

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.

M16C/28, 29 Group

16-Bit PWM Output with the Single-phase Waveform Output Mode of Timer S

1. Abstract

This application note shows the PWM output of variable period and duty by using the waveform generation function of Timer S.

2. Introduction

This application note is applied to the following microcomputers:

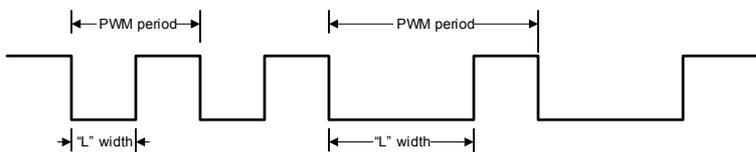
- MCU: M16C/28 Group
- M16C/29 Group

3. Detailed description

Timer S has one 16-bit base timer for free-run operation and eight 16-bit registers (channel 0 to 7) for the time measurement function and the waveform generation function.

In this example, PWM period is set in the base timer reset register, and "L" width is set in the channel j (j=0 to 7). And PWM waveform is output from the OUTC1j pin for channel j.

PWM Output Waveform



(1) PWM Period

The base timer is reset by matching the base timer reset register (G1BTRR Register) with the base timer. The formula of the PWM period is shown below.

$$\text{PWM period: } \frac{1}{f_{BT1}} \times (n+2)$$

Where

- f_{BT1} is the count source frequency of the base timer.
- 'n' is a setting value for the G1BTRR register.

(2) "L" Width

The channel j is used in the single-phase waveform output mode of the waveform generation function. "L" width can be calculated by the following formula.

$$\text{"L" width: } \frac{1}{f_{BT1}} \times m$$

Where

- "m" is a setting value for the G1P0j register.
- INV bit in the G1P0CRj register is "0" (output is not inverted).

(3) PWM Period and “L” Width Modification

The PWM period and “L” width can be modified by rewriting the G1BTRR and G1P0j registers during the base timer interrupt process.

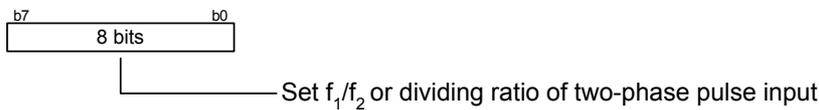
3.1 How to Set Up

This section shows setting procedures and values to execute “3.Detailed Description”. Refer to the hardware manual (M16C/28 Group or M16C/29 Group) for details of each register.

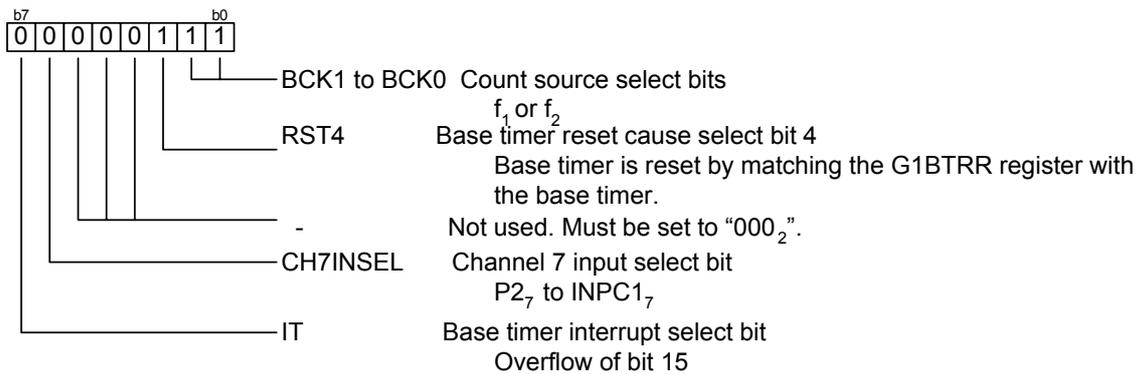
(1) Inhibiting an Interrupt

Set I flag=“0”. Or set interrupt priority level=“000₂” in interrupt control register that received interrupt requests issued by the timer S to be used.

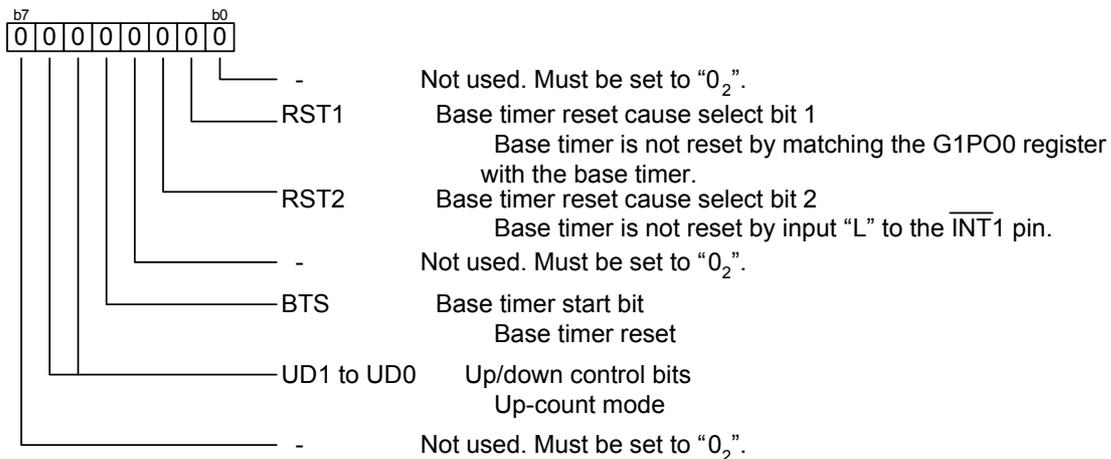
(2) G1DV register



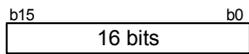
(3) G1BCR0 register



(4) G1BCR1 register



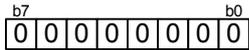
(5) G1BTRR register



PWM period can be set.
When a setting value is n, the PWM period can be obtained from

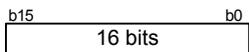
$$\frac{1}{f_{BT1}} \times (n+2)$$

(6) G1POCR0 to G1POCR7 register



- MOD1 to MOD0 Operation mode select bits
Single-phase waveform output mode
- Not used. Must be set to "00₂".
- IVL Output initial value select bit
Output "0" as an initial value
- RLD Register reload timing select bit
Reloaded when writing
- Not used. Must be set to "0₂".
- INV Invert output function select bit
Output is not inverted

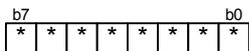
(7) G1PO0 to G1PO7 register



"L" width can be set.
"L" width time is defined by the following formula, where "m" is a setting value of G1PO register.

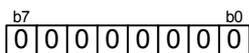
$$\frac{1}{f_{BT1}} \times m$$

(8) G1FS register



FSC7 to FSC0 Channel 7 to 0 time measurement/ waveform generation function select bits
Select waveform generation function
(Note) It does not matter either "0" or "1" is set to other channels.

(9) G1IE0 register

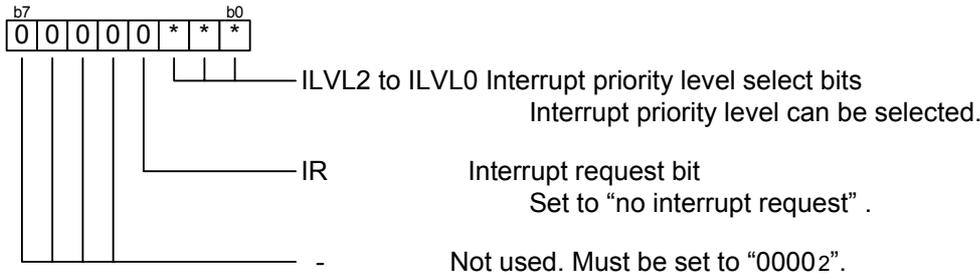


G1IE7 to G1IE0 Set the channels of unused interrupt to "0".

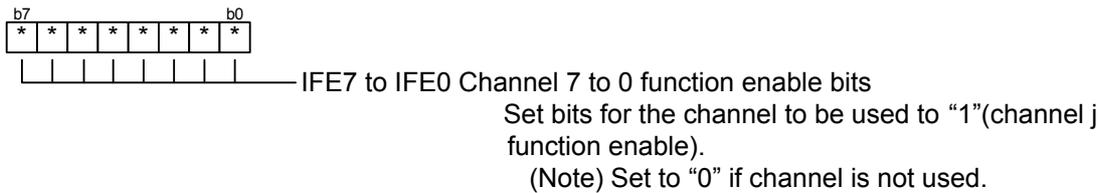
(10) G1IR register



(11) BTIC register



(12) G1FE register



3.2 Precaution on Interrupt

In the process of Timer S interrupt, the description varies depending on the interrupt routine by the base timer or by each channel.

In the case of the base timer interrupt, interrupt request bit is "0" when the request is accepted. (It is not necessary to set to "0" by the program.)

In the case of interrupt by each channel, interrupt requests for each channel are set in the interrupt request register (G1IR Register). When an interrupt request in the channel i occurs, the bit i in the G1IR Register is set to "1".

If the bit i in the interrupt enable register 0 (G1IE0 Register) is "1", the interrupt request bit in the IC/OC0 interrupt control register (ICOC0IC Register) is set to "1".

If the bit i in the G1IE1 register is "1", the interrupt request bit in the IC/OC1 interrupt control register (ICOC1IC Register) is set to "1".

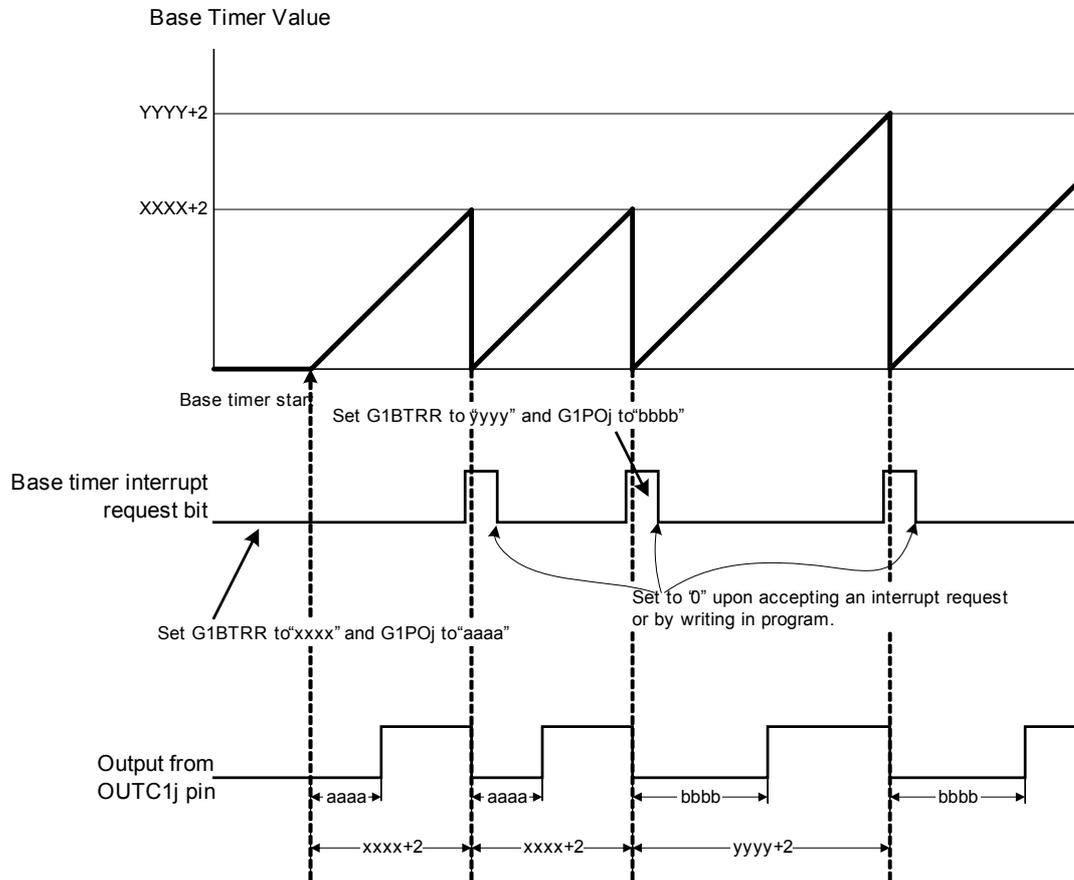
Interrupt request bits in the IC/OC0 and IC/OC1 interrupt control register are set to "0" automatically when they receive the interrupt request. However the interrupt request bits of each channel in the G1IR register are not set to "0" automatically, so set to "0" (no interrupt request) by the program.

Use the following instructions when writing "0" to each bit in the G1IR register.

AND, BCLR

3.3 Timing Diagram

The following diagram shows PMW output according to the section "3.1" and "3.2".



4. Sample Program

```

/*****
 *
 * FILE NAME :
 * Version : 1.10
 * Function : 16-bit PWM
 *
 * Copyright (C)2004, Renesas Technology Corp.
 * Copyright (C)2004, Renesas Solutions Corp.
 *
 *****/
/*****
 * include file
 *****/
#include "sfr28.h"

/*****
 * Function Definition
 *****/
void bt_int(void);
#pragma INTERRUPT bt_int

void port_init(void);
void icoc_init(void);
/*****
 * main
 *****/
void main(void) {

    port_init();
    icoc_init();

    bts_glbcr1 = 1;          /* Base Timer Start */
    asm (" fset I");
    while (1) {
    }

}

void port_init() {
    p0 = 0;
    p1 = 0;
    p2 = 0;
    p3 = 0;

    p7 = 0;
    p8 = 0;
    p9 = 0;
    p10 = 0;

    pd0 = 0xff;
    pd1 = 0xff;
    pd2 = 0x00;
    pd3 = 0xff;

    pd7 = 0xff;
    pd8 = 0xff;
    prcr = 4;
    pd9 = 0xff;
    pd10 = 0xff;

    ifsr2a = 1;

}

void icoc_init() {

    gldv = 20-1;          /* fBT is 1MHz */
    glbcr0 = 0x07;

```

```

glbcr1 = 0x00;          /* The base timer is reset by matching the G1P00 regiser */

glbtrr = 4000-2;

glpocr0 = 0x00;        /* ch-0 Single waveform output mode */
glpo0 = 3500;

glpocr1 = 0x00;        /* ch-1 Single waveform output mode */
glpo1 = 500;

glpocr4 = 0x00;        /* ch-4 Single waveform output mode */
glpo4 = 2000;

glpocr5 = 0x00;        /* ch-5 Single waveform output mode */
glpo5 = 3000;

glfs = 0x00;          /* ch-0,7 Waveform generation function select */

glie0 = 0x00;         /* Interrupt enable register 0 set */

glir = 0;             /* Interrupt request register initialize */

btic = 0x04;          /* IC/OC 0 Interrupt control register set */

glfe = 0x33;          /* ch-0,ch-4 function enable */
}

void bt_int() {
    p1++;
    if (p1==5) {
        glbtrr = 6000-2;
        glpo0 = 4000;
        glpo1 = 1000;
        glpo4 = 4000;
        glpo5 = 5500;
        p10_7 = 1;
    }
    if (p1==10) {
        glbtrr = 4000-2;
        glpo0 = 3500;
        glpo1 = 500;
        glpo4 = 2000;
        glpo5 = 3000;
        p1=0;
        p10_7 = 0;
    }
}

```

5. Example of PWM Output

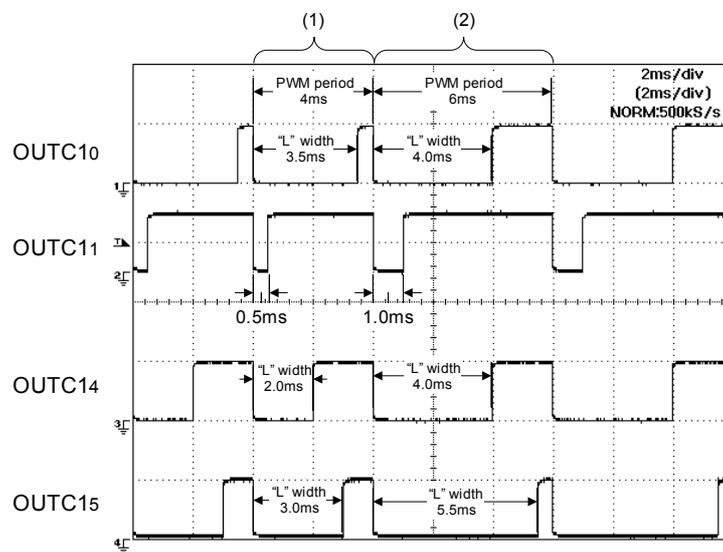
The following shows examples of the PWM output from OUTC1₀(P2₀), OUTC1₁(P2₁), OUTC1₄(P2₄) and OUTC1₅(P2₅) when the Timer S is used.

Conditions: Supply voltage = 5V

Main clock = 20MHz

Base timer operation clock (f_{BT1}) = 1MHz

Item	Register	(1) in the following figure	(2) in the following figure
PWM period	G1BTRR	Setting value n = 3998 $1 \mu\text{s} \times (3998+2) = 4.00\text{ms}$	Setting value n = 5998 $1 \mu\text{s} \times (5998+2) = 6.00\text{ms}$
"L" width of OUTC1 ₀ (P2 ₀) output	G1P00	Setting value m = 3500 $1 \mu\text{s} \times 3500 = 3.50\text{ms}$	Setting value m = 4000 $1 \mu\text{s} \times 4000 = 4.00\text{ms}$
"L" width of OUTC1 ₁ (P2 ₁) output	G1P01	Setting value m = 500 $1 \mu\text{s} \times 500 = 0.50\text{ms}$	Setting value m = 1000 $1 \mu\text{s} \times 1000 = 1.00\text{ms}$
"L" width of OUTC1 ₄ (P2 ₄) output	G1P04	Setting value m = 2000 $1 \mu\text{s} \times 2000 = 2.00\text{ms}$	Setting value m = 4000 $1 \mu\text{s} \times 4000 = 4.00\text{ms}$
"L" width of OUTC1 ₅ (P2 ₅) output	G1P05	Setting value m = 3000 $1 \mu\text{s} \times 3000 = 3.00\text{ms}$	Setting value m = 5500 $1 \mu\text{s} \times 5500 = 5.50\text{ms}$



6. Reference

Hardware Manual

M16C/28 Group Hardware Manual

M16C/29 Group Hardware Manual

(The latest version is available on the website: <http://www.renesas.com>)

7. Website and Contact for Support

Renesas Website

<http://www.renesas.com/>

For technical information related to M16C family

E-mail: support_apl@renesas.com

REVISION HISTORY

Rev.	Date	Description	
		Page	Summary
1.00	2004.09.23	-	First edition issued
1.10	2004.11.30	3,4,6,7	How to set up revised

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.