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 Family

How to Generate Variable Resolution PWM Using IAR C-Compiler

Introduction

This application note describes how to make use of the M16C family of microcontrollers one shot Timer mode to generate user defined PWM resolution.

M16C devices are able to automatically generate 5 independent PWM outputs. This is called the timer A PWM mode, but these have fixed selectable resolution of 8 or 16bit. The 8bit PWM mode can achieve high frequencies (up to 93KHZ) with a relatively low resolution while the 16bit PWM mode is high resolution but quite low frequency (typically fXin/65536) ranging from a few HZ to a maximum of 366HZ.

Many applications may need to have resolutions higher than 8bit, with higher PWM frequency than 16bit resolution can achieve. Therefore this application note explains how M16C is initialized in order to generate a 10bit resolution PWM without any CPU load, external hardware or extra MCU pin usage.

Contents

Operation mode

M16C family processors have two Timer groups which are group A and group B. For any of the M16C devices a minimum of three type B timers and five type A timers are integrated (M16C6x and M32C have six B type timers).

Please note that only type A timers have output function which restricts output signal generation to these timers only.

The B group timers can be used to measure external signals and/or generate internal signals as well as interrupts.

Of the group B timers, timer B2 (TB2) internal overflow output is distributed (and made available) to the group A timers which makes it useful for this application note.

In this application note Timer A3 (TA3) has been chosen to generate the PWM output signal but any other group A timer could be used as well as they all have TB2 as trigger source. TA3 is programmed in one shot timer mode trigged by TB2. No external connection is needed which allows to optimise the pin usage.

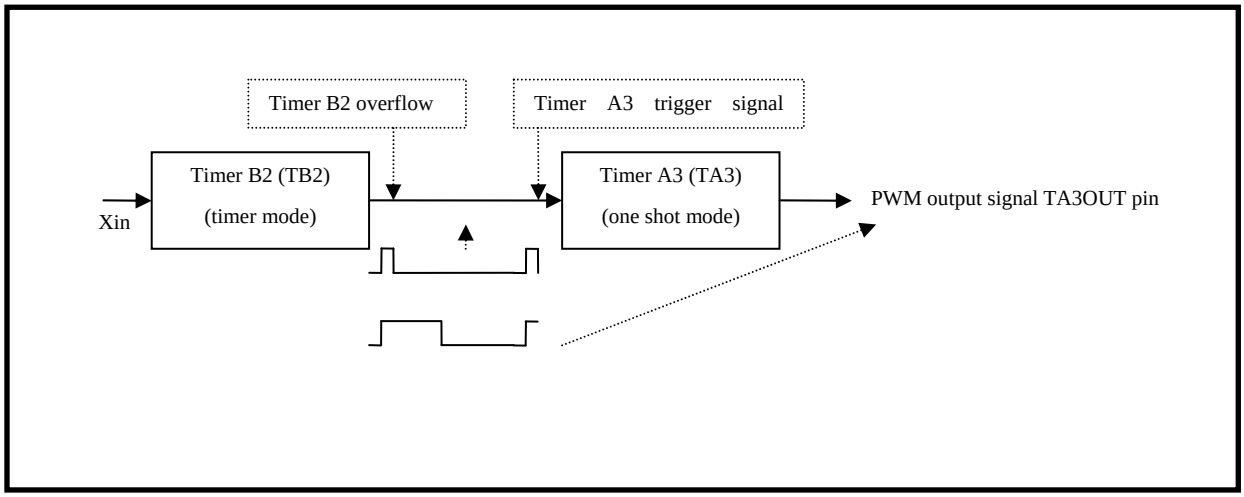
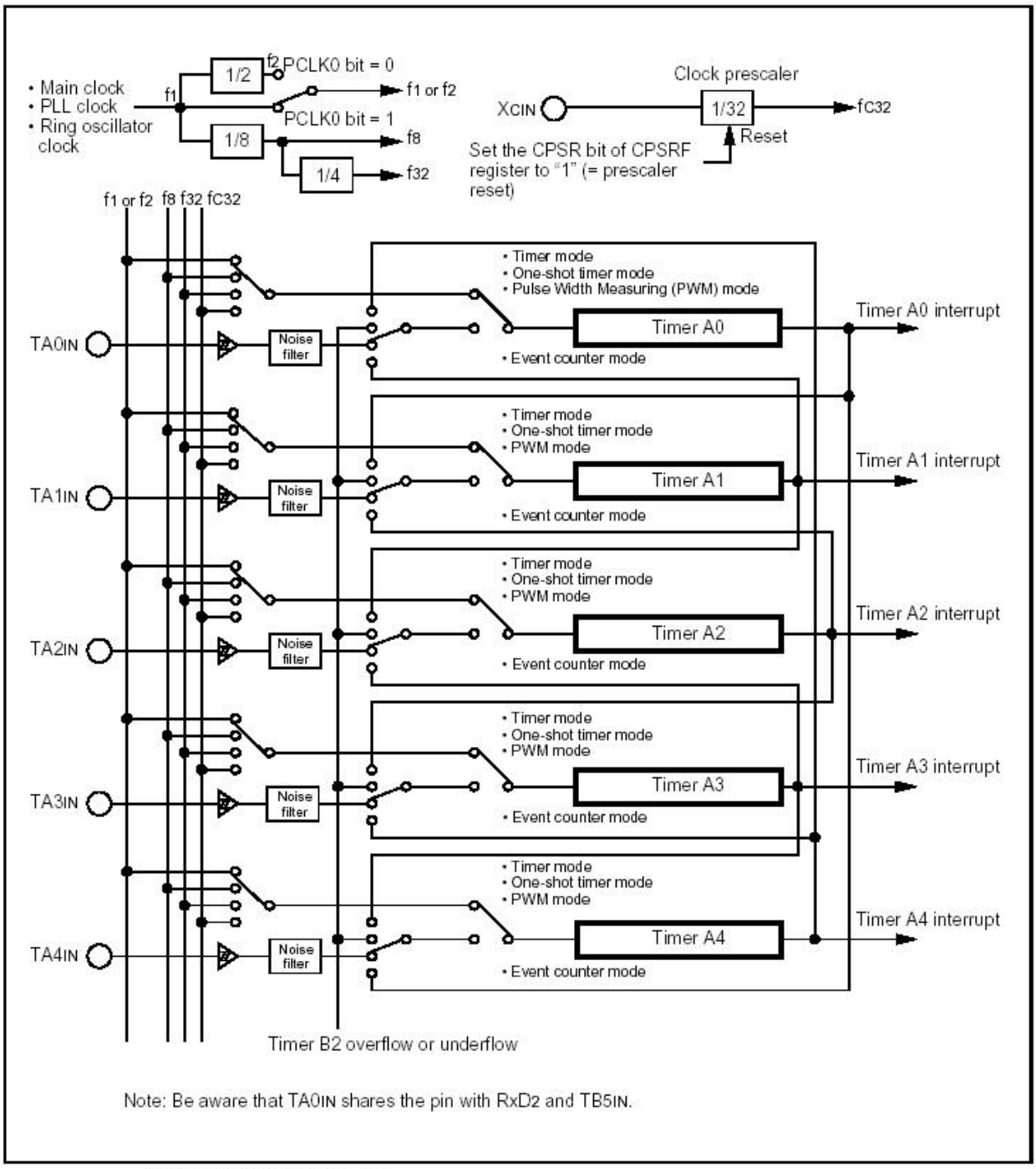


Fig 1.

Timer A block structure



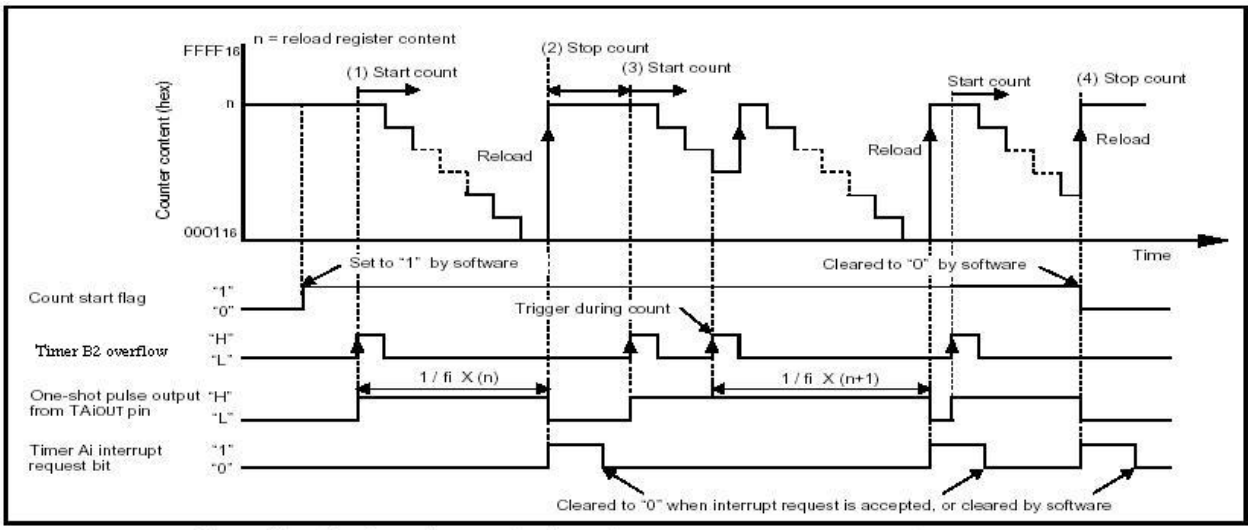
Timer A Configuration

Timer A one shot mode

Once initialized, every time TA3 is triggered by TB2 overflow the TA3OUT pin goes to high state and the counter starts decrementing. When timer reaches value 0000 the TAIOUT pin goes low and TA3 stops waiting for next trig.

TB2 is used as trig source to automatically re-start TA3 to define the signal period (see drawing below).

1. Operation timing of Timer A one-shot mode



Operation timing of one-shot mode

2. Timer A registers

Timer Ai mode register (i=0 to 4)

b7	b6	b5	b4	b3	b2	b1	b0
		0				1	0

Symbol	Address	After reset
TA0MR to TA4MR	39616 to 039A16	0016

Bit symbol	Bit name	Function	RW
TMOD0	Operation mode select bit	b1 b0 1 0 : One-shot timer mode	RW
TMOD1			RW
MR0	Pulse output function select bit	0 : Pulse is not output (TAiOUT pin functions as I/O port) 1 : Pulse is output (Note 1) (TAiOUT pin functions as a pulse output pin)	RW
MR1	External trigger select bit (Note 2)	0 : Falling edge of input signal to TAiIN pin (Note 3) 1 : Rising edge of input signal to TAiIN pin (Note 3)	RW
MR2	Trigger select bit	0 : TAiOS bit is enabled 1 : Selected by TAiTGH to TAiTGL bits	RW
MR3	Must be set to "0" in one-shot timer mode		RW
TCK0	Count source select bit	b7 b6 0 0 : f1 or f2 0 1 : f8 1 0 : f32 1 1 : fC32	RW
TCK1			RW

Note 1: TA0OUT pin is N-channel open drain output.
Note 2: Effective when the TAiTGH and TAiTGL bits of ONSF or TRGSR register are '002' (TAiIN pin input).
Note 3: The port direction bit for the TAiIN pin must be set to "0" (= input mode).

TAiMR Register in One-shot Timer Mode

One-shot start flag

Symbol	Address	After reset
ONSF	038216	0016

b7	b6	b5	b4	b3	b2	b1	b0

Bit symbol	Bit name	Function	RW
TA0OS	Timer A0 one-shot start flag	The timer starts counting by setting this bit to "1" while the TMOD1 to TMOD0 bits of TAiMR register (i = 0 to 4) = '102' (= one-shot timer mode) and the MR2 bit of TAiMR register = "0" (=TAiOS bit enabled). When read, its content is "0".	RW
TA1OS	Timer A1 one-shot start flag		RW
TA2OS	Timer A2 one-shot start flag		RW
TA3OS	Timer A3 one-shot start flag		RW
TA4OS	Timer A4 one-shot start flag		RW
TA4OS	Z-phase input enable bit	0 : Z-phase input disabled 1 : Z-phase input enabled	RW
TA0TGL	Timer A0 event/trigger select bit	b7 b6 0 0 : Input on TA0IN is selected (Note 1) 0 1 : TB2 overflow is selected (Note 2) 1 0 : TA4 overflow is selected (Note 2) 1 1 : TA1 overflow is selected (Note 2)	RW
TA0TGH			RW

Trigger select register

Symbol	Address	After reset
TRGSR	038316	0016

b7	b6	b5	b4	b3	b2	b1	b0

Bit symbol	Bit name	Function	RW
TA1TGL	Timer A1 event/trigger select bit	b1 b0 0 0 : Input on TA1IN is selected (Note) 0 1 : TB2 is selected 1 0 : TA0 is selected 1 1 : TA2 is selected	RW
TA1TGH			RW
TA2TGL	Timer A2 event/trigger select bit	b3 b2 0 0 : Input on TA2IN is selected (Note) 0 1 : TB2 is selected 1 0 : TA1 is selected 1 1 : TA3 is selected	RW
TA2TGH			RW
TA3TGL	Timer A3 event/trigger select bit	b5 b4 0 0 : Input on TA3IN is selected (Note) 0 1 : TB2 is selected 1 0 : TA2 is selected 1 1 : TA4 is selected	RW
TA3TGH			RW
TA4TGL	Timer A4 event/trigger select bit	b7 b6 0 0 : Input on TA4IN is selected (Note) 0 1 : TB2 is selected 1 0 : TA3 is selected 1 1 : TA0 is selected	RW
TA4TGH			RW

Software Description

The application software project is available for download from our website and includes all necessary code to run the application with 10bit resolution PWM at 19KHZ minimum frequency (20MHZ/1024 ~ 19KHZ) using the MCU at maximum speed which is 20MHZ or 24MHZ depending on target device (M16C/62P or M16CTiny).

Signal period is defined by Timer B2, and pulse high duration is defined by contents of Timer TA3.

The timer B2 is loaded with 2^{10}-1 = 1023 (this gives the 10bits resolution) and counts from f1, this generates a Xin/1024 with 10bit resolution PWM signal on TA3OUT.

The initialisation routine and main routine described in next page were tested on a 3DKM16C62P starter kit with IAR C/C++ compiler. (mentioned already)

Conclusion

After the peripherals have been initialised the CPU is free for the application as the timers are in auto-reload mode. When a new PWM value is required a simple change to the timer TA3 contents is enough to get the new value in operation. The basic peripheral initialisation functions are provided in a separate “c” file. It is also possible to create the initialisation functions with IAR MakeUp (download for free from www.iar.com).

Code

```
// ------------------------------------------------------------------------
// Initialises processor and peripherals
// ------------------------------------------------------------------------
// Input Parameters:     None
// ------------------------------------------------------------------------
// Returned Parameters:  None
// ------------------------------------------------------------------------
// modified globales:    None
// ------------------------------------------------------------------------
void init(void)
{
  // configure the system clock
  // Xin / Xout Oscillation at 6MHz
  PRCR |= 0x01;           // Enable write to system clock
  CM1 = 0x20;             // Setting System clock control register 1
  CM0 = 0x18;             // Setting System clock control register 0
  PLC0 = 0x12;            // for M16C/62P using 6MHZ Xin
  PLC0 = 0x92;            // for M16C/62P using 6MHZ Xin (remove this line without PLL)
  CM1 = 0x22;             // Select PLL clock
  PRCR &= ~0x01;          // Inhibit write to system clock
  P2   = 0;
  PD2   = 0xff;
}
```

```
// ------------------------------------------------------------------------
// Scans 3DKM16C62P switches and changes PWM value
// SW_INT2 increases duty ratio, SW_INT0 restores default value,
// SW_INT1 decreases duty ratio.
// ------------------------------------------------------------------------
// Input Parameters:     None
// ------------------------------------------------------------------------
// Returned Parameters:  None
// ------------------------------------------------------------------------
// modified globales:    None
// ------------------------------------------------------------------------
void main (void)
{
unsigned int t; // Timer Period
  init();
  timer_a3_init_one_shot_timer_mode ();
  timer_b2_init_timer_mode ();
  timer_b2_set (1024-1);   // BCLK = 24MHZ => 23.437KHZ periodic pulse
  timer_a3_set (256-1 );   // Set PWM to 256 (means 25% modulation ratio).
  timer_a3_start ();
  timer_b2_start ();
  tempo = TEMPO;
  t = T0;
  for(;;)         // Never ending loop
    {
// Increase duty cycle
  if(!SW_INT2)    {
    LED4 = 1; // Light ON LED to show push button is pressed.
    tempo--;
    if(tempo == 0)      // Slow down loop
      {
      tempo = TEMPO;
      if(t<TMAX)  t++;  // Increase duty cycle by one unit
      }
    }
    else LED4 = 0;
// Decrease duty cycle
  if(!SW_INT0)    {
    LED8 = 1;
    tempo--;
    if(tempo == 0)
      {
      tempo = TEMPO;
      if(t>TMIN) t--;
```

```
      }
    }
    else LED6 = 0;
// restore default duty cycle
  if(!SW_INT1)    {
    LED6 = 1;
    t = T0 ;
    }
    else LED8 = 0;
  timer_a3_set(t);
  };
}
```

Website and Support

Renesas Technology Website
http://www.renesas.com/

Inquiries
http://www.renesas.com/inquiry
csc@renesas.com

Notes regarding these materials

1. This document is provided for reference purposes only so that Renesas customers may select the appropriate Renesas products for their use. Renesas neither makes warranties or representations with respect to the accuracy or completeness of the information contained in this document nor grants any license to any intellectual property rights or any other rights of Renesas or any third party with respect to the information in this document.
2. Renesas shall have no liability for damages or infringement of any intellectual property or other rights arising out of the use of any information in this document, including, but not limited to, product data, diagrams, charts, programs, algorithms, and application circuit examples.
3. You should not use the products or the technology described in this document for the purpose of military applications such as the development of weapons of mass destruction or for the purpose of any other military use. When exporting the products or technology described herein, you should follow the applicable export control laws and regulations, and procedures required by such laws and regulations.
4. All information included in this document such as product data, diagrams, charts, programs, algorithms, and application circuit examples, 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 products listed in this document, please confirm the latest product information with a Renesas sales office. Also, please pay regular and careful attention to additional and different information to be disclosed by Renesas such as that disclosed through our website. (http://www.renesas.com)
5. Renesas has used reasonable care in compiling the information included in this document, but Renesas assumes no liability whatsoever for any damages incurred as a result of errors or omissions in the information included in this document.
6. When using or otherwise relying on the information in this document, you should evaluate the information in light of the total system before deciding about the applicability of such information to the intended application. Renesas makes no representations, warranties or guaranties regarding the suitability of its products for any particular application and specifically disclaims any liability arising out of the application and use of the information in this document or Renesas products.
7. With the exception of products specified by Renesas as suitable for automobile applications, Renesas products are not designed, manufactured or tested for applications or otherwise in systems the failure or malfunction of which may cause a direct threat to human life or create a risk of human injury or which require especially high quality and reliability such as safety systems, or equipment or systems for transportation and traffic, healthcare, combustion control, aerospace and aeronautics, nuclear power, or undersea communication transmission. If you are considering the use of our products for such purposes, please contact a Renesas sales office beforehand. Renesas shall have no liability for damages arising out of the uses set forth above.
8. Notwithstanding the preceding paragraph, you should not use Renesas products for the purposes listed below:
   (1) artificial life support devices or systems
   (2) surgical implantations
   (3) healthcare intervention (e.g., excision, administration of medication, etc.)
   (4) any other purposes that pose a direct threat to human life

   Renesas shall have no liability for damages arising out of the uses set forth in the above and purchasers who elect to use Renesas products in any of the foregoing applications shall indemnify and hold harmless Renesas Technology Corp., its affiliated companies and their officers, directors, and employees against any and all damages arising out of such applications.
9. You should use the products described herein within the range specified by Renesas, especially with respect to the maximum rating, operating supply voltage range, movement power voltage range, heat radiation characteristics, installation and other product characteristics. Renesas shall have no liability for malfunctions or damages arising out of the use of Renesas products beyond such specified ranges.
10. Although Renesas endeavors to improve the quality and reliability of its products, IC products have specific characteristics such as the occurrence of failure at a certain rate and malfunctions under certain use conditions. Please be sure to implement safety measures to guard against the possibility of physical injury, and injury or damage caused by fire in the event of the failure of a Renesas 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 applicable measures. Among others, since the evaluation of microcomputer software alone is very difficult, please evaluate the safety of the final products or system manufactured by you.
11. In case Renesas products listed in this document are detached from the products to which the Renesas products are attached or affixed, the risk of accident such as swallowing by infants and small children is very high. You should implement safety measures so that Renesas products may not be easily detached from your products. Renesas shall have no liability for damages arising out of such detachment.
12. This document may not be reproduced or duplicated, in any form, in whole or in part, without prior written approval from Renesas.
13. Please contact a Renesas sales office if you have any questions regarding the information contained in this document, Renesas semiconductor products, or if you have any other inquiries.