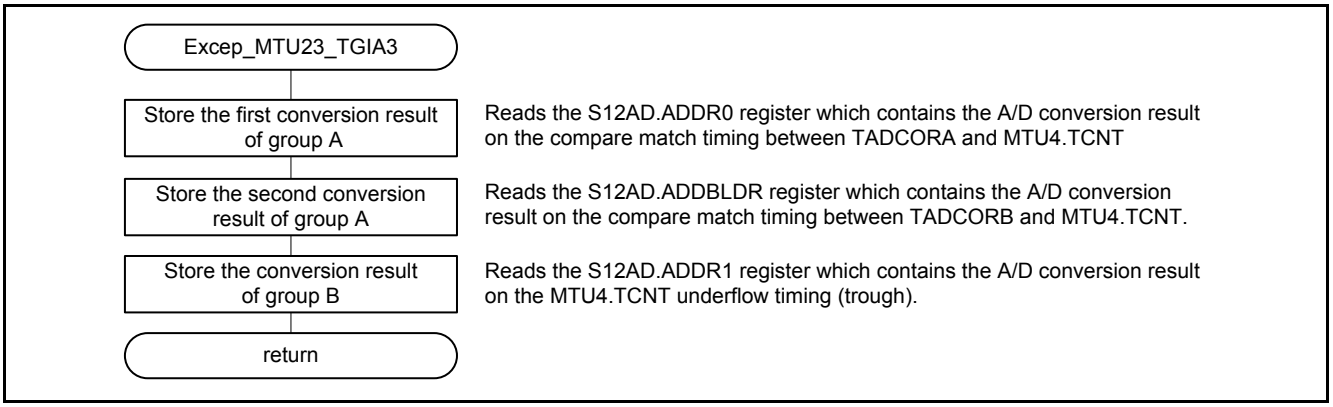

Figure 5.9 TGIA3 Interrupt Handling

6. Sample Code

Sample code can be downloaded from the Renesas Electronics website.

7. Reference Documents

User's Manual: Hardware

RX220 Group User's Manual: Hardware Rev.1.00 (R01UH0292EJ)
The latest version 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.

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REVISION HISTORY	RX220 Group Application Note A/D Conversion in Group Scan Mode with Double Trigger Mode

Rev.	Date	Description	
		Page	Summary
1.00	Dec. 16, 2013	—	First edition issued

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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Renesas Electronics America Inc.
2880 Scott Boulevard Santa Clara, CA 95050-2554, U.S.A.
Tel: +1-408-588-6000, Fax: +1-408-588-6130

Renesas Electronics Canada Limited
1101 Nicholson Road, Newmarket, Ontario L3Y 9C3, Canada
Tel: +1-905-898-5441, Fax: +1-905-898-3220

Renesas Electronics Europe Limited
Dukes Meadow, Millboard Road, Bourne End, Buckinghamshire, SL8 5FH, U.K
Tel: +44-1628-651-700, Fax: +44-1628-651-804

Renesas Electronics Europe GmbH
Arcadiastrasse 10, 40472 Düsseldorf, Germany
Tel: +49-211-65030, Fax: +49-211-6503-1327

Renesas Electronics (China) Co., Ltd.
7th Floor, Quantum Plaza, No.27 ZhiChunLu Haidian District, Beijing 100083, P.R.China
Tel: +86-10-8235-1155, Fax: +86-10-8235-7679

Renesas Electronics (Shanghai) Co., Ltd.
Unit 301, Tower A, Central Towers, 555 LanGao Rd., Putuo District, Shanghai, China
Tel: +86-21-2226-0888, Fax: +86-21-2226-0999

Renesas Electronics Hong Kong Limited
Unit 1601-1613, 16/F., Tower 2, Grand Century Place, 193 Prince Edward Road West, Mongkok, Kowloon, Hong Kong
Tel: +852-2886-9318, Fax: +852 2886-9022/9044

Renesas Electronics Taiwan Co., Ltd.
13F, No. 363, Fu Shing North Road, Taipei, Taiwan
Tel: +886-2-8175-9600, Fax: +886 2-8175-9670

Renesas Electronics Singapore Pte. Ltd.
80 Bendemeer Road, Unit #06-02 Hyflux Innovation Centre Singapore 339949
Tel: +65-6213-0200, Fax: +65-6213-0300

Renesas Electronics Malaysia Sdn.Bhd.
Unit 906, Block B, Menara Amcorp, Amcorp Trade Centre, No. 18, Jln Persiaran Barat, 46050 Petaling Jaya, Selangor Darul Ehsan, Malaysia
Tel: +60-3-7955-9390, Fax: +60-3-7955-9510

Renesas Electronics Korea Co., Ltd.
12F., 234 Teheran-ro, Gangnam-Gu, Seoul, 135-080, Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5141

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