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.

SH7144/45 Group

2-Phase Encoder Count

1. Specifications

Two external clocks are input to channel 1 (ch1), and a counter is incremented or decremented according to the phase difference of the pulses, as shown in figure 1. The ch1 count is measured in synchronization with a measurement times set in ch0 (measurement times 1 and 2), and the result is set in RAM.

H'0000 is set as the timer counter initial value, and counting can be performed from -2,147,483,648 to 2,147,483,647 using a software counter.

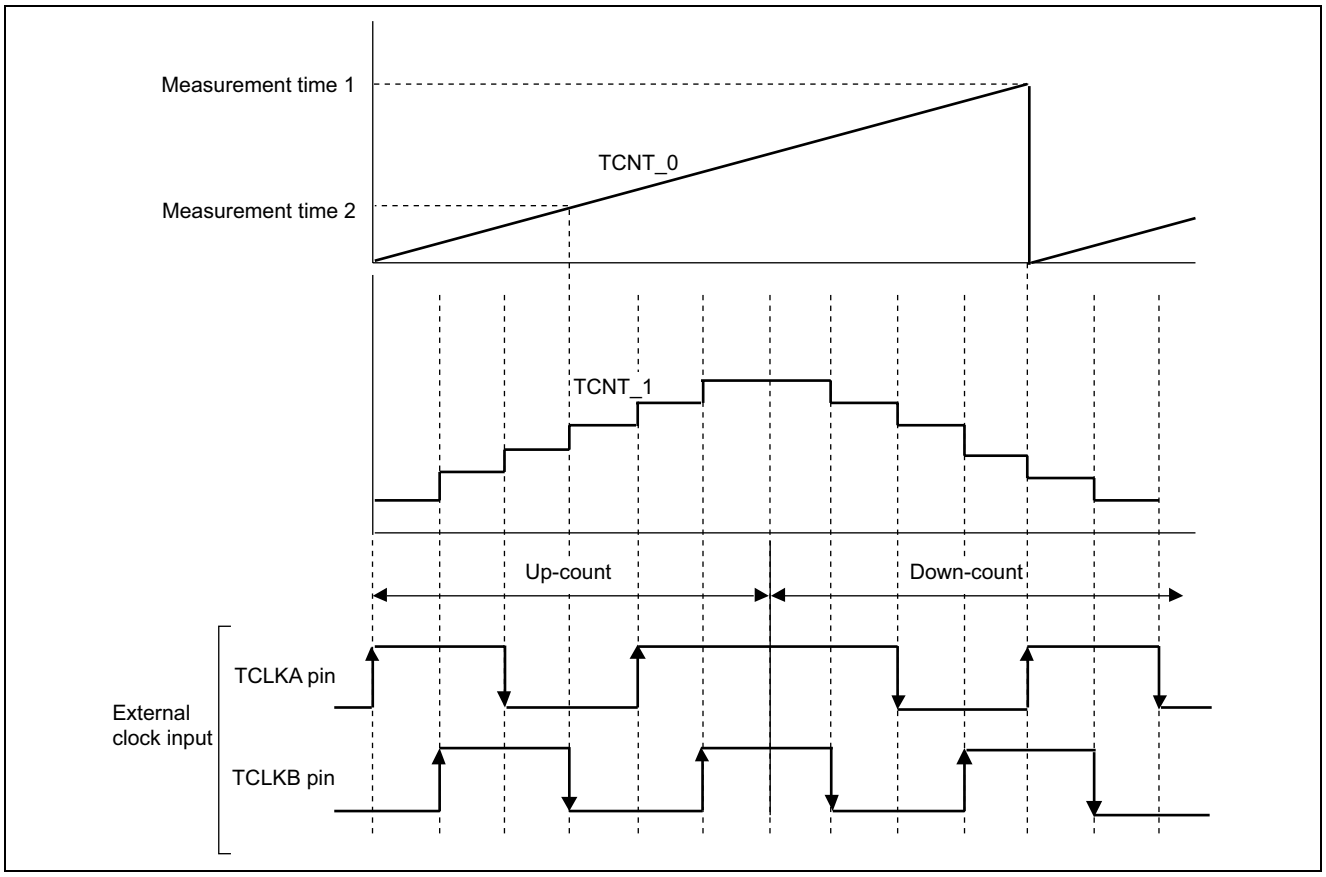


Figure 1 2-Phase Encoder Counter Capture

2. Functions Used

In this sample task, measurement times are set in TGRA/B_0 using an MTU ch1 up/down-counter.

Using a TGRA/B_0 output compare as a trigger, the TCNT_1 value for the control period is captured by ch1 input capture. In addition, the ch1 counter input clock width is captured using ch0 input capture.

Figure 2 shows a block diagram of ch0. In ch0, a ch1 input capture trigger is output every measurement time using the following functions. In ch1, the TCNT_1 value is measured when an input capture signal is input.

- A function that outputs pulses automatically by hardware without software intervention (output compare)
- A function that performs pulse input edge detection, and captures a timer value in an internal register (input capture)

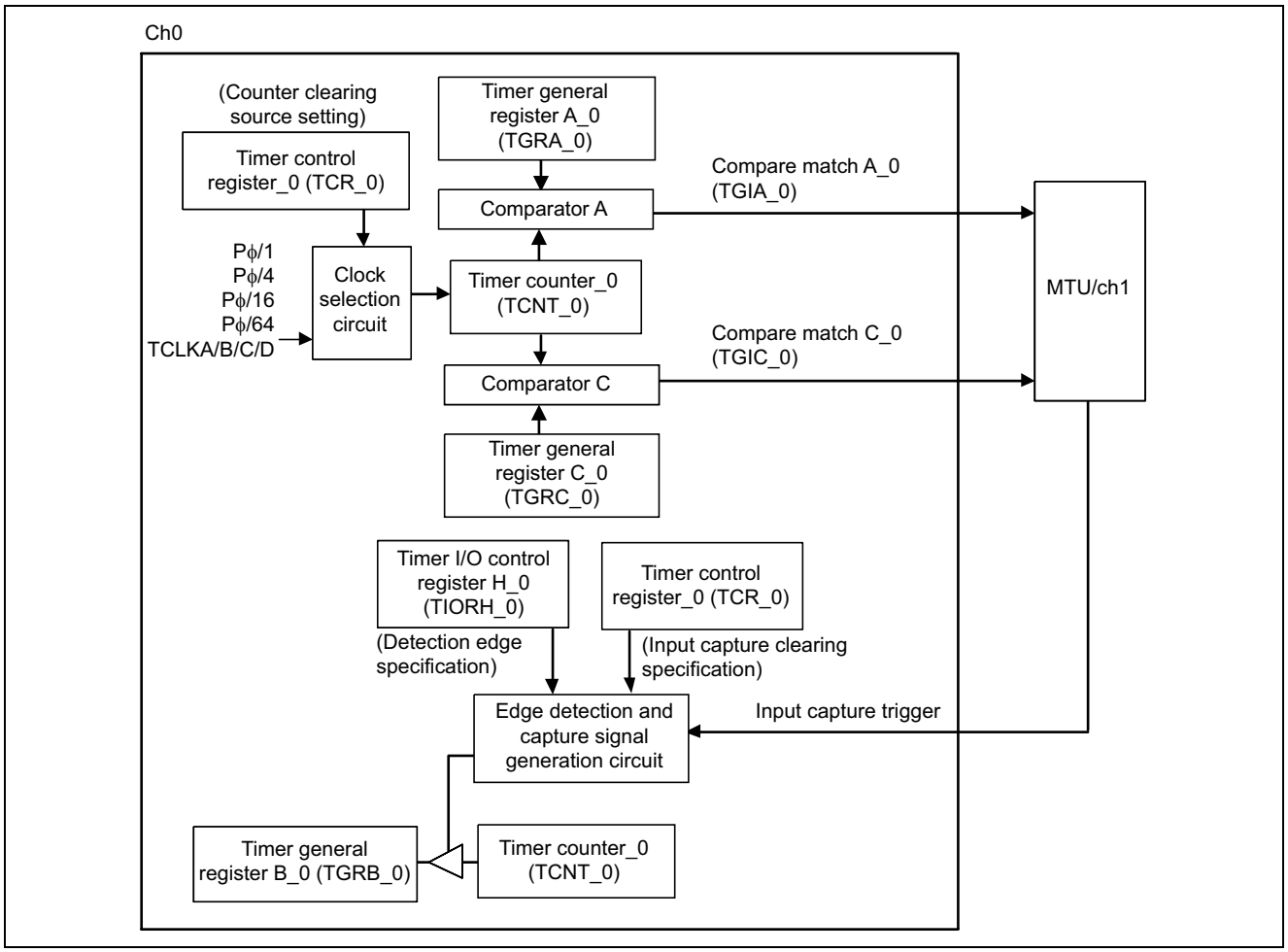


Figure 2 Block Diagram of MTU/ch0

Figure 3 shows a block diagram of ch1. In ch1, a timer counter is incremented/decremented using the following functions. The counter value when an input capture signal rising edge is detected is taken as the measurement result.

- A function that detects the phase difference between two external clocks, and increments/decrements a timer counter (phase counting mode)
- A function that performs pulse input edge detection, and captures a timer value in an internal register (input capture)
- A function that initiates interrupt handling when input capture occurs
- A function that clears the timer counter when a pulse input edge is detected
- A function that initiates interrupt handling when timer counter overflow or underflow is detected

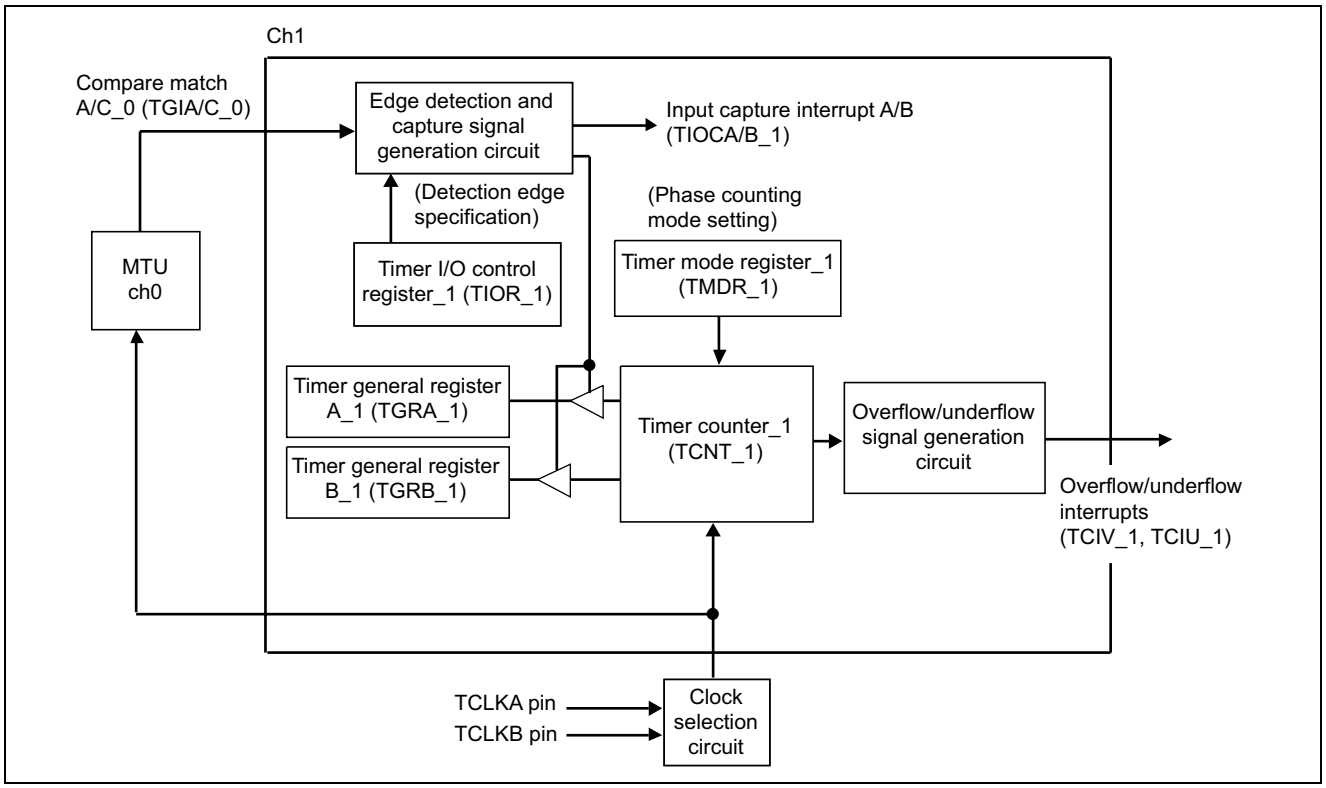


Figure 3 Block Diagram of MTU/ch1

Table 1 shows the function assignments used in this sample task. MTU functions are assigned as shown in the table to detect the phase difference between two 2-phase encoder pulses, and increment/decrement a counter.

Table 1 Function Assignments

Pin or Register Name	Function Assignment
TCLKA	External clock input pins
TCLKB	
TSTR	Enabling/disabling of MTU ch0, ch1 timer counter operation
TCR_0	Selection of counter clock and counter clearing source
TIORH_0	TIOC0A output compare setting. Setting of TIOC0B for input capture on TCNT_1 increment/decrement
TIORL_0	TIOC0C output compare setting
TGRA_0	Measurement time 1 setting
TGRB_0	Count result stored on input capture B
TGRC_0	Measurement time 2 setting
TMDR_1	Sets phase counting mode for MTU/ch1
TCR_1	Selection of counter clock and counter clearing source
TIOR_1	Setting of TIOC1A/B for input capture on TGRA_0, TGRC_0 output compare occurrence
TIER_1	Enables TIOC1A/B, TCIU_1, TCIV_1 interrupts
TGRA_1	Count result storage on input capture
TGRB_1	

3. Principles of Operation

Figure 4 illustrates the principles of operation. A counter is incremented or decremented by SH7145 hardware and software processing.

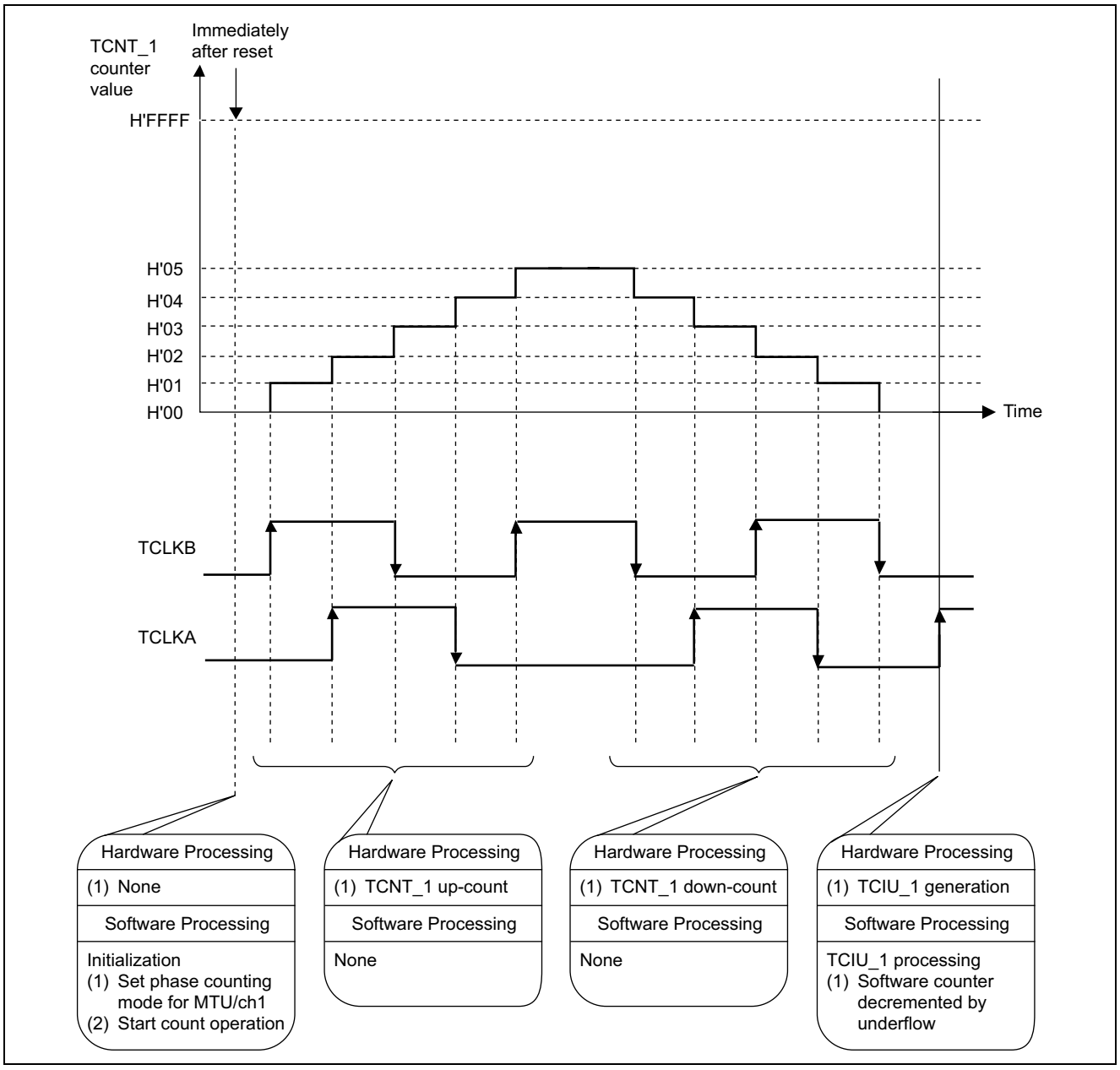


Figure 4 Principles of Operation in Phase Counting Mode (1)

The TCNT_1 count is measured on MTU/ch0 output compare occurrence by means of SH7145 hardware and software processing as shown in figure 5.

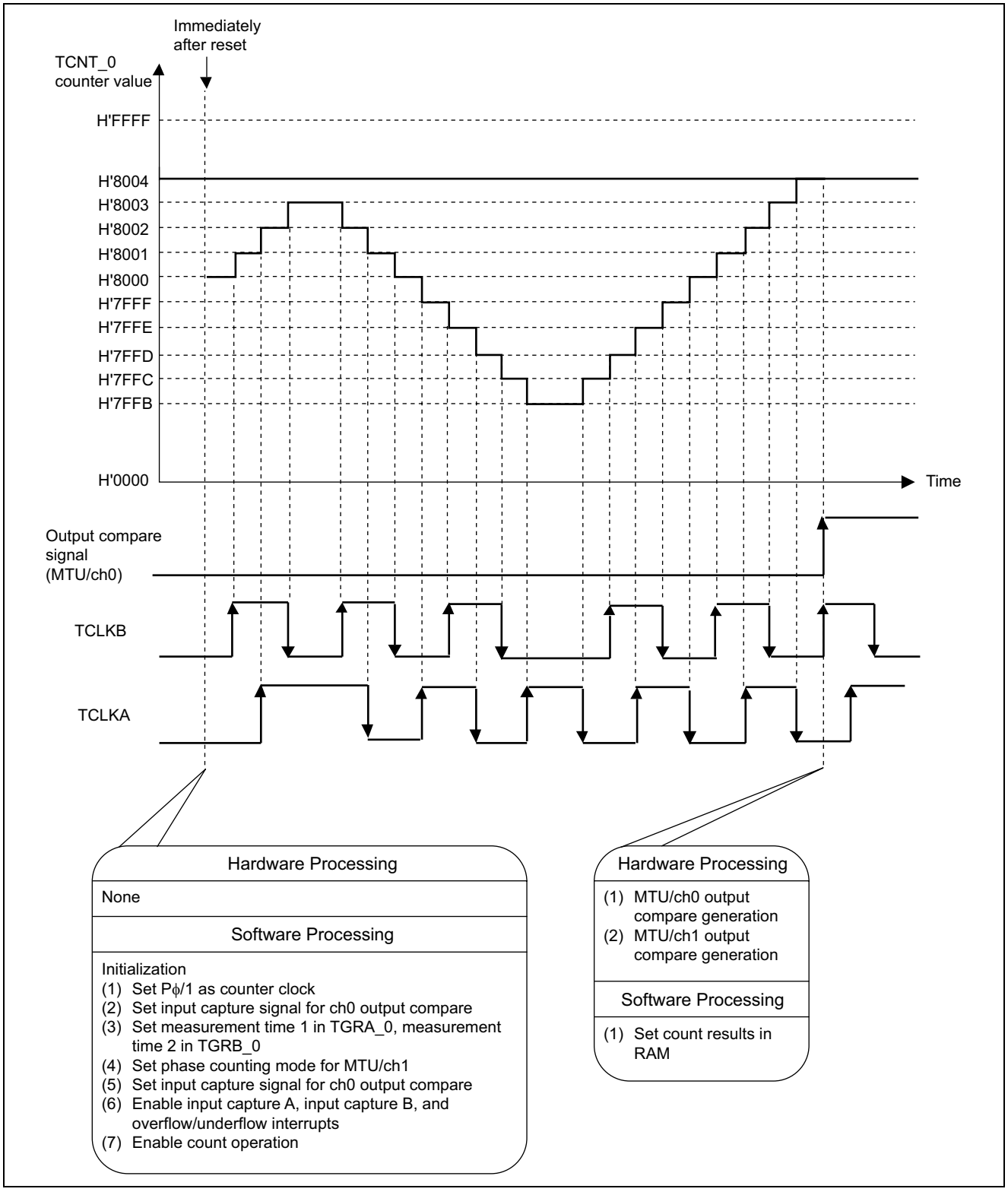


Figure 5 Principles of Operation in Phase Counting Mode (2)

4. Software

(1) Modules

Module Name	Label	Function Assignment
Main routine	en2	Initialization of MTU, etc.
Counter value measurement 1	phacnt1	Initiated by TGIA_1. Sets up/down-count result in RAM based on TGRA_1 value. Sets counter period result in RAM based on TGRB_0 value
Counter value measurement 2	phacnt2	Initiated by TGIB_1. Sets up/down-count result in RAM based on TGRB_1 value
Overflow	ovf1	Initiated by TGIV_1. Software counter incrementing
Underflow	unf1	Initiated by TGIU_1. Software counter decrementing

(2) Arguments

Label or Register Name	Function Assignment	Data Length	Module	Input/Output
msr_tim1 msr_tim2	Used to set timer value for counter measurement time Measurement time is calculated using following equation: Measurement time (ns) = timer value × ϕ period (25.0 ns at 40.0 MHz operation)	Word	Main routine	Input
cnt_data1 cnt_data2	Used to set up/down-count results	Longword	Counter value measurement 1 Counter value measurement 2	Output
p_cycle	Used to set count period result	Longword	Counter value measurement 2	

(3) Internal Registers Used

Register Name	Function	Address	Set Value
P_STBY.MSTCR2	MTU module standby mode clearing	H'FFFF861E	H'd0fd
P_PORTA.PACRL2	Sets PA6 as TCLKA input pin, PA7 as TCLKB input pin	H'FFFF838E	H'5000
P_MTU0.TCR_0	Selection of counter clock and counter clearing source	H'FFFF8260	H'20
P_MTU0.TIORH_0	TIOC0A output compare setting. Setting of TIOBC0B for input capture on TCNT_1 increment/decrement	H'FFFF8262	H'f0
P_MTU0.TIORL_0	TIOC0C output compare setting	H'FFFF8263	H'00
P_MTU0.TGRA_0	Measurement time 1 setting	H'FFFF8268	msr_tim1
P_MTU0.TGRC_0	Measurement time 2 setting	H'FFFF826C	msr_tim2
P_MTU1.TMDR_1	Sets phase counting mode	H'FFFF8281	H'04
P_MTU1.TIOR_1	Setting of TIOC1A/B for input capture on TGRA_0, TGRC_0 output compare occurrence	H'FFFF8282	H'ff
P_MTU1.TIER_1	Enables interrupts by TGIA/B, TCIU_1, TCIV_1	H'FFFF8284	H'73
P_INTC.IPRD	Sets 15 as MTU0, MTU1 interrupt priority level	H'FFFF834E	H'00ff

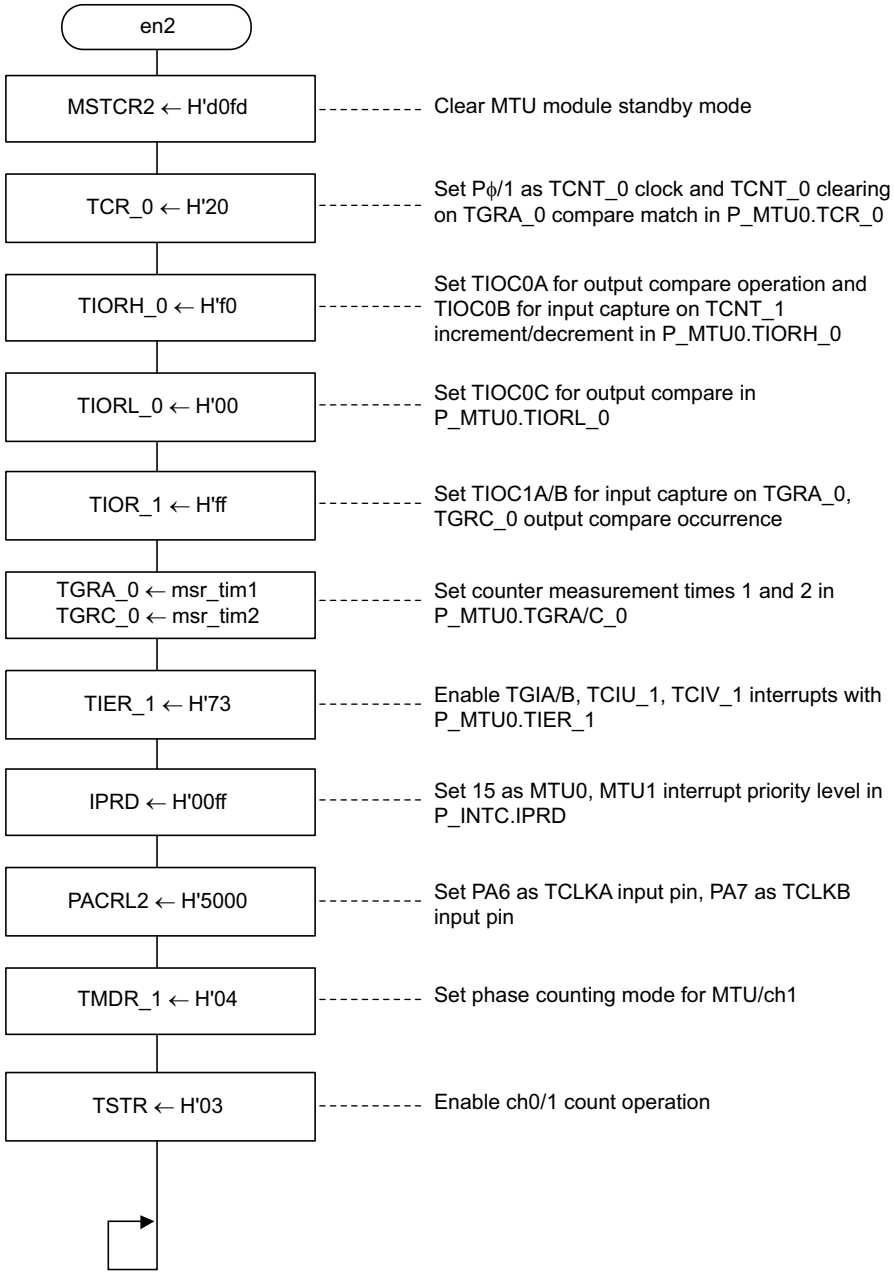
(4) RAM Used

Module	Label	Function Assignment
Counter value measurement 1, 2	wrk	Used as work area for data setting
All modules	cnt	Software counter

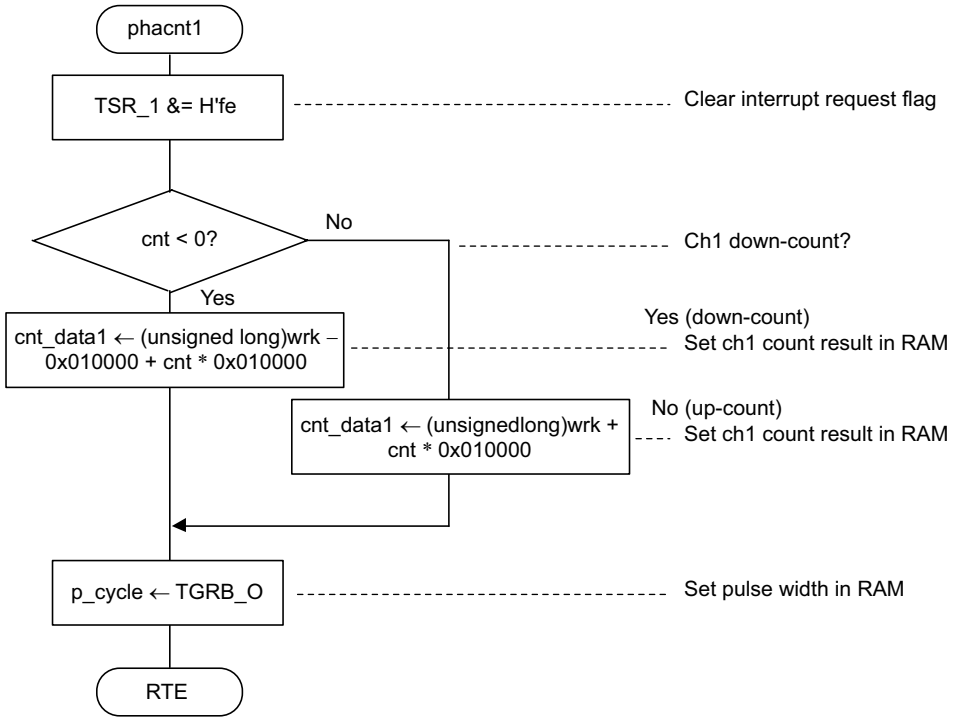
Note: SH7145 header file names are used for register label names.

5. Flowcharts

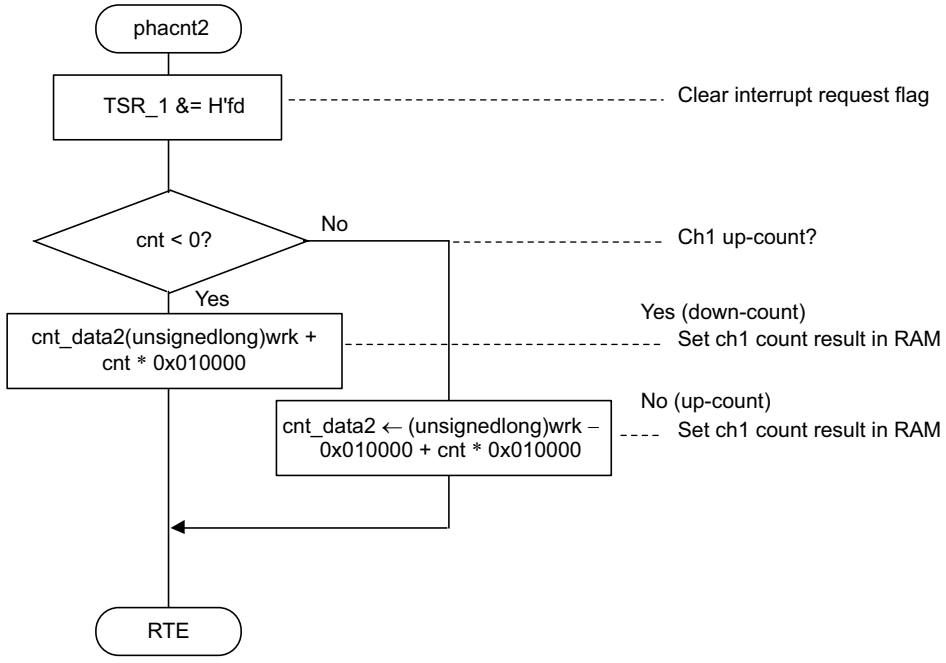
(1) Main routine



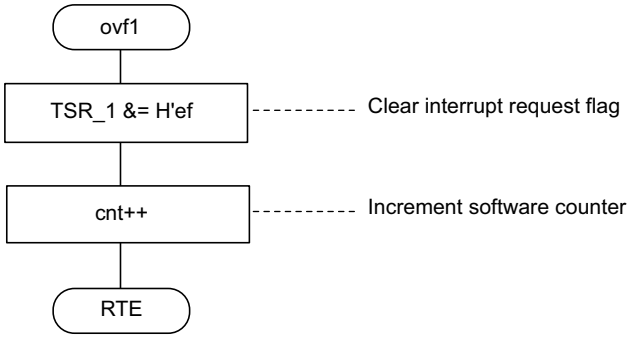
(2) Counter value measurement 1



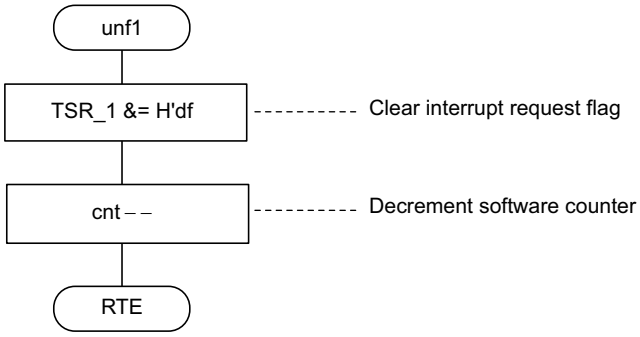
(3) Counter value measurement 2



(4) Overflow



(5) Underflow



6. Program Listing

```
/*----------------------------------------------------------------------*/
/*                           INCLUDE FILE                               */
/*----------------------------------------------------------------------*/
#include <machine.h>
#include "iodefine_7145F.h"
/*----------------------------------------------------------------------*/
/*                            PROTOTYPE                                 */
/*----------------------------------------------------------------------*/
void en2(void);
#pragma interrupt(phacnt1,phacnt2,ovf1,unf1)
/*----------------------------------------------------------------------*/
/*                        RAM ALLOCATION                                */
/*----------------------------------------------------------------------*/
#define msr_tim1    (*(unsigned short *)0xffffe000)
#define msr_tim2    (*(unsigned short *)0xffffe002)
#define cnt_data2   (*(signed long *)0xffffe004)
#define cnt_data1   (*(signed long *)0xffffe008)
#define p_cycle     (*(unsigned long *)0xffffe00c)
#define cnt         (*(signed long *)0xffffe010)
#define wrk         (*(unsigned short *)0xffffe014)
/*----------------------------------------------------------------------*/
/*                          MAIN PROGRAM                                */
/*----------------------------------------------------------------------*/
void en2(void)
 {
   P_STBY.MSTCR2.WORD = 0xd0fd;    /* MTU module stop mode clear */
   P_MTU_0.TCR_0.BYTE = 0x20;      /* timer clear output compare TGRA_0 */
   P_MTU_0.TIORH_0.BYTE = 0xf0;    /* output compare TIOC0B */
   P_MTU0.TIORL_0.BYTE = 0x00;     /* output compare TIOC0C */
   P_MTU1.TIOR_1.BYTE = 0xff;      /* input capture TIOC1A,B */
   P_MTU1.TIER_1.BYTE = 0x73;      /* enable TGIA,TGIB,TCIU,TCIV */
   P_MTU0.TGRC_0 = msr_tim2;       /* set position cycle */
   P_MTU0.TGRA_0 = msr_tim1;       /* set speed cycle */
   INTC.IPRD.WORD = 0x00ff;        /* set interrupt level=15 */
   P_PORTA.PACRL2.WORD = 0x5000;   /* TCLKA,TCLKB select */
   P_MTU1.TMDR_1.BYTE = 0x04;      /* set phase counting mode1 */
   P_MTU34.TSTR.BYTE = 0x03;       /* start MTU/ch0,1 */
   set_imask(0x0);                 /* set imask level=0 */
   while(1);                       /* loop */
  }

void phacnt1(void)
 {
  P_MTU1.TSR_1.BYTE &= 0xfe;                                /* clear flag */
  wrk = P_MTU1.TGRA_1;
  if(cnt < 0)                                               /* down count? */
     cnt_data1 = (unsigned long)wrk-0x010000+cnt*0x010000;  /* set sp */
  else
     cnt_data1 = (unsigned long)wrk+cnt*0x010000;           /* set sp */
     p_cycle = P_MTU0.TGRB_0;                               /* set width pulse */
 }
```

```
void phacnt2(void)
 {
   P_MTU1.TSR_1.BYTE &= 0xfd;                                  /* clear flag */
   wrk = P_MTU1.TGRB_1;
   if(cnt < 0)
      cnt_data2 = (unsigned long)wrk+cnt*0x010000;             /* set po */
   else
      cnt_data2 = (unsigned long)wrk-0x010000+cnt*0x010000;    /* set po */
 }


void ovf1(void)
 {
    P_MTU1.TSR_1.BYTE &= 0xef;                                 /* clear flag */
     cnt++;                                                    /* count up */
 }


void unf1(void)
 {
    P_MTU1.TSR_1.BYTE &= 0xdf;                                 /* clear flag */
    cnt--;                                                     /* count down */
 }
```

Keep safety first in your circuit designs!

1. Renesas Technology Corp. 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 Corp. 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 Corp. or a third party.
2. Renesas Technology Corp. 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 Corp. without notice due to product improvements or other reasons. It is therefore recommended that customers contact Renesas Technology Corp. or an authorized Renesas Technology Corp. 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 Corp. 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 Corp. by various means, including the Renesas Technology Corp. 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 Corp. assumes no responsibility for any damage, liability or other loss resulting from the information contained herein.
5. Renesas Technology Corp. 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 Corp. or an authorized Renesas Technology Corp. 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 Corp. 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 Corp. for further details on these materials or the products contained therein.