To our customers,

Old Company Name in Catalogs and Other Documents

On April 1st, 2010, NEC Electronics Corporation merged with Renesas Technology Corporation, and Renesas Electronics Corporation took over all the business of both companies. Therefore, although the old company name remains in this document, it is a valid Renesas Electronics document. We appreciate your understanding.

Renesas Electronics website: http://www.renesas.com

April 1st, 2010
Renesas Electronics Corporation

Issued by: Renesas Electronics Corporation (http://www.renesas.com)

Send any inquiries to http://www.renesas.com/inquiry.

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.

H8SX Series

PWM 15-Phase Output

Introduction

As well as having an architecture that is upward-compatible with each CPU of the H8/300, H8/300H, and H8S series, so as to inherit a full complement of peripheral functions, the H8SX microcomputer series has a maximum operating frequency of 50 MHz and uses a 32-bit H8SX core CPU as well as an on-chip multiplier/divider to improve performance.

This H8SX series Application Note provides information you may be need during software and hardware design. This is a basic edition that provides operation examples that each use a single H8SX series on-chip peripheral function.

Although the operation of each program, circuit, and other aspects covered by this application note has been checked, make sure that you conduct your own operation checks before actually using the H8SX series.

Contents

1. Overview

The six channels of the 16-bit timer pulse unit (TPU) of the H8SX series are all used to output 15-phase PWM waveforms. You can control up to 15 phases for PWM waveform output by setting the timer operating mode of each channel to PWM mode 2 and enabling synchronous operation.

2. Configuration

When synchronous operation is specified for all the channels of the 16-bit timer pulse unit (TPU), the count and clear operations of the timer counters (TCNT_0 to TCNT_5) of all the channels are performed synchronously. The sample shown below uses timer general register A (TGRA_0) of channel 0 for PWM cycle setting and the other timer general registers for the duty setting. This sample outputs pulses at any duty cycle from the output compare output pin (TIOCB0, TIOCC0, TIOCD0, TIOCA1, ..., or TIOCB5) for each timer general register other than TGRA_0. When the peripheral module clock (Pϕ) is 25 MHz and the count clock is Pϕ/1, you can set any output pulse cycle between 80 nsec and 2.62 msec. You can also set a duty cycle with a resolution of 1/65535.

In the following explanation, channel 0 of the 16-bit timer pulse unit is called TPU0 while channel 1 is called TPU1. Figure 1 is a block diagram.

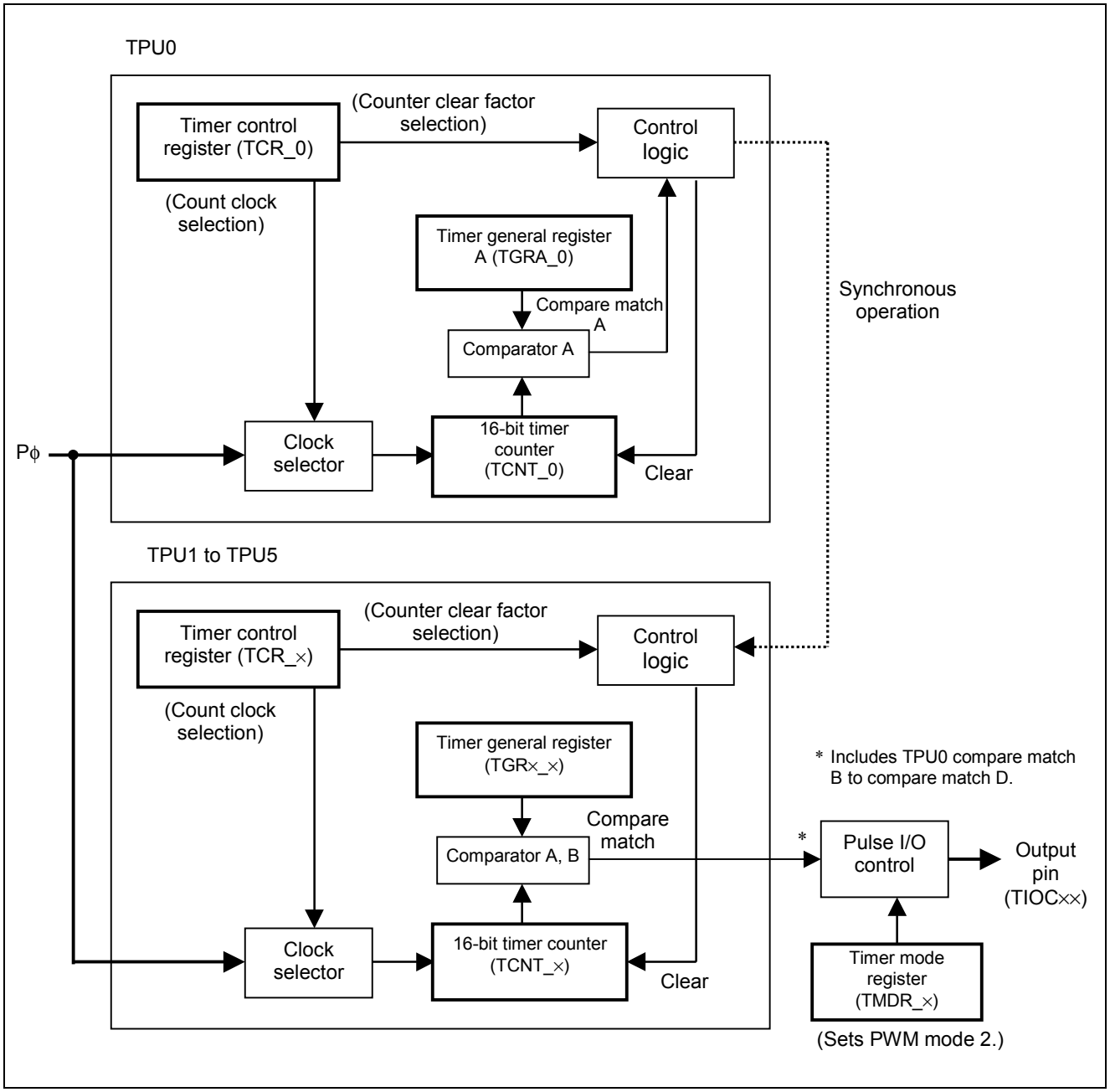


Figure 1 Block Diagram of PWM 15-Phase Output

Figure 2 shows an example of PWM 15-phase output.

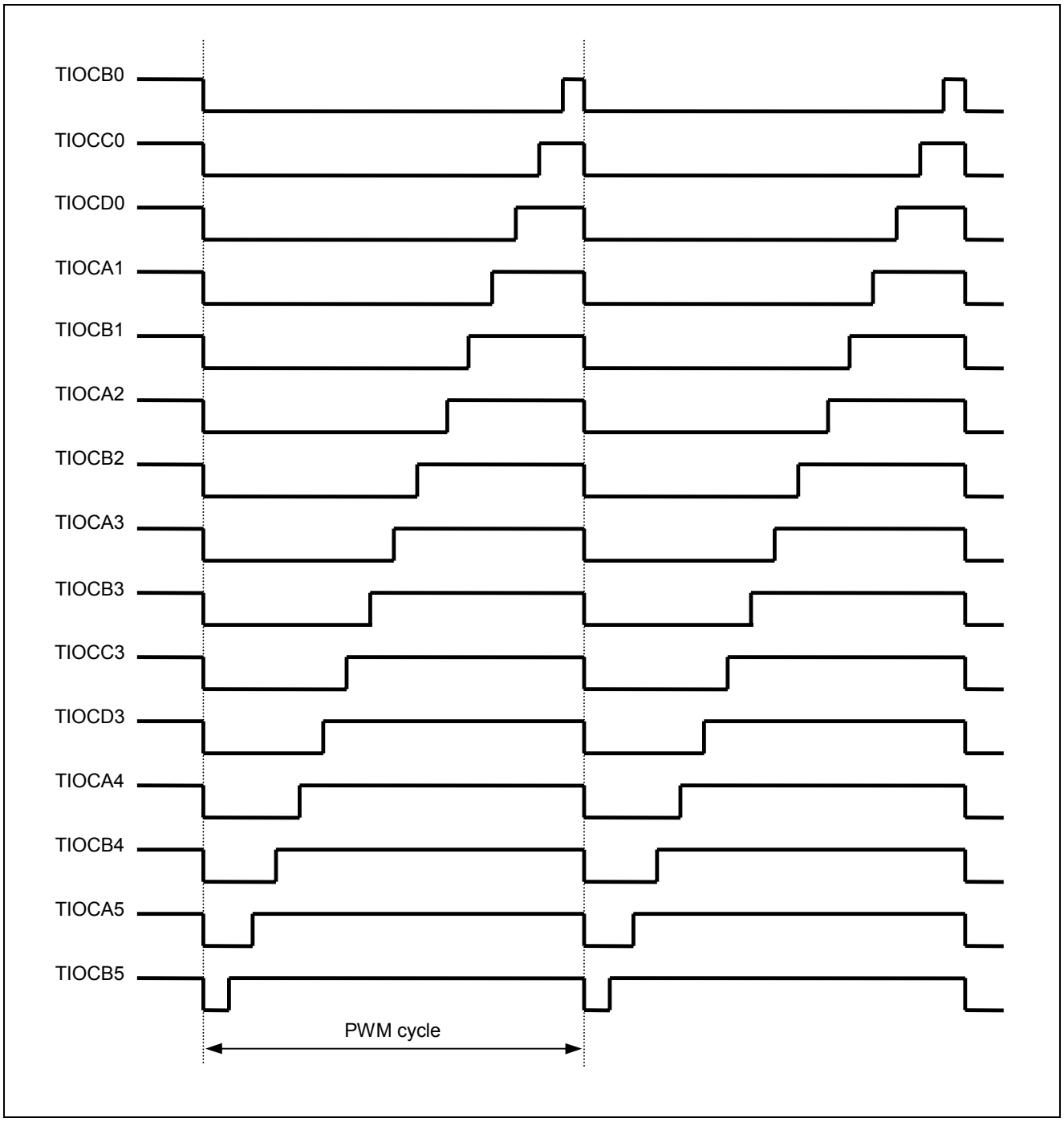


Figure 2 Example of PWM 15-Phase Output

3. Sample Program

3.1 Function

This sample program outputs PWM waveforms according to the timer value for the PWM cycle and each duty cycle (low or high width). You can calculate the timer value for the PWM cycle and each pulse low width using the following equations:

PWM-cycle = timer-value × TPU1-count clock
low-width = timer-value × TPU1-count-clock

Assume that the TPU1 count clock is peripheral module (Pϕ)/1. When Pϕ is 25 MHz, the TPU1 count clock will be 40 nsec. Figure 3 shows an example of operation.

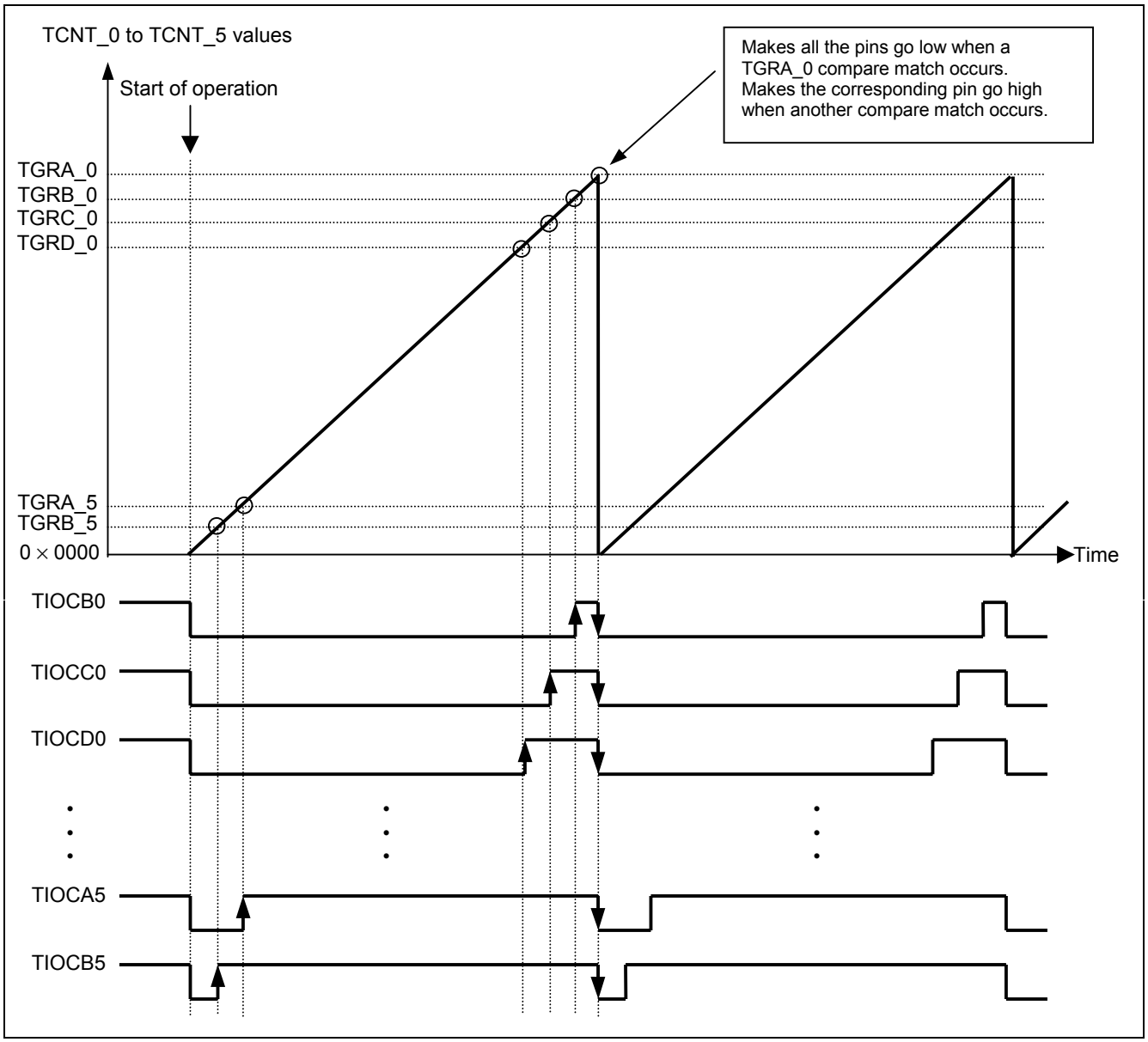


Figure 3 Example of PWM 15-Phase Output Operation

Table 1 lists the function allocations of the 16-bit timer pulse unit (TPU).

Table 1 Function Allocation of the TPU

Type		Name	Function
Common	Register	MSTPCRA	Cancels the TPU module stop mode.
		TSYR	Sets synchronous operation of TPU channels 0 to 5.
		TSTR	Specifies whether to start or stop timer count of TPU channels 0 to 5.
TPU0	Register	TMDR_0	Sets the TPU0 operating mode (PWM mode 2).
		TCR_0	Sets the TCNT_0 count clock and counter clear factor.
		TGRA_0	Sets the compare match counter value for the PWM cycle.
		TGRB_0 to TGRD_0	Sets the compare match counter value for the pulse output low width of each corresponding pin.
		TIORH_0 TIORL_0	Sets the output level when a compare match occurs.
	Output pin	TIOCB0 to TIOCD0	Compare match output pins
TPU1	Register	TMDR_1	Sets the TPU1 operating mode (PWM mode 2).
		TCR_1	Sets the TCNT_1 count clock and counter clear factor.
		TGRA_1 to TGRB_1	Sets the compare match counter value for the pulse output low width of each corresponding pin.
		TIOR_1	Sets the output level when a compare match occurs.
	Output pin	TIOCA1 to TIOCB1	Compare match output pins
TPU2	Register	TMDR_2	Sets the TPU2 operating mode (PWM mode 2).
		TCR_2	Sets the TCNT_2 count clock and counter clear factor.
		TGRA_2 to TGRB_2	Sets the compare match counter value for the pulse output low width of each corresponding pin.
		TIOR_2	Sets the output level when a compare match occurs.
	Output pin	TIOCA2 to TIOCB2	Compare match output pins
TPU3	Register	TMDR_3	Sets the TPU3 operating mode (PWM mode 2).
		TCR_3	Sets the TCNT_3 count clock and counter clear factor.
		TGRA_3 to TGRD_3	Sets the compare match counter value for the pulse output low width of each corresponding pin.
		TIORH_3 TIORL_3	Sets the output level when a compare match occurs.
	Output pin	TIOCA3 to TIOCD3	Compare match output pins
TPU4	Register	TMDR_4	Sets the TPU4 operating mode (PWM mode 2).
		TCR_4	Sets the TCNT_4 count clock and counter clear factor.
		TGRA_4 to TGRB_4	Sets the compare match counter value for the pulse output low width of each corresponding pin.
		TIOR_4	Sets the output level when a compare match occurs.
	Output pin	TIOCA4 to TIOCB4	Compare match output pins
TPU5	Register	TMDR_5	Sets the TPU5 operating mode (PWM mode 2).
		TCR_5	Sets the TCNT_5 count clock and counter clear factor.
		TGRA_5 to TGRB_5	Sets the compare match counter value for the pulse output low width of each corresponding pin.
		TIOR_5	Sets the output level when a compare match occurs.
	Output pin	TIOCA5 to TIOCB5	Compare match output pins

3.2 Function Specifications

The function that sets the PWM 15-phase output is shown as a sample program. The function specifications are listed below.

```
void  pwm15_set ( unsigned short  *low_ count, unsigned short  cyc_count )
```

Argument	Description
*low_count	Start address of the array for storing the timer value for the low width of each PWM pulse. A value between 0 × 0001 and 0 × FFFE can be specified for each array element. The value must be smaller than cyc_count. If 0 × 0000 or a value greater than or equal to cyc_count is specified, normal operation is not performed. Each array suffix corresponds to a PWM output pin, as follows: [0] ··· TIOCB0 [1] ··· TIOCC0 [2] ··· TIOCD0 [3] ··· TIOCA1 [4] ··· TIOCB1 [5] ··· TIOCA2 [6] ··· TIOCB2 [7] ··· TIOCA3 [8] ··· TIOCB3 [9] ··· TIOCC3 [10] ··· TIOCD3 [11] ··· TIOCA4 [12] ··· TIOCB4 [13] ··· TIOCA5 [14] ··· TIOCB5 The count clock is fixed to Pϕ/1.
cyc_count	Specifies the timer value for the PWM cycle. A value of between 0 × 0002 and 0 × FFFF can be specified. The value must be greater than each low_count element. If 0 × 0000 or a value smaller than or equal to low_count is specified, normal operation is not performed. The count clock is fixed to Pϕ/1.

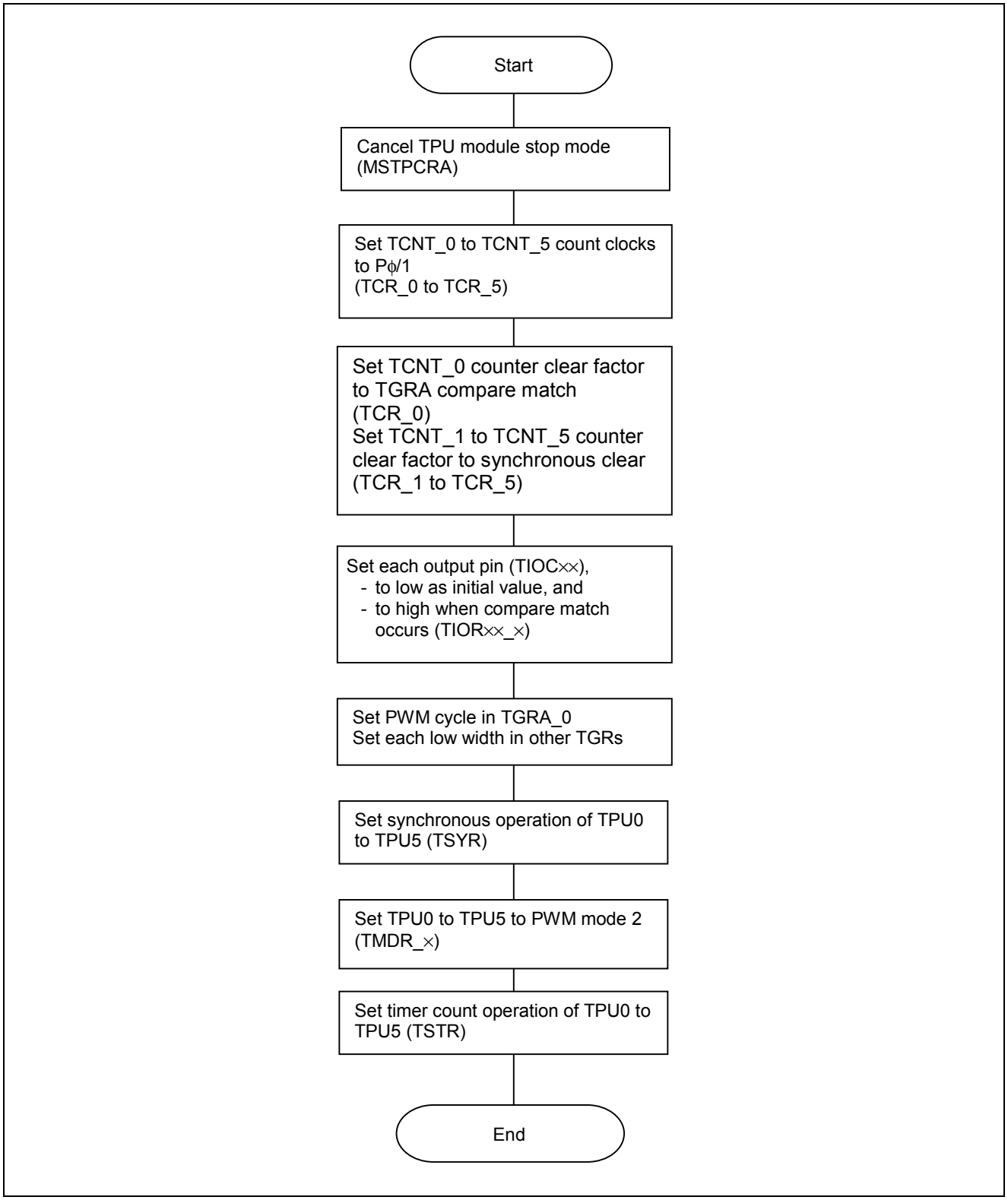
Return value	Description
None	—

Example)

```
#define CYCLE_TIME   2400                    // Pulse cycle:  2400 µsec
#define LOW_TIME_U    150                    // Low width:  150 µsec
#define P_CLOCK        25                    // Pϕ (MHz)
                                             // External function reference declaration
extern void  pwm15_set ( unsigned short *, unsigned short  );
void   main( void )                          // Main routine
{
   char                 i;                   // Loop counter
unsigned long  cyc_count;                    // Timer value for the pulse cycle
unsigned long  low_work;
unsigned short low_count[15];                // Timer value for the low width

   cyc_count = ((unsigned long)CYCLE_TIME*P_CLOCK);
   for ( i= 0; i<15; i++ )
   {
       low_work     =((unsigned long)(CYCLE_TIME - LOW_TIME_U*(i+1))*P_CLOCK);
              low_count [i]=(unsigned short)low_work;
   }
                                             // Sets pulse output.
   pwm15_set ( low_count,  (unsigned short)cyc_count );

. .

}
```

3.3 Flowchart

The processing flow is shown below.



3.4 Program Listing

A source program listing is shown below. In this source program, Renesas's standard definition (file automatically generated by High-performance Embedded Workshop: iodefine.h) defines the I/O register structure. To specify your own definition, change the I/O register structure in the sample program.

```
/************************************************************/
/* include file                                             */
/************************************************************/
#include <machine.h>
#include "iodefine.h"

/************************************************************/
/* function prototype                                       */
/************************************************************/
void pwm15_set( unsigned short *, unsigned short );

/************************************************************/
/* function definition                                      */
/************************************************************/
void  pwm15_set( unsigned short *low_count,
              unsigned short  cyc_count )
{
    P_MSTPCRA.BIT.MSTPA0 = 0;    // reset module-standby for TPU

    P_TPU0.TCR.BIT.TPSC  = 0;    // set TPU countup clock source
    P_TPU1.TCR.BIT.TPSC  = 0;
    P_TPU2.TCR.BIT.TPSC  = 0;
    P_TPU3.TCR.BIT.TPSC  = 0;
    P_TPU4.TCR.BIT.TPSC  = 0;
    P_TPU5.TCR.BIT.TPSC  = 0;

    P_TPU0.TCR.BIT.CCLR  = 1;    // set TPU counter clear cause
    P_TPU1.TCR.BIT.CCLR  = 3;
    P_TPU2.TCR.BIT.CCLR  = 3;
    P_TPU3.TCR.BIT.CCLR  = 3;
    P_TPU4.TCR.BIT.CCLR  = 3;
    P_TPU5.TCR.BIT.CCLR  = 3;

    P_TPU0.TIOR.BIT.IOA  = 0;    // set TPU output for terminal
    P_TPU0.TIOR.BIT.IOB  = 2;
    P_TPU0.TIOR.BIT.IOC  = 2;
    P_TPU0.TIOR.BIT.IOD  = 2;
    P_TPU1.TIOR.BIT.IOA  = 2;
    P_TPU1.TIOR.BIT.IOB  = 2;
    P_TPU2.TIOR.BIT.IOA  = 2;
    P_TPU2.TIOR.BIT.IOB  = 2;
    P_TPU3.TIOR.BIT.IOA  = 2;
    P_TPU3.TIOR.BIT.IOB  = 2;
    P_TPU3.TIOR.BIT.IOC  = 2;
    P_TPU3.TIOR.BIT.IOD  = 2;
    P_TPU4.TIOR.BIT.IOA  = 2;
    P_TPU4.TIOR.BIT.IOB  = 2;
```

```
    P_TPU5.TIOR.BIT.IOA  = 2;
    P_TPU5.TIOR.BIT.IOB  = 2;
                                // set TPU compare value
    P_TPU0.TGRA = (unsigned int)cyc_count;
    P_TPU0.TGRB = (unsigned int)low_count[ 0];
    P_TPU0.TGRC = (unsigned int)low_count[ 1];
    P_TPU0.TGRD = (unsigned int)low_count[ 2];
    P_TPU1.TGRA = (unsigned int)low_count[ 3];
    P_TPU1.TGRB = (unsigned int)low_count[ 4];
    P_TPU2.TGRA = (unsigned int)low_count[ 5];
    P_TPU2.TGRB = (unsigned int)low_count[ 6];
    P_TPU3.TGRA = (unsigned int)low_count[ 7];
    P_TPU3.TGRB = (unsigned int)low_count[ 8];
    P_TPU3.TGRC = (unsigned int)low_count[ 9];
    P_TPU3.TGRD = (unsigned int)low_count[10];
    P_TPU4.TGRA = (unsigned int)low_count[11];
    P_TPU4.TGRB = (unsigned int)low_count[12];
    P_TPU5.TGRA = (unsigned int)low_count[13];
    P_TPU5.TGRB = (unsigned int)low_count[14];

    P_TPU.TSYR.BIT.SYNC0 = 1;    // set TPU0～TPU5 synchronous
    P_TPU.TSYR.BIT.SYNC1 = 1;
    P_TPU.TSYR.BIT.SYNC2 = 1;
    P_TPU.TSYR.BIT.SYNC3 = 1;
    P_TPU.TSYR.BIT.SYNC4 = 1;
    P_TPU.TSYR.BIT.SYNC5 = 1;

    P_TPU0.TMDR.BIT.MD   = 3;    // set TPU0～TPU5 PWM-mode-2
    P_TPU1.TMDR.BIT.MD   = 3;
    P_TPU2.TMDR.BIT.MD   = 3;
    P_TPU3.TMDR.BIT.MD   = 3;
    P_TPU4.TMDR.BIT.MD   = 3;
    P_TPU5.TMDR.BIT.MD   = 3;

    P_TPU.TSTR.BIT.CST0  = 1;    // start TPU0～TPU5
    P_TPU.TSTR.BIT.CST1  = 1;
    P_TPU.TSTR.BIT.CST2  = 1;
    P_TPU.TSTR.BIT.CST3  = 1;
    P_TPU.TSTR.BIT.CST4  = 1;
    P_TPU.TSTR.BIT.CST5  = 1;
}
```

Revision Record

		Description	
Rev.	Date	Page	Summary
1.00	Sept.19.03	—	First edition issued

Keep safety first in your circuit designs!

1. Renesas Technology Corporation puts the maximum effort into making semiconductor products better and more reliable, but there is always the possibility that trouble may occur with them. Trouble with semiconductors may lead to personal injury, fire or property damage.
   Remember to give due consideration to safety when making your circuit designs, with appropriate measures such as (i) placement of substitutive, auxiliary circuits, (ii) use of nonflammable material or (iii) prevention against any malfunction or mishap.

Notes regarding these materials

1. These materials are intended as a reference to assist our customers in the selection of the Renesas Technology Corporation product best suited to the customer's application; they do not convey any license under any intellectual property rights, or any other rights, belonging to Renesas Technology Corporation or a third party.
2. Renesas Technology Corporation assumes no responsibility for any damage, or infringement of any third-party's rights, originating in the use of any product data, diagrams, charts, programs, algorithms, or circuit application examples contained in these materials.
3. All information contained in these materials, including product data, diagrams, charts, programs and algorithms represents information on products at the time of publication of these materials, and are subject to change by Renesas Technology Corporation without notice due to product improvements or other reasons. It is therefore recommended that customers contact Renesas Technology Corporation or an authorized Renesas Technology Corporation product distributor for the latest product information before purchasing a product listed herein.
   The information described here may contain technical inaccuracies or typographical errors.
   Renesas Technology Corporation assumes no responsibility for any damage, liability, or other loss rising from these inaccuracies or errors.
   Please also pay attention to information published by Renesas Technology Corporation by various means, including the Renesas Technology Corporation Semiconductor home page (http://www.renesas.com).
4. When using any or all of the information contained in these materials, including product data, diagrams, charts, programs, and algorithms, please be sure to evaluate all information as a total system before making a final decision on the applicability of the information and products. Renesas Technology Corporation assumes no responsibility for any damage, liability or other loss resulting from the information contained herein.
5. Renesas Technology Corporation semiconductors are not designed or manufactured for use in a device or system that is used under circumstances in which human life is potentially at stake. Please contact Renesas Technology Corporation or an authorized Renesas Technology Corporation product distributor when considering the use of a product contained herein for any specific purposes, such as apparatus or systems for transportation, vehicular, medical, aerospace, nuclear, or undersea repeater use.
6. The prior written approval of Renesas Technology Corporation is necessary to reprint or reproduce in whole or in part these materials.
7. If these products or technologies are subject to the Japanese export control restrictions, they must be exported under a license from the Japanese government and cannot be imported into a country other than the approved destination.
   Any diversion or reexport contrary to the export control laws and regulations of Japan and/or the country of destination is prohibited.
8. Please contact Renesas Technology Corporation for further details on these materials or the products contained therein.