

RX62T Group

R01AN0821EJ0100

Rev.1.00

2012.02.17

Usage Example of 12-Bit AD Converter in One Shunt Current Detection Method

Contents

1	Overview	2
1.1	Configuration	2
1.2	List of Used Functions	3
2	Contents of Control	4
2.1	Port Assignment	4
2.2	Timing Diagram	5
2.3	12-bit AD Converter (S12ADA).....	6
2.4	Port Output Enable 3 (POE3).....	8
2.5	Multi-Function Timer Unit 3 (MTU3)	8
3	PDG2 Setting	9
3.1	System Setting	9
3.2	MTU3ch3 Setting.....	10
3.3	POE3 Setting.....	14
3.4	12-Bit ADA Setting.....	17
4	S/W Descriptions	18
4.1	Register Settings	18
4.2	Settings of Variables	18
4.3	Settings of Constants	18
4.4	Main Function Flow	19
4.5	MTU3 Interrupt Flow.....	20
4.6	POE Interrupt Flow	20

1 Overview

1.1 Configuration

This application note describes a setting example of AD detection timing synchronized with PWM output and examples of using built-in programmable gain amplifiers (hereinafter referred to as PGA) and built-in comparators on the basis of a motor control board using one shunt current detection method (Figure 1).

Settings for S/W registers in this application note are generated by using Renesas Electronics' free tool, 'Peripheral I/O driver generator tool: Peripheral Driver Generator V.2 (hereinafter called PDG2) Ver2.02'. For details of register setting values, refer to PDG2 User's Manual.

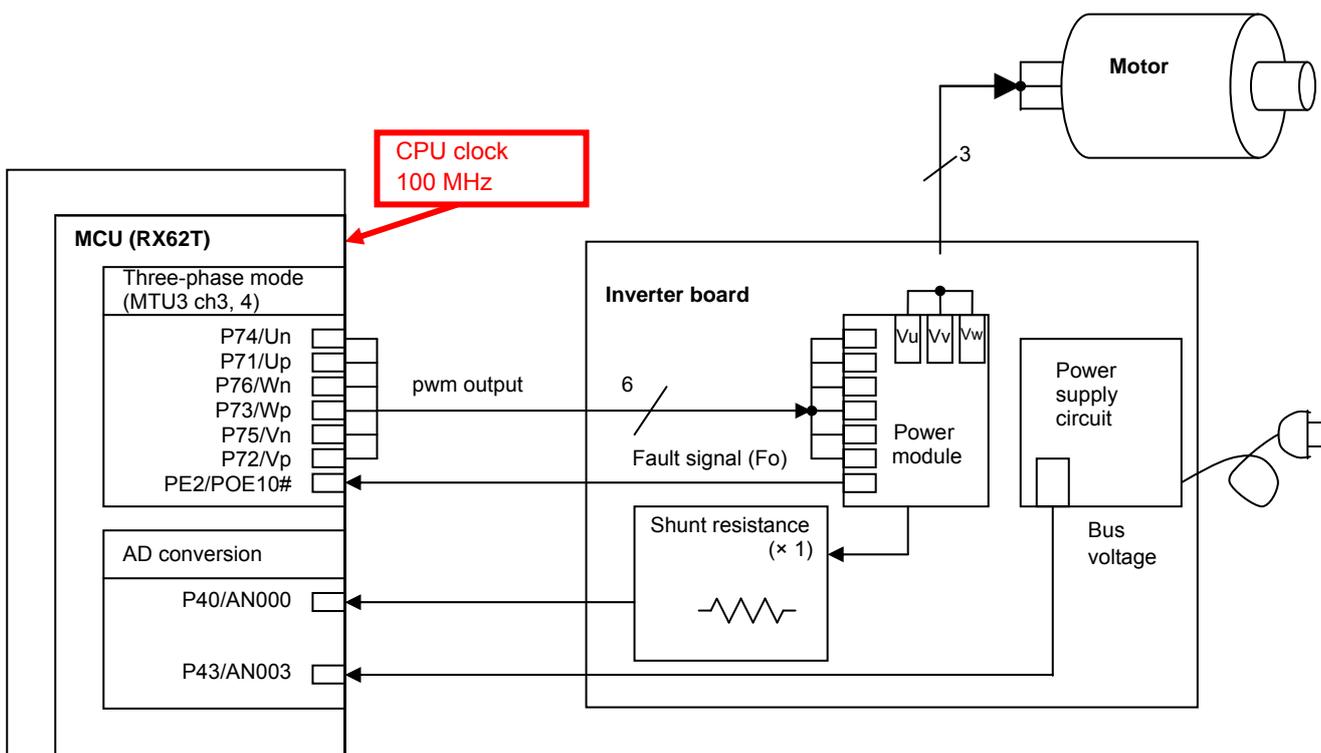


Figure 1. System Configuration Diagram

1.2 List of Used Functions

Table 1 shows a list of RX62T functions used in this application note.

Table 1. List of Functions Used by S/W

Function	Name	Content
Three-phase output	MTU3 (ch3,4)	<ul style="list-style-type: none"> · Sine wave output using the complementally PWM mode by MTU3 (ch3, 4) · Input two times at any given timing of three-phase PWM using AD delayed trigger generator function
Current input for shunt	12-bit ADA (AN000)	<ul style="list-style-type: none"> · Support one shunt current detection method with AD 1 ch (double data registers)
Shunt current amplification	PGA	<ul style="list-style-type: none"> · The shunt current is amplified twice by using a built-in PGA.
Bus voltage input	12-bit ADA (AN003)	<ul style="list-style-type: none"> · AD input by trigger from MTU3 synchronization
Fault signal input	POE (POE10)	<ul style="list-style-type: none"> · Shutdown of three-phase outputs upon detecting the “falling” edge of overcurrent signal when a fault occurs from IPM. (High impedance)
Overcurrent detection	Comparator in 12-bit ADA	<ul style="list-style-type: none"> · Shutdown of three-phase outputs upon detecting positive and negative overcurrents by using the window comparator function.

2 Contents of Control

2.1 Port Assignment

Table 2. Port Assignment

Purpose of Use	I/O	RX62T		RX62T-RSK	
		Use function	Pin No	JA	J
Vcc	HW	Vcc	14,42,60	JA1-1,JA6-23	J1-1,J2-17,J3-10
Vss	HW	Vss	3,12,44,62	JA1-2,4,JA2-4,JA6-24	J1-3,12,J2-19,J3-12
VCL	HW	VCL	5	–	–
AVcc	HW	AVCC0	92	JA1-5	J4-17
AVss	HW	AVSS0	95	JA1-6	J4-20
PLLVss	HW	PLLVss	31	–	–
EXTAL	HW	EXTAL	13	–	J1-13
XTAL	HW	XTAL	11	–	J1-11
MD1	HW	MD1	6	–	J1-6
RESET	HW	RES#	10	JA2-1	J1-10
ASEMD0	HW	MD0	7	–	J1-7
Fault signal input	IN	POE10#-A	15	JA2-3	J1-15
Motor UP-phase output	OUT	MTIOC3B	56	JA2-13	J3-6
Motor UN-phase output	OUT	MTIOC3D	53	JA2-14	J3-3
Motor VP-phase output	OUT	MTIOC4A	55	JA2-15	J3-5
Motor WP-phase output	OUT	MTIOC4B	54	JA2-17	J3-4
Motor VN-phase output	OUT	MTIOC4C	52	JA2-16	J3-2
Motor WN-phase output	OUT	MTIOC4D	51	JA2-18	J3-1
AD input for bus voltage	IN	AN003	88	JA1-12	J4-13
AD input for 1-shunt current	IN	AN000	91	JA1-9	J4-16

2.2 Timing Diagram

Figure 2 is a diagram showing one carrier of PWM and timing to capture AD values.

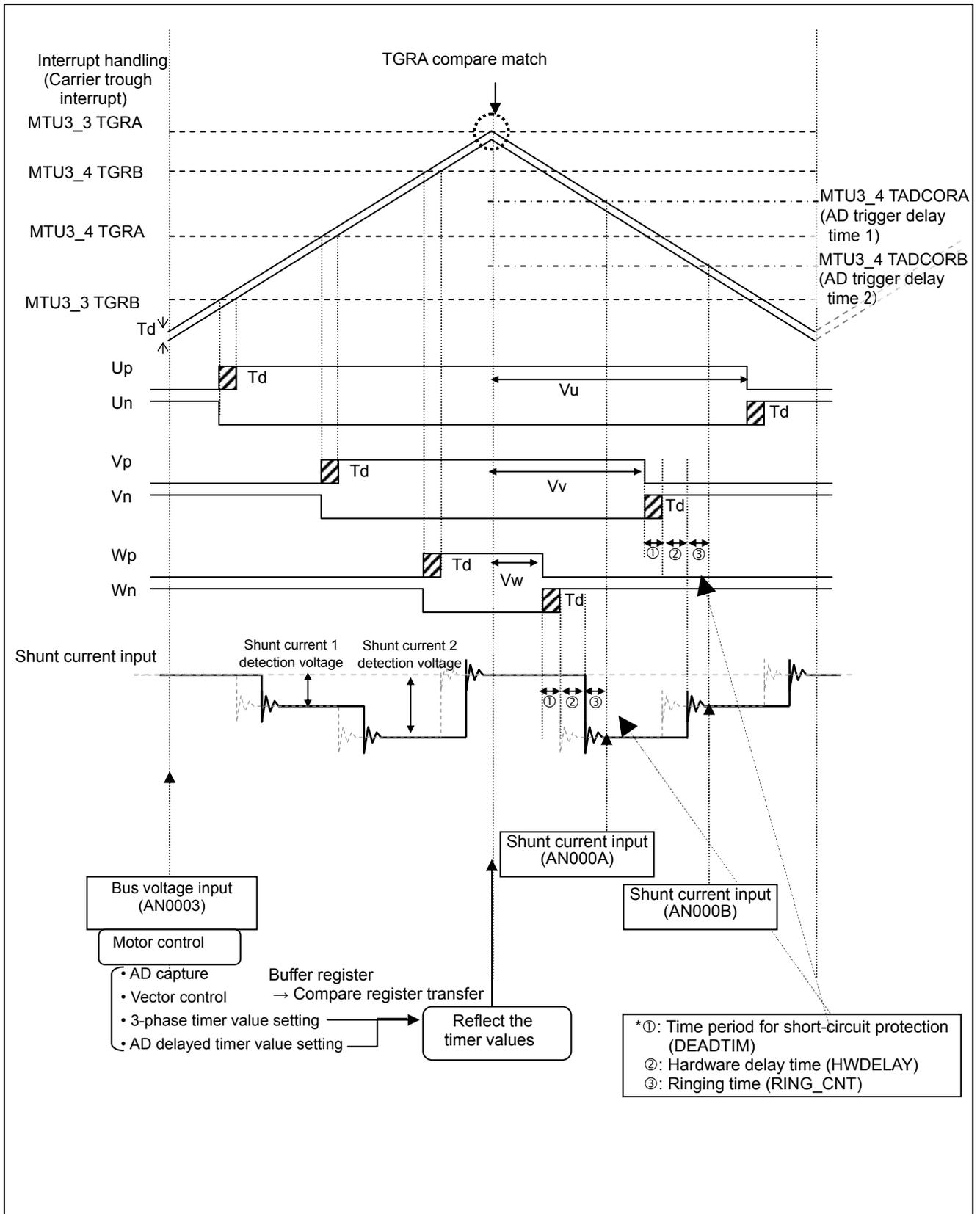


Figure 2. AD Conversion Timing Diagram

2.3 12-bit AD Converter (S12ADA)

(1) AD Detection Items

Table 3 lists items detected by the AD converters.

Table 3. AD Detection Items

Item	A/D input port
Shunt current 1	AN000A
Shunt current 2	AN000B
Bus voltage	AN003

(2) AD Converter Settings

Table 4 shows settings for the 12-bit AD converters.

Table 4. AD Conversion Mode Setting

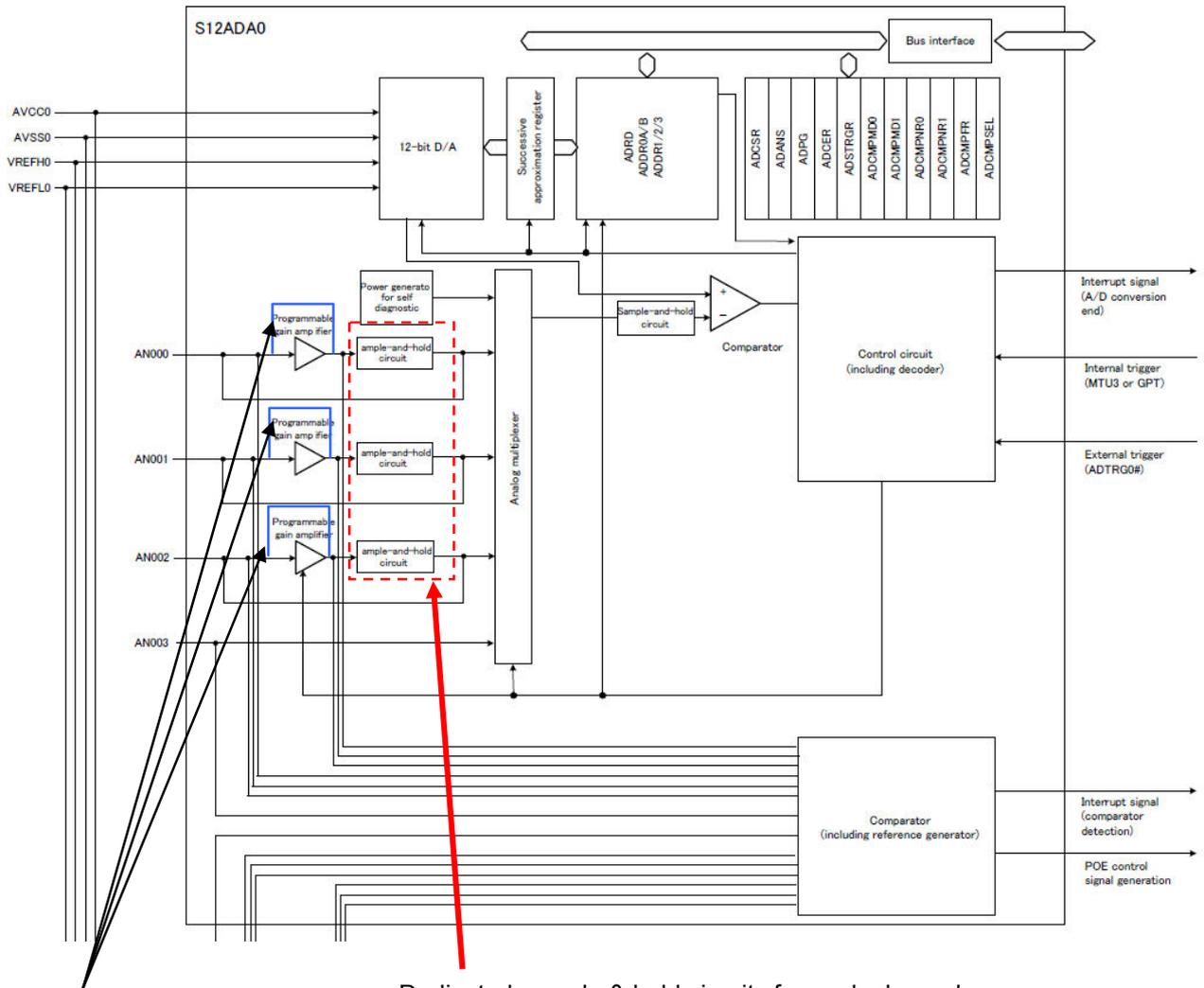
Item	Content
Conversion mode	2-channel scan mode
Conversion pin	Group 0: AN000A, AN000B Group 1: AN001 to AN003
Trigger select	Group 0: MTU3 TRG4AN or TRG4BN Group 1: MTU3 TRGA4N (carrier trough)
Bit select	12 bits (right aligned)
Sampling method	Sample-and-hold function + dedicated sample-and-hold for each channel
Frequency select	PCLK = 50MHz, ADCLK = 50MHz
A/D conversion time	1.82μs (4 cycles ÷ PCLK + 88 cycles ÷ ADCLK)
A/D conversion interrupt	Unused
PGA	Amplification rate: 2 times (AN000A, AN000B)
Comparator function select	Window comparator (High: 6/8AVCC, Low: 1/8AVCC)
Noise cancellation filter	Comparator detection results are sampled 16 times with PCLK/8
Comparator interrupt	Used as a POE interrupt request

(3) How to Calculate the AD Conversion Time

To use PGA, it is necessary to use a dedicated sample-and-hold circuit set for each channel of 12-bit AD converters (excluding AN003 and AN103).

The AD conversion time can be calculated by a below formula which is described in Section 27.3.3, p.1225 in RX62T Group Hardware Manual Rev1.10 .

- When a dedicated sample-and-hold circuit for the channel is used and self diagnosis function is not used:
 $t_{SCAN} = t_D + t_{SPLSH} + (t_{CONV} \times n) + t_{ED}$



Dedicated sample & hold circuits for each channel

Bypass lines which can be selected by the programmable gain amplifier select bit

Figure 3. Excerpt from AD Converter Block Diagram

2.4 Port Output Enable 3 (POE3)

(1) Item Detected by Port Output Enable 3

Table 5 shows an item detected by Port Output Enable 3.

Table 5. Item Detected by Port Output Enable 3

Item	Port	Content
Fault signal input	POE10	Detect a fault signal from IPM

(2) Settings for Port Output Enable 3

Table 6 shows settings for POE3.

Table 6. Settings for POE3

Item	Content
Target	Three-phase output ports (6 pins)
High-impedance conditions	<ul style="list-style-type: none"> • Comparator detection (AN000) • POE10 input level detection • When upper and lower arms in any phase of the three-phase PWM outputs have simultaneously reached an active level
Interrupt	POE10: priority level 15
Interrupt source	A request is accepted at the falling edge of POE10 pin.

2.5 Multi-Function Timer Unit 3 (MTU3)

(1) Settings for the multi-function timer unit 3

Table 7 shows settings for the multi-function timer unit 3.

Table 7. Setting Items in Multi-Function Timer Unit 3

Item	Content
Used channel	MTU3 ch3, 4
Operating mode	Complementary PWM mode
Frequency select	ICLK = 100MHz
Dead time	2 μ s
Buffer transfer timing	Buffer transfer at counter trough
Interrupt skipping	None
Interrupt	Interrupts at MTU3_4 underflow (priority level 10)

3 PDG2 Setting

Sample S/W registers for this application note are generated and set by using PDG2. This chapter illustrates settings to configure an operation environment in user system by using PDG2.

*Note

The sample S/W is adjusted to operate on a PC in which PDG2 has not been installed. Therefore, settings according to displays shown below do not mean that a project built on the High-performance Embedded Workshop (HEW) has the same configuration as the sample S/W.

There is no difference in operations.

3.1 System Setting

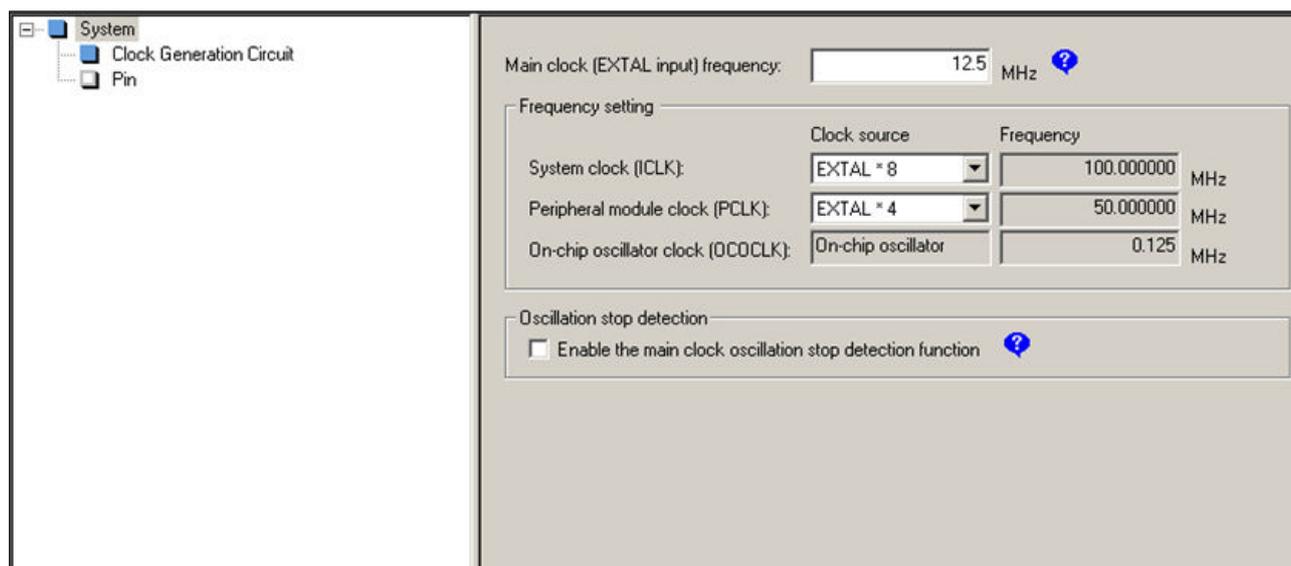


Figure 4. System Setting Display

3.2 MTU3ch3 Setting

When the complementary PWM mode is selected as operation mode for MTU3ch3, ch4 is automatically set in accordance with ch3 setting.

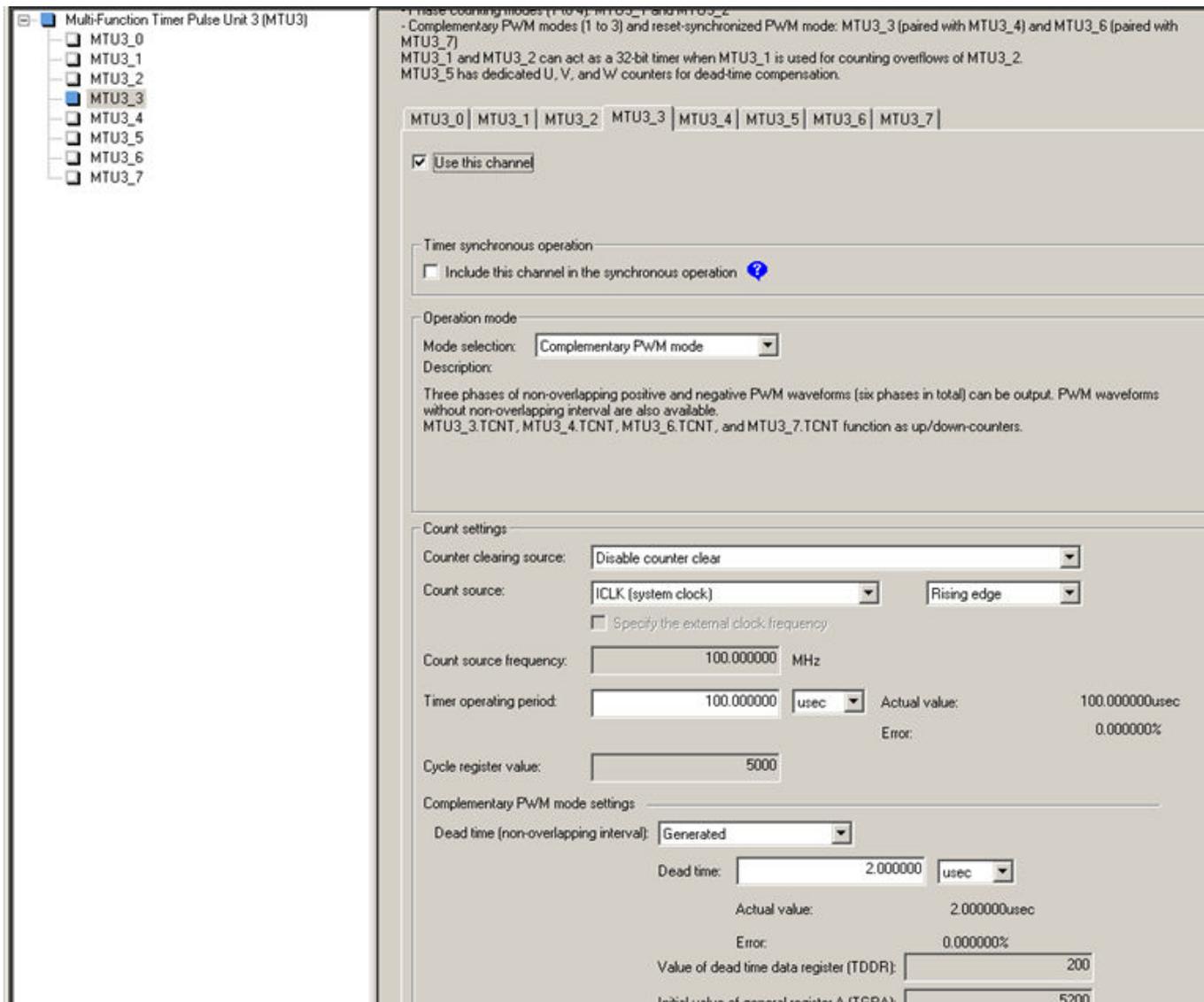


Figure 5. MTU3 Setting Display 1

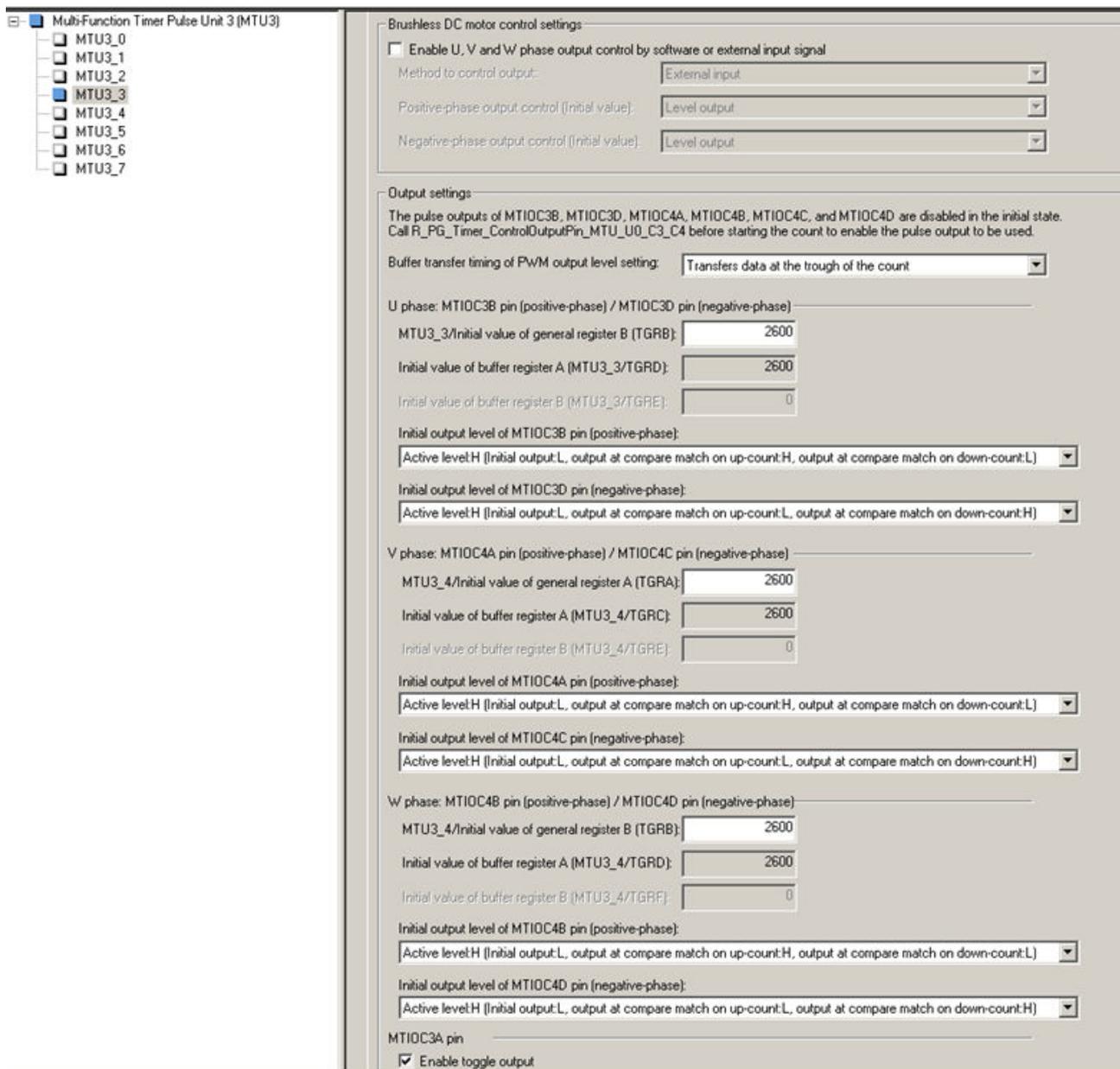


Figure 6. MTU3 Setting Display 2

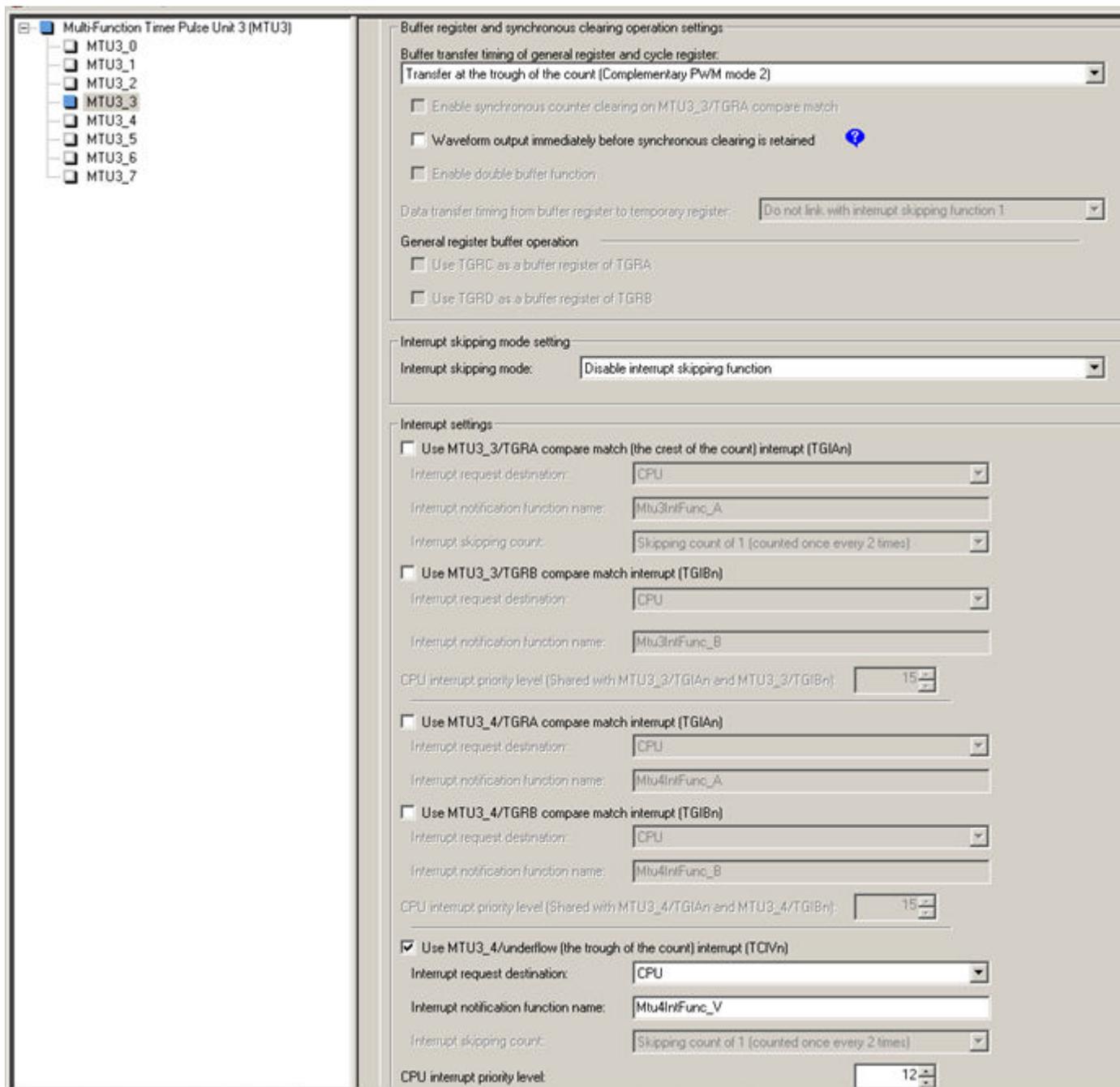


Figure 7. MTU3 Setting Display 3

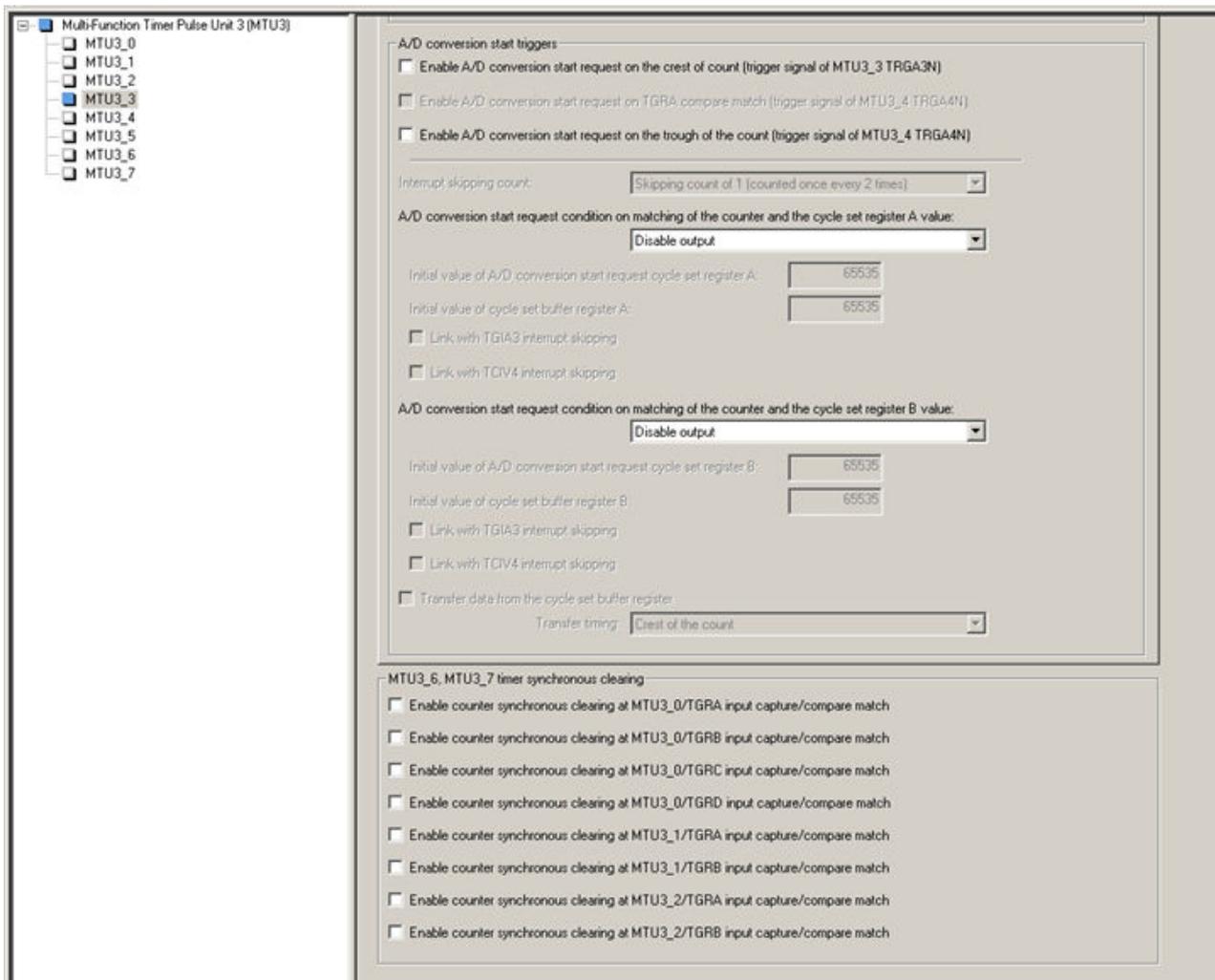


Figure 8. MTU3 Setting Display 4

3.3 POE3 Setting

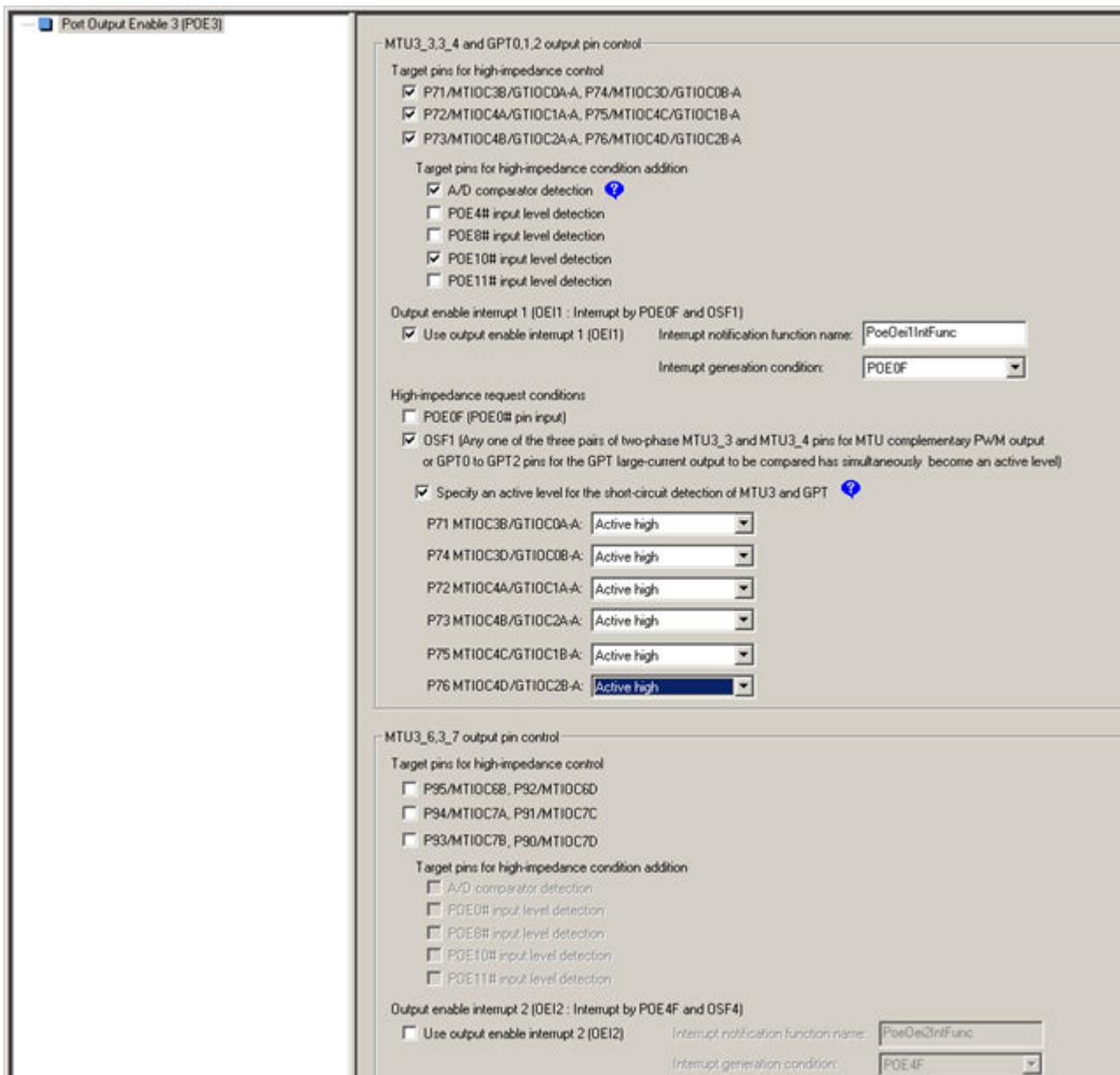


Figure 9. POE3 Setting Display 1

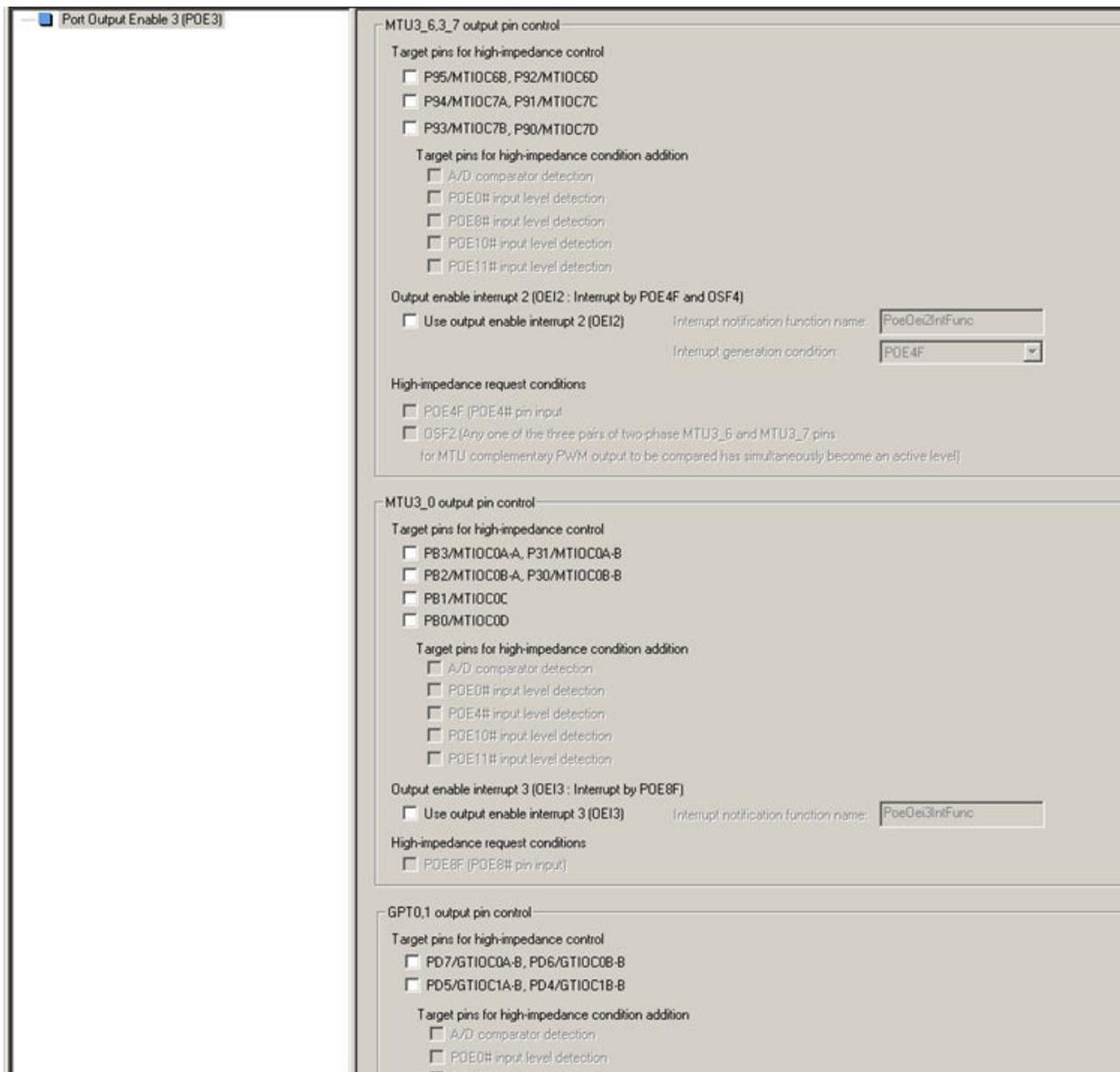


Figure 10. POE3 Setting Display 2

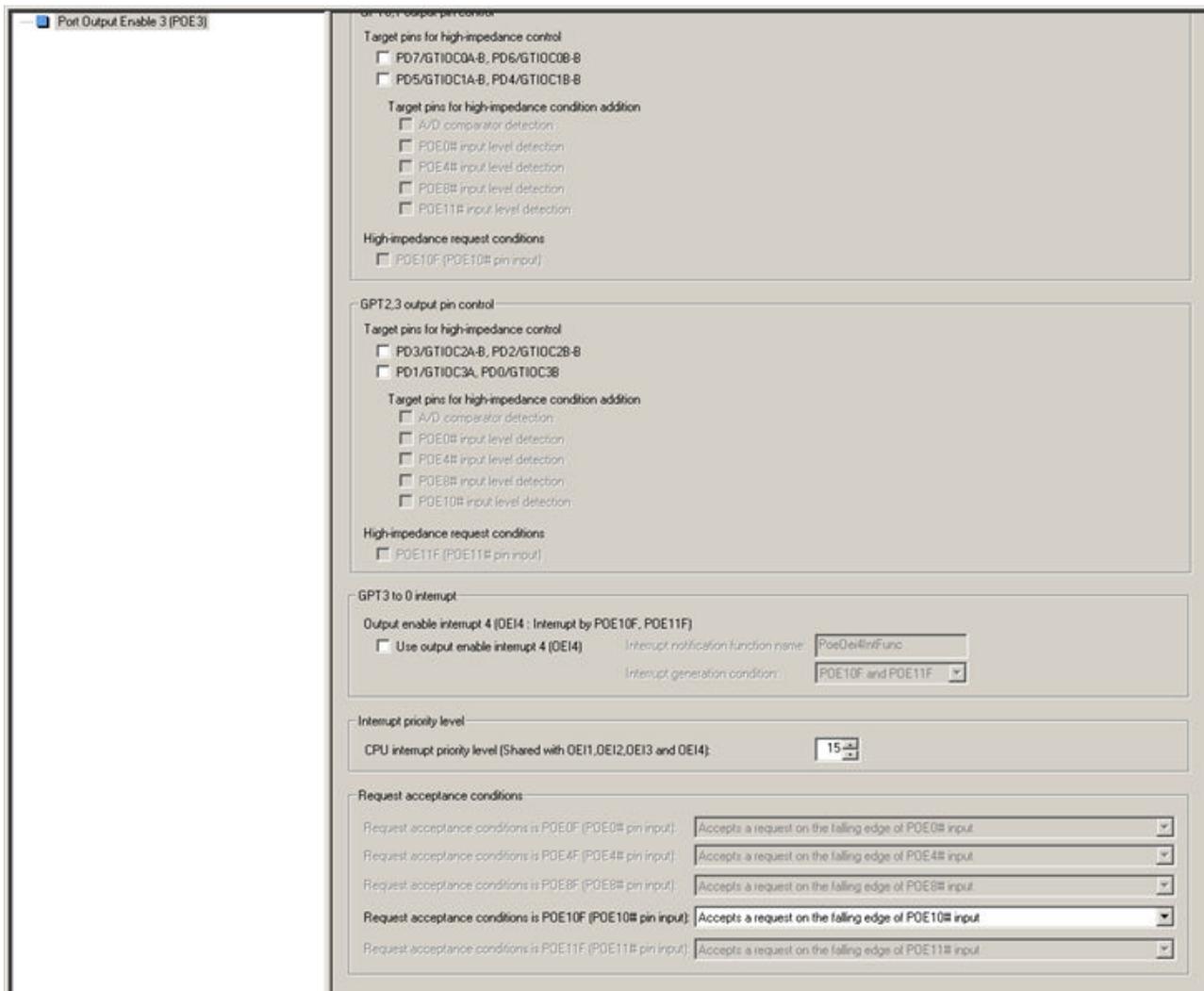


Figure 11. POE3 Setting Display 3

3.4 12-Bit ADA Setting

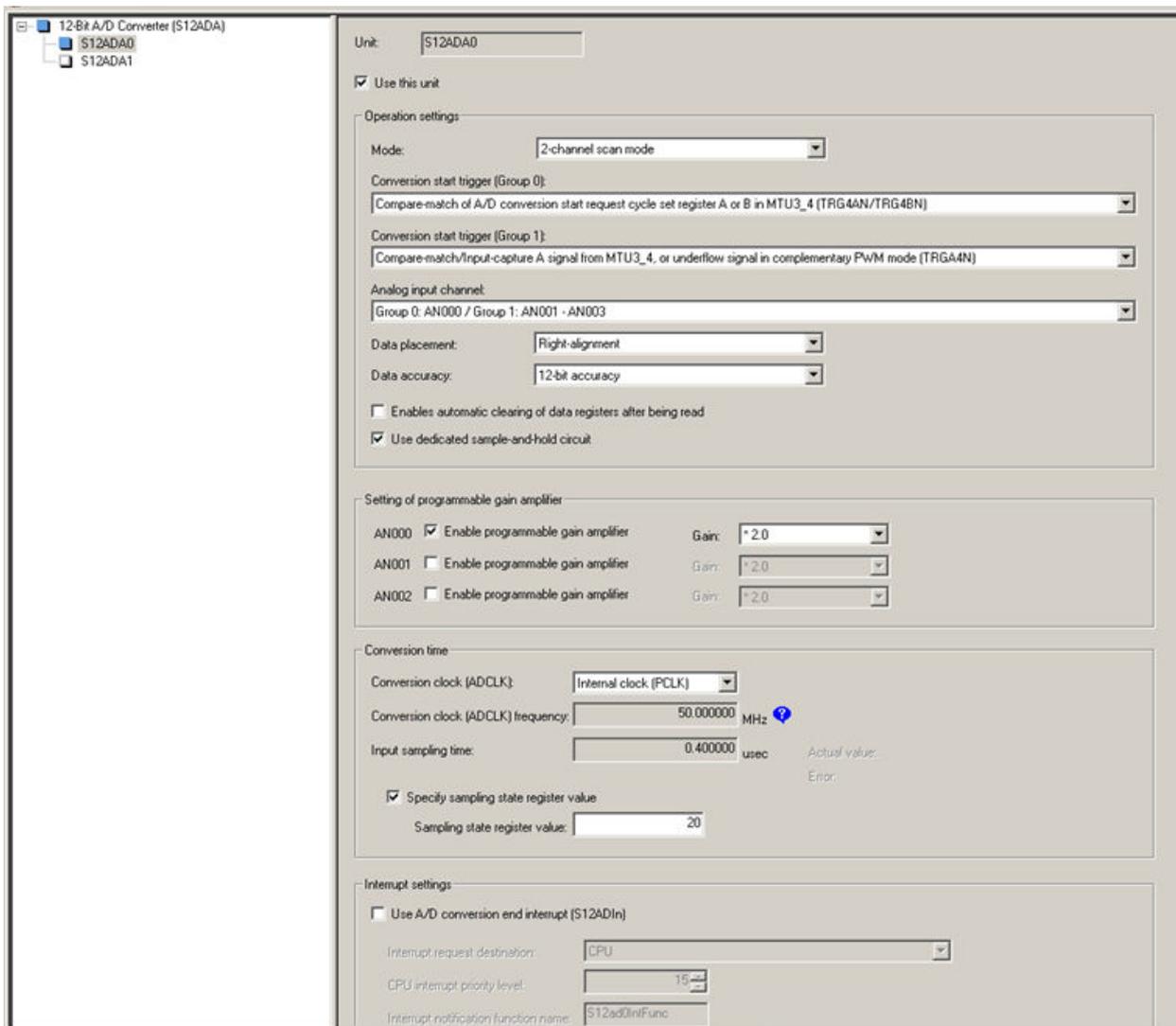


Figure 12. 12-Bit AD Setting Display

4 S/W Descriptions

This chapter describes settings of modules which are not supported by PDG2 and control flows.

4.1 Register Settings

Register	Initial value	Content
MTU4.TIER.BIT.TTGE	1	Enable to generate an AD conversion start request
MTU4.TIER.BIT.TTGE2	1	Enable an AD conversion request at trough
MTU4.TADCOBRA	5200	Set a cycle for AD conversion start request (buffer)
MTU4.TADCOBRB	5200	Set a cycle for AD conversion start request (buffer)
MTU4.TADCORA	5200	Set a cycle for AD conversion start request
MTU4.TADCORB	5200	Set a cycle for AD conversion start request
MTU4.TADCR.WORD	0x4050	Buffer transfer at TCNT4 peak As for TRG4AN and TRG4BN, AD converter start requests are enabled when TCNT4 decrements. Not link the transfer with interrupt skipping function
S12AD.ADCMPFR.BIT.C000FLAG	0	Clear the comparator detection flag for AN000
S12AD.ADCMPMD0.BIT.CEN000	3	Use AN000 as the window comparator (Low/High)
S12AD.ADCMPMD1.WORD	0x0661	REFL: AVCC0 × 1/8, REFH: AVCC0 × 6/8 Use a signal before amplified by the PGA as a comparator input with reference to REFH/REFL
S12AD.ADCMPNR0.BIT.C000NR	10	Sample the comparator result 16 times at PCLK/2
S12AD.ADCMPSEL.WORD	0x0301	Use the detection in the comparator as an interrupt or POE request
POE.POECR4.BIT.CMADDMT34ZE	1	Add the S12ADA.ADCMPFR.CjFLAG (j = 0 to 2 and 4 to 6) flag to high-impedance conditions of MTU3_3 and MTU3_4
IR (S12AD,CMPI)	0	Clear the interrupt request flag (comparator IR)
IPR (S12AD,CMPI)	0x0c	Comparator interrupt priority level = 12
IEN (S12AD,CMPI)	1	Enable comparator interrupts
POE.ICSR4.BIT.POE10F	0	Clear the POE10 interrupt request flag
POE.OCSR1.BIT.OSF1	0	Clear the output short flag

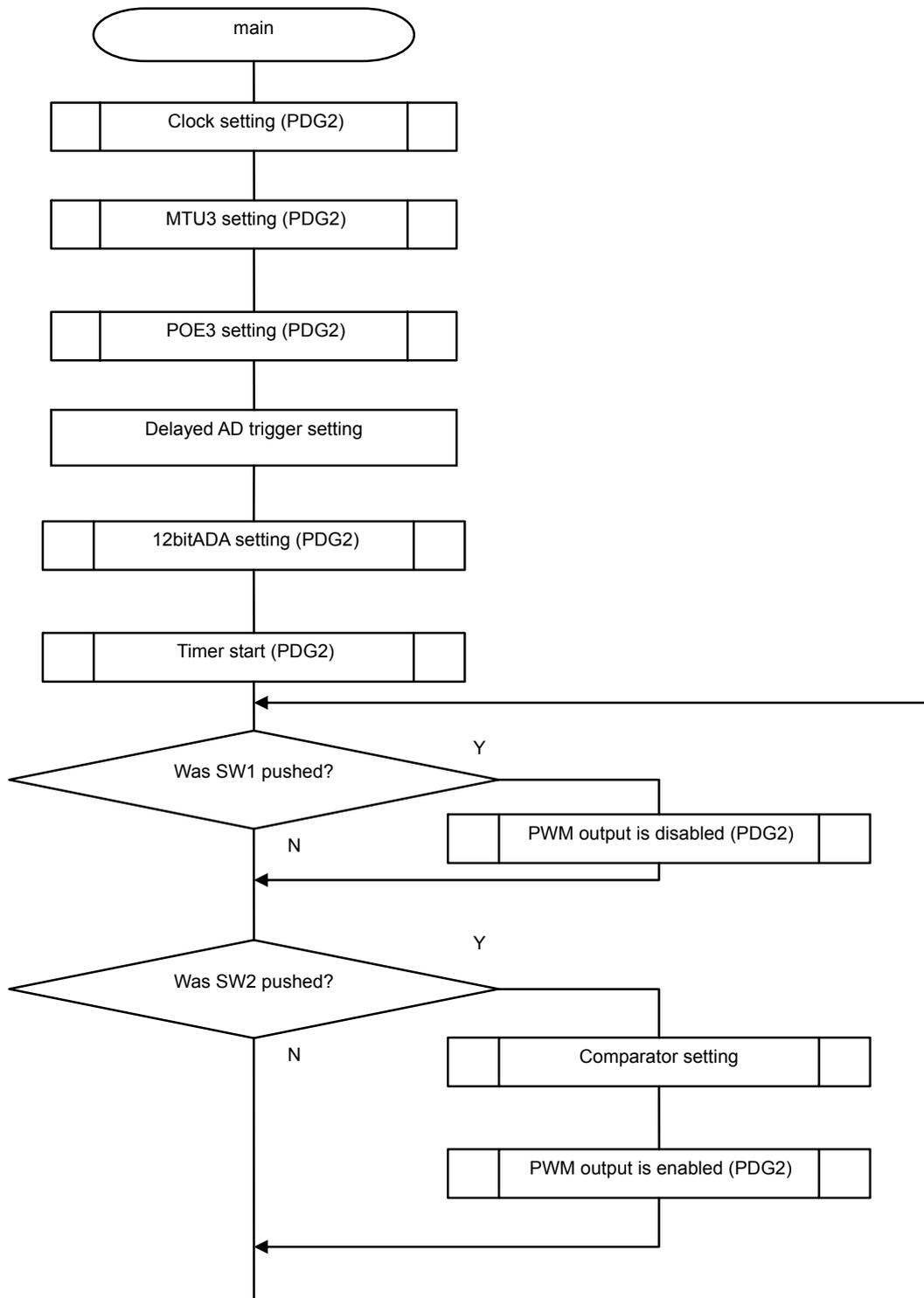
4.2 Settings of Variables

Defined name	(Type) Initial value	Content
du	(float) 0	Variable to store the U-phase output value
dv	(float) 5200 / 3	Variable to store the V-phase output value
dw	(float) 5200 / 3 × 2	Variable to store the W-phase output value
AD_data [5]	(short) 0	Variable to store the AD conversion result (For details, refer to the section about 12-bit A/D converter in PDG2 reference manual.)
t_c1	(int) 0	Counter to prevent chattering (for SW1)
t_c2	(int) 0	Counter to prevent chattering (for SW2)

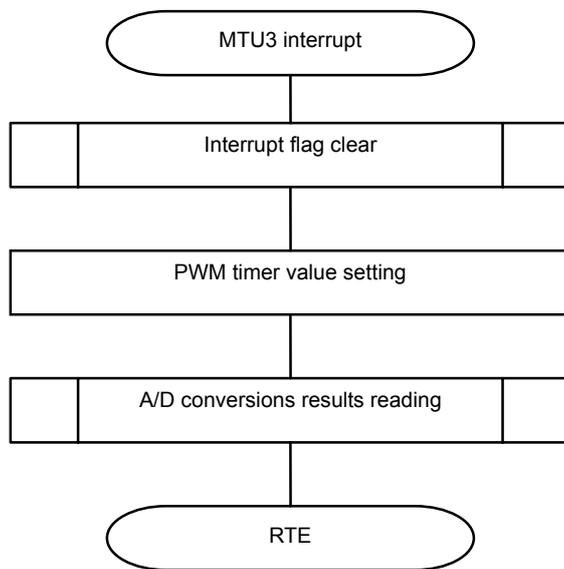
4.3 Settings of Constants

Defined name	Value	Content
CARR_CNT	10000	Carrier cycle
DTT_CNT	200	Dead time
CMP_TIMING_1	5	Constant to generate a timing for AD conversion start trigger
CMP_TIMING_2	15	Constant to generate a timing for AD conversion start trigger
PWM_CHANGE_VAL	0.1	Constant to control changes in PWM output

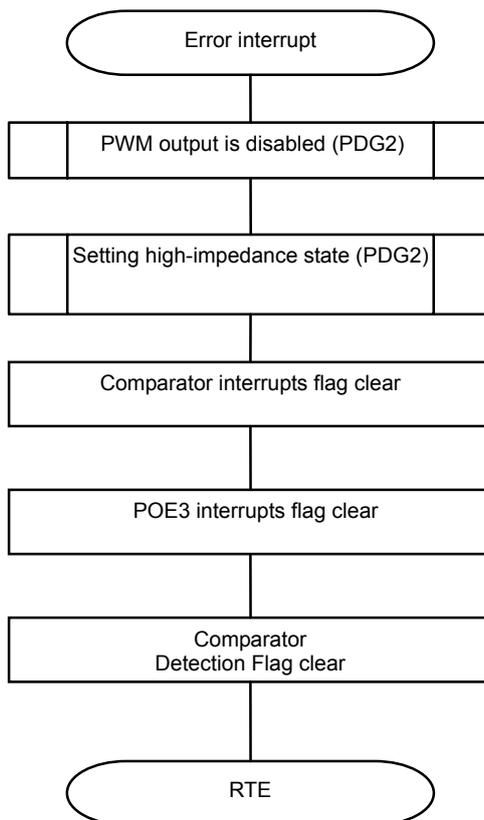
4.4 Main Function Flow



4.5 MTU3 Interrupt Flow



4.6 Error Interrupt Flow



Website and Support

- Renesas Electronics Website
<http://www.renesas.com/>
- Inquiries
<http://www.renesas.com/inquiry>

All trademarks and registered trademarks are the property of their respective owners.

Revision Record

Rev.	Date	Description	
		Page	Summary
1.00	2012.02.17	—	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 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. 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.

Notice

1. All information included in this document is current as of the date this document is issued. Such information, however, is subject to change without any prior notice. Before purchasing or using any Renesas Electronics products listed herein, please confirm the latest product information with a Renesas Electronics sales office. Also, please pay regular and careful attention to additional and different information to be disclosed by Renesas Electronics such as that disclosed through our website.
2. Renesas Electronics does not assume any liability for infringement of patents, copyrights, or other intellectual property rights of third parties by or arising from the use of Renesas Electronics products or technical information described in this document. No license, express, implied or otherwise, is granted hereby under any patents, copyrights or other intellectual property rights of Renesas Electronics or others.
3. You should not alter, modify, copy, or otherwise misappropriate any Renesas Electronics product, whether in whole or in part.
4. Descriptions of circuits, software and other related information in this document are provided only to illustrate the operation of semiconductor products and application examples. You are fully responsible for the incorporation of these circuits, software, and information in the design of your equipment. Renesas Electronics assumes no responsibility for any losses incurred by you or third parties arising from the use of these circuits, software, or information.
5. When exporting the products or technology described in this document, you should comply with the applicable export control laws and regulations and follow the procedures required by such laws and regulations. You should not use Renesas Electronics products or the technology described in this document for any purpose relating to military applications or use by the military, including but not limited to the development of weapons of mass destruction. Renesas Electronics products and technology may not be used for or incorporated into any products or systems whose manufacture, use, or sale is prohibited under any applicable domestic or foreign laws or regulations.
6. Renesas Electronics has used reasonable care in preparing the information included in this document, but Renesas Electronics does not warrant that such information is error free. Renesas Electronics assumes no liability whatsoever for any damages incurred by you resulting from errors in or omissions from the information included herein.
7. Renesas Electronics products are classified according to the following three quality grades: "Standard", "High Quality", and "Specific". The recommended applications for each Renesas Electronics product depends on the product's quality grade, as indicated below. You must check the quality grade of each Renesas Electronics product before using it in a particular application. You may not use any Renesas Electronics product for any application categorized as "Specific" without the prior written consent of Renesas Electronics. Further, you may not use any Renesas Electronics product for any application for which it is not intended without the prior written consent of Renesas Electronics. Renesas Electronics shall not be in any way liable for any damages or losses incurred by you or third parties arising from the use of any Renesas Electronics product for an application categorized as "Specific" or for which the product is not intended where you have failed to obtain the prior written consent of Renesas Electronics. The quality grade of each Renesas Electronics product is "Standard" unless otherwise expressly specified in a Renesas Electronics data sheets or data books, etc.
"Standard": Computers; office equipment; communications equipment; test and measurement equipment; audio and visual equipment; home electronic appliances; machine tools; personal electronic equipment; and industrial robots.
"High Quality": Transportation equipment (automobiles, trains, ships, etc.); traffic control systems; anti-disaster systems; anti-crime systems; safety equipment; and medical equipment not specifically designed for life support.
"Specific": Aircraft; aerospace equipment; submersible repeaters; nuclear reactor control systems; medical equipment or systems for life support (e.g. artificial life support devices or systems), surgical implantations, or healthcare intervention (e.g. excision, etc.), and any other applications or purposes that pose a direct threat to human life.
8. You should use the Renesas Electronics products described in this document within the range specified by Renesas Electronics, especially with respect to the maximum rating, operating supply voltage range, movement power voltage range, heat radiation characteristics, installation and other product characteristics. Renesas Electronics shall have no liability for malfunctions or damages arising out of the use of Renesas Electronics products beyond such specified ranges.
9. Although Renesas Electronics endeavors to improve the quality and reliability of its products, semiconductor products have specific characteristics such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Further, Renesas Electronics products are not subject to radiation resistance design. Please be sure to implement safety measures to guard them against the possibility of physical injury, and injury or damage caused by fire in the event of the failure of a Renesas Electronics product, such as safety design for hardware and software including but not limited to redundancy, fire control and malfunction prevention, appropriate treatment for aging degradation or any other appropriate measures. Because the evaluation of microcomputer software alone is very difficult, please evaluate the safety of the final products or system manufactured by you.
10. Please contact a Renesas Electronics sales office for details as to environmental matters such as the environmental compatibility of each Renesas Electronics product. Please use Renesas Electronics products in compliance with all applicable laws and regulations that regulate the inclusion or use of controlled substances, including without limitation, the EU RoHS Directive. Renesas Electronics assumes no liability for damages or losses occurring as a result of your noncompliance with applicable laws and regulations.
11. This document may not be reproduced or duplicated, in any form, in whole or in part, without prior written consent of Renesas Electronics.
12. Please contact a Renesas Electronics sales office if you have any questions regarding the information contained in this document or Renesas Electronics products, or if you have any other inquiries.
(Note 1) "Renesas Electronics" as used in this document means Renesas Electronics Corporation and also includes its majority-owned subsidiaries.
(Note 2) "Renesas Electronics product(s)" means any product developed or manufactured by or for Renesas Electronics.



SALES OFFICES

Renesas Electronics Corporation

<http://www.renesas.com>

Refer to "<http://www.renesas.com/>" for the latest and detailed information.

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: +44-1628-585-100, Fax: +44-1628-585-900

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 204, 205, AZIA Center, No.1233 Lujiazui Ring Rd., Pudong District, Shanghai 200120, China
Tel: +86-21-5877-1818, Fax: +86-21-6887-7858 / -7898

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.

1 harbourFront Avenue, #06-10, Keppel Bay Tower, Singapore 098632
Tel: +65-6213-0200, Fax: +65-6278-8001

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.

11F., Samik Lavied' or Bldg., 720-2 Yeoksam-Dong, Kangnam-Ku, Seoul 135-080, Korea
Tel: +82-2-558-3737, Fax: +82-2-558-5141