

## Lab 3 – Part 2

# Using the MC9S12 Timer Overflow Interrupt and Real Time Interrupt

### Introduction and Objectives

Enabling an interrupt on the MC9S12 allows your program to respond to an external event without continually checking to see if that event has occurred. Once the event occurs, the MC9S12 interrupt subsystem will transfer control of your program to an interrupt service routine (ISR) to handle the event, and then return control to your original code sequence. In this week's lab you will write assembly and C language program which enable and use interrupts.

The interrupts on the MC9S12 which are easiest to use are the Timer Overflow Interrupt and the Real Time Interrupt. These interrupts allow you to interrupt the microcontroller after a specified amount of time has passed.

### 1. Prelab

For the prelab write the program for Parts 6 and 7. Also, calculate the time asked for in 5.

### 2. The Lab

1. Connect your MC9S12 to your computer. At the DDebug 12 prompt, display the contents of the TCNT register. Do this several times. How do the values compare?
2. Use DDebug12 to modify the TSCR1 register to enable the counter. Repeat Part 1.
3. Use DDebug12 to modify the TSCR1 register to disable the counter. Repeat Part 1.
4. Start with Program 1: The file "vectors12.inc" is available at <http://www.ee.nmt.edu/~rison/ee308>. This file contains addresses of the DDebug12 RAM-based interrupt vectors.

Add code to make **PORTB** an output port, to enable the eight individual LEDs, and disable the seven segment LEDs. Then add a Timer Overflow Interrupt to increment the four lower bits for **PORTB**. Set the timer overflow rate to be 175 ms. You should increment the four lower bits of **PORTB** in the interrupt service routine, and leave the four upper bits of **PORTB** unchanged. Verify that the lower four bits of **PORTB** function as an up-counter.

**Program 1** Program snippet.

---

```
        INCLUDE 'derivative.inc'
        INCLUDE 'vectors12.inc'
prog:   equ $2000
stack:  equ $2000

        org prog
        lds #stack;    ; Need stack when using interrupts

loop:   wai
        bra loop
```

---

Suppose you want to use the Timer Overflow interrupt in your program. You would need to write a Timer Overflow ISR, with a label (say, `tof_isr`) at the first instruction of the ISR. To set the Timer Overflow interrupt vector in your program, you would include the following instruction in your program, before the instruction which enables interrupts:

```
movw #tof_isr, UserTimerOvf
```

5. Calculate how long it should take for the lower bits of `PORTB` to count from 0x0 to 0xF and roll over to 0x0. Use a watch to measure the time. How do the two times agree?
6. Add a Real Time Interrupt to your assembly language program. Set up the RTI to generate an interrupt every 65.536 ms. In the RTI interrupt service routine, implement a Johnson counter on the four upper bits of `PORTB`, while leaving the four lower bits of `PORTB` unchanged. Verify that the bit takes the correct amount of time to rotate through the four upper bits.
7. Implement the above program in C. (What you need to do to use interrupts in C is discussed in the textbook and lecture notes, and described briefly in 11 below.)
8. Change your C program so that you do not reset the Timer Overflow Flag in the Timer Overflow ISR. Does your up-counter work? Does your rotating bit work? Why?
9. Restore your original C program from Part 7. Now change your C program so that you do not reset the Real Time Interrupt Flag in the Real Time Interrupt ISR. Does your up-counter work? Does your rotating bit work? Why?
10. Restore your original C program from Part 7. Change your C program so that you do not set the address for the Timer Overflow Interrupt. Run your program. What happens now? Why?

11. To add interrupt vector in C you will need a file listing the addresses of the interrupt service routines. Note that the different versions of the HCS12 have different interrupt vectors, and hence use different vector files. The file vectors12.h (available on the EE 308 homepage) has the appropriate vectors for the MC9S12DP256 chip running DDebug12. Here is part of vectors12.h:

```
#define VECTOR_BASE 0x3E00
#define INTERRUPT __attribute__((interrupt))
#define VEC16(off) *(volatile unsigned short *) (VECTOR_BASE + off*2)
#define UserTimerOvf_VEC16 (47)
#define UserRTI_VEC16 (56)
```

12. This tells the compiler that, for example, UserTimerOvf is a pointer to a short (16bit) number at address 0x3E5E (0x3E00 + 2\*47).

13. To compile your program with interrupts, include the vectors12.h file in your program. Then, before enabling interrupts, set the interrupt vectors for those interrupts you are using. For example, if you are using the Timer Overflow Interrupt, and the name of the Timer Overflow ISR is `toi_isr()`, put the following line in your program:

```
UserTimerOvf = (unsigned short)&toi_isr;
```