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M16C/62

Using the M16C/62 Timer in Pulse Output Mode

1.0 Abstract

The following article describes how to use the M16C/62 timers A's as square wave generators (Pulse Output Mode).

2.0 Introduction

The M16C/62 is a 16-bit MCU, based on the M16C CPU core, with features including 10-bit A/D, D/A, UARTS, timers, DMA, etc., and up to 256k bytes of user flash. The MCU has 5 timer A's, and Pulse Output Mode is an additional feature of timer A's Timer Mode. All 5 timer A's can operate in Pulse Output Mode.

Timer A has the following additional modes of operation:

- Timer Mode (without Pulse Output)
- Event Counter Mode
- PWM Mode
- One-Shot Mode

Figure 1 illustrates the operation of timer A. The remainder of this article will focus on setting up timer A0 in Pulse Output Mode.

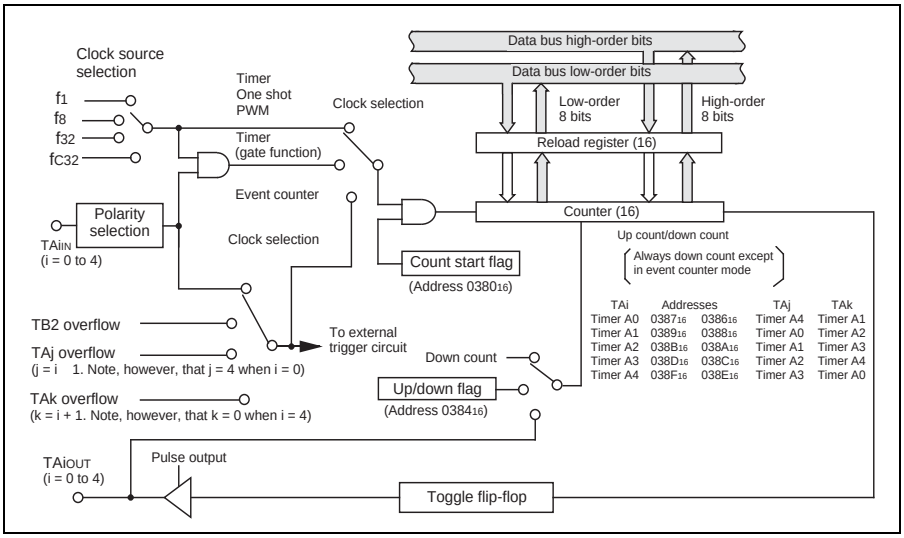


Figure 1 Bock Diagram of Timer A

3.0 Pulse Output Mode Description

In Pulse Output Mode, the counter register counts down using the selected clock source until the counter underflows (0000 to FFFFh). At this point, the TAiout pin toggles and the contents of the reload register are loaded back into the TAi register and the interrupt request bit is set. An interrupt will be accepted when all of the following conditions are met:

- interrupt enable flag (I flag) = "1"
- interrupt request bit = "1"
- interrupt priority level > IPL (Processor Interrupt Priority Level)

Note that the pulse output is free running and interrupts need not be enabled or serviced. If at any time during countdown the count start flag is cleared, the TAiout pin outputs an "L" and the count is suspended until the count start flag is set. Figure 2 illustrates this.

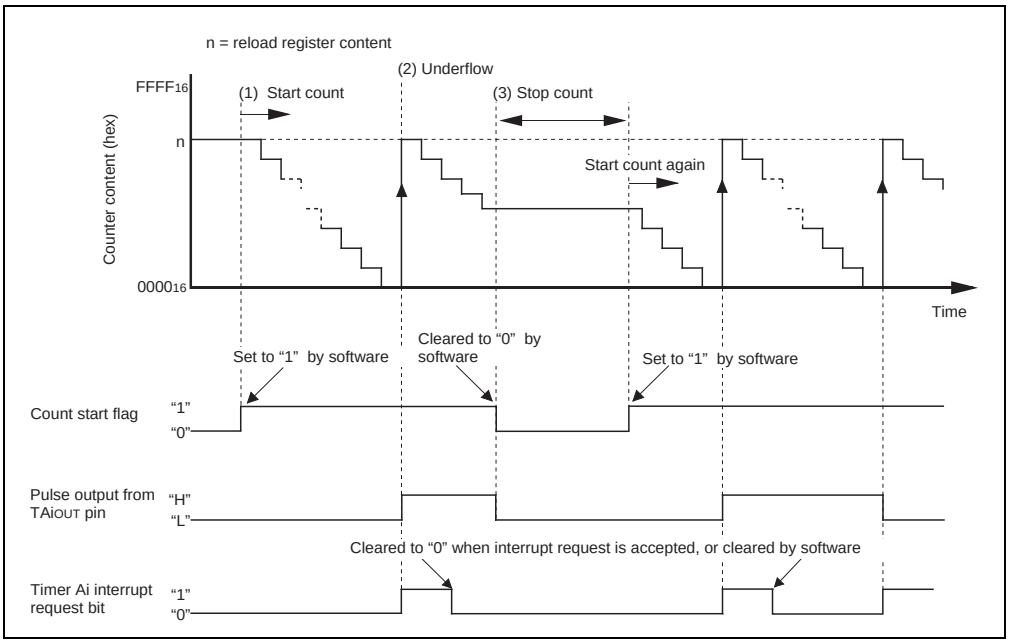


Figure 2 Operation Timing of Timer Mode, Pulse Output Function Selected

4.0 Configuring Pulse Output Mode

To configure a timer for Pulse Output Mode:

1. Load the Timer Ai register, TAi (which also loads the reload register) with the count source.
2. Load the Timer Ai Mode register, TAiMR:
   - Select timer mode: bits TMOD0, TMOD1 = 0.
   - Select pulse out: MR0 bit = 1.
   - Select the clock source (f1, f/8, f/32, or fc/32): bits TCK0,TCK1.
3. Load the Timer Interrupt Control register (TAiIC) with an interrupt priority level (ILVL), value of at least 1 if interrupts are required.
4. Ensure interrupts are enabled (I flag set).
5. Set the 'start count' flag bit, TAiS, in the Count Start Flag register, TABSR.

It is not necessary to perform these steps in the order listed, but the count register should be loaded before the 'start count' flag is set. Also, the priority level should not be modified when there is a possibility of an interrupt occurring.

The required registers are shown in Figure 3 hrough Figure 6.

Timer Ai register (Note)

(b15 b7 b8) b0 b7 b0

Symbol	Address	When reset
TA0	0387_{16}, 0386_{16}	Indeterminate
TA1	0389_{16}, 0388_{16}	Indeterminate
TA2	$038B_{16}$, $038A_{16}$	Indeterminate
TA3	$038D_{16}$, $038C_{16}$	Indeterminate
TA4	$038F_{16}$, $038E_{16}$	Indeterminate

Function	Values that can be set	R	W
• Timer mode Counts an internal count source	0000_{16} to $FFFF_{16}$	O	O
• Event counter mode Counts pulses from an external source or timer overflow	0000_{16} to $FFFF_{16}$	O	O
• One-shot timer mode Counts a one-shot width	0000_{16} to $FFFF_{16}$	X	O
• Pulse width modulation mode (16-bit PWM) Functions as a 16-bit pulse width modulator	0000_{16} to $FFFF_{16}$	X	O
• Pulse width modulation mode (8-bit PWM) timer low-order address functions as an 8-bit prescaler and high-order address functions as an 8-bit pulse width modulator	00_{16} to FE_{16} (Both high-order and low-order addresses)	X	O

Note: Read and write data in 16-bit units

Figure 3 Timer Ai Register

Timer Ai mode register

b7	b6	b5	b4	b3	b2	b1	b0
		0				0	0

Symbol: TAiMR(i=0 to 4) | Address: 0396_{16} to $039A_{16}$ | When reset: 00_{16}

Bit symbol	Bit name	Function	R	W
TMOD0	Operation mode select bit	b1 b0 0 0 : Timer mode	O	O
TMOD1			O	O
MR0	Pulse output function select bit	0 : Pulse is not output (TAiOUT pin is a normal port pin) 1 : Pulse is output (Note 1) (TAiOUT pin is a pulse output pin)	O	O
MR1	Gate function select bit	b4 b3 0 X (Note 2): Gate function not available (TAiIN pin is a normal port pin) 1 0 : Timer counts only when TAiIN pin is held "L" (Note 3) 1 1 : Timer counts only when TAiIN pin is held "H" (Note 3)	O	O
MR2			O	O
MR3	0 (Must always be fixed to "0" in timer mode)		O	O
TCK0	Count source select bit	b7 b6 0 0 : f_1 0 1 : f_8 1 0 : f_{32} 1 1 : f_{C32}	O	O
TCK1			O	O

Note 1: The settings of the corresponding port register and port direction register are invalid.
Note 2: The bit can be "0" or "1".
Note 3: Set the corresponding port direction register to "0".

Figure 4 Timer Ai Mode Register in Timer Mode, Pulse Output

Count start flag

b7	b6	b5	b4	b3	b2	b1	b0

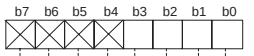
Symbol: TABSR | Address: 0380_{16} | When reset: 00_{16}

Bit Symbol	Bit Name	Function	R	W
TA0S	Timer A0 count start flag	0 : Counting stops 1 : Counting starts	O	O
TA1S	Timer A1 count start flag		O	O
TA2S	Timer A2 count start flag		O	O
TA3S	Timer A3 count start flag		O	O
TA4S	Timer A4 count start flag		O	O
TB0S	Timer B0 count start flag		O	O
TB1S	Timer B1 count start flag		O	O
TB2S	Timer B2 count start flag		O	O

Figure 5 Count Start Flag Register

Interrupt control register (Note 2)

Symbol	Address	When reset
TBiIC (i = 0 to 4)	0055_{16} to 0059_{16}	$XXXXX000_2$



Bit Symbol	Bit Name	Function	R	W
ILVL0	Interrupt priority level select bit	b2 b1 b0 0 0 0 : Level 0 (interrupt disabled) 0 0 1 : Level 1 0 1 0 : Level 2 0 1 1 : Level 3 1 0 0 : Level 4 1 0 1 : Level 5 1 1 0 : Level 6 1 1 1 : Level 7	O	O
ILVL1			O	O
ILVL2			O	O
IR	Interrupt request bit	0 : Interrupt not requested 1 : Interrupt requested	O	O Note 2
Nothing is assigned. Write "0" when writing to these bits. The value is "0" if read.			–	–

Note 1: Rewrite the interrupt control register only if it will not generate an interrupt request for that register. See precautions listed at end of the Interrupts chapter.
Note 2: This bit can only be accessed for reset (=0) Set (=1) cannot be accessed.

Figure 6 Interrupt Control Register

5.0 Program Output

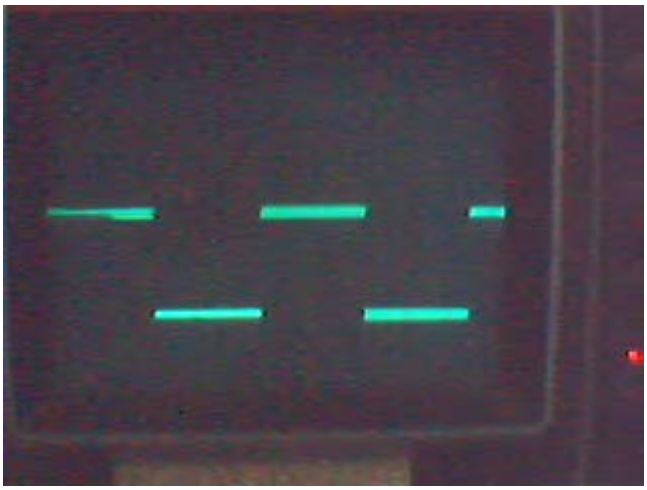


Figure 7

6.0 Reference

Renesas Technology Corporation Semiconductor Home Page

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Data Sheets

- M16C/62 datasheets, 62aeds.pdf

User's Manual

- M16C/62 User's Manual, 62eum.pdf
- M16C/60 and M16C/20 C Language Programming Manual, 6020EC.pdf
- NC30 Ver. 4.0 User's Manual, NC30UE.pdf

7.0 Software Code

Following is a simple program written for Renesas' NC30 compiler to illustrate how to set up Pulse Output Mode on timer A0. This program runs on the MSV1632/62 Starter Kit Board and generates a 200Hz square wave on P7.0. A scope can be connected to pin 4 of JP3 to view the waveform. Be sure to remove IC4 (if installed) or the jumper across pins 3 and 4 at JP3 before running the program.

Note that when you stop the program (under KD30), the square wave output does not stop until the system is reset.

To become familiar with the timer, try changing the output frequency, the clock source, or even switch to a different timer (e.g. TA1, etc.).

```
/***********************************************************************
*
*       File Name: pulsout.c
*
*       Content: Example program for the "TIMER PULSE OUTPUT MODE ON THE
*             M16C/62" application note. Generates a 200 Hz square wave
*             on the P7.0 pin. For the MSV1632/62 starter kit board.
*
*        Compiled with NC30 ver. 3.20.00.
*
*        All timing based on 16 Mhz Xtal
*
*       Copyright, 2003 Renesas Technology Corporation, Inc.
*=======================================================================
*       $Log:$
*=======================================================================*/
#include "sfr62.h"

#define  TIME_CONFIG 0x44  /*  01000100 value to load into Timer Ai mode register
                               ||||||||_  TMOD0,TMOD1: TIMER MODE SELECTED
                               ||||||_____ MR0:         PULSE OUTPUT
                               |||||______ MR1,MR2:     GATE FUNCTION NOT SELECTED
                               |||________ MR3:         SET TO 0 IN TIMER MODE
                               ||_________ TCK0,TCK1:   F DIVIDED BY 8 SELECTED */


#define  CNTR_IPL 0x00   // TA0 priority interrupt level: interrupts not required

//prototypes
 void initial(void);

/***********************************************************************
Name:    main()
Parameters: none
Returns:  nothing
Description: initializes variables. Then does nothing but wait for TA0 interrupts.
*********************************************************************** */

void main (void)
{

  init();
  while (1);      // square wave output is free running
}
```

```
/************************************************************************
Name:  init ()
Parameters: none
Returns:  nothing
Description: timer TA0 setup for Pulse Output Mode.
************************************************************************ */
 void init()
  {
   ta0 = 10000;   // 16meg xtal, divide by 8, times 10,000 counts-> 5msec pulse widths.

/* the following procedure for writing an Interrupt Priority Level follows that as
described in the M16C data sheets under 'Interrupts' */

   _asm ("   fclr i") ;         // turn off interrupts before modifying IPL
   ta0ic &= CNTR_IPL;        // *?* use read-modify-write instruction to write IPL
   ta0mr = TIME_CONFIG;
   _asm ("   fset i");

   ta0s = 1;  //start counting
  }
```

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