EE-3306 HC6811 Lab #3

Interrupt and Output Compare Systems

Objectives:
The purpose of this lab is to become familiar with the 68HC11 real time interrupt system and the output compare functions. In part 1 of this lab, you will program the Real Time Interrupt system to generate a square wave of different frequencies. In part 2, you will learn to use the compare register(s) to generate a waveform of different duty cycles.

Prelab Questions:
1. What are maskable and unmaskable interrupts? Give two examples of each.
2. Where are the vector addresses for the following interrupts:
   (a) Real Time Interrupt
   (b) Timer Output Compare 2
   (c) Pulse Accumulator Overflow
   (d) Software Interrupts
   List them according to increasing priority (i.e. the lowest priority interrupt first and the highest priority interrupt last).
3. Define duty cycle.

References

Equipment for this lab:
• 68HC11 trainer kit, to include 68HC11 EVBU and prototyping strips.
• IBM compatible PC to connect to the trainer kit via an RS-232 serial cable.
• Agilent 54621D oscilloscope.
• Floppy disk provided by student.

Laboratory Exercise
Notes:
• Make sure your development EVBU board is connected to power (green LED on board ON)
and the serial port of the EVBU is connected to the serial port of your development PC containing
the AXIDE software, configured to the correct port at the correct baud rate, etc.
• Be sure to bring your control.RTF file from 68HC11 lab #2.
• The lab TA has a copy of the .s19 files for each part of the lab. The TA will demonstrate the waveforms to you at the beginning of the class.
**Part 1**

In this part, you will program the Real Time Interrupt (RTI) system to generate interrupts at a known rate, and use the interrupts to generate a waveform of known frequency. Please read pages 382 - 385 of the 68HC11 reference manual for a detailed description of the RTI system. The bits “RTR1” and “RTR0” in register “PACTL” determine the prescaler for the clock input. These bits can be changed to get different RTI rates. The following table shows the different rates obtained by changing the bits. These rates are for a crystal frequency of 8MHz at which the Axiom board operates.

<table>
<thead>
<tr>
<th>RTR1</th>
<th>RTR0</th>
<th>Rates</th>
<th>Period</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>4.10ms</td>
<td>8.2ms</td>
<td>122 Hz</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>8.19ms</td>
<td>16.35ms</td>
<td>61.2 Hz</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>16.38ms</td>
<td>32.75ms</td>
<td>30.53 Hz</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>32.77ms</td>
<td>65.4ms</td>
<td>15.29 Hz</td>
</tr>
</tbody>
</table>

The bit “RTII” in register “TMSK2” enables the RTI interrupts. The bit “RTIF” in register “TFLG2” indicates that a RTI has occurred. Write a program to generate real time interrupts at all the rates given in the table and create a square wave of 50% duty cycle using the interrupt service routine at PORT D. The frequencies and periods of the wave should match with the values given in the above table. Use the Agilent 54621D oscilloscope to monitor the waveform.

Set all other bits except RTR1 and RTR0 to 0 in the PACTL reg. Similarly set only the RTII bit to 1 in the TMSK2 reg. Disable all the other interrupts except RTI. In addition to enabling Real Time Interrupts, you also need to globally enable all the maskable interrupts.

Please note that the interrupt vectors are re-mapped in the Axiom board to lower RAM locations. You can find these locations in page 23 of the “CME11E9-EVBU development board” documentation under “Buffalo Monitor Interrupt Jump Table.” For example, RTI is relocated at $00EB - $00ED, and you should put a “jmp int_RTI” at this location. (“int_RTI” is the name of the Real Time Interrupt service routine.)

The required subroutines are provided for this program (stud_RTI.RTF) on the website. Fill in the rest of the code. Check the output at PD5 pin on the board. Demonstrate to the TA that your program is working. 

T. A. Initials: ________________________
Part 2
In this part you will learn how to use different output-compare function of the 68HC11 to generate waveforms of a known duty cycle. Please read pages 372 - 373 of the 68HC11 reference manual for a detailed description of the output-compare function.

There are as many as 5 output compare functions for this microcontroller. So, there are 5 different counters (TOCx) to control these functions. An output compare is generated when the free running counter of the 68HC11 matches the value of “TOCx” counter. This signal can be used to generate an interrupt if the corresponding interrupt enable bit in the register “TMSK1” is set. The “OMx” and “OLx” bits in register “TCTL1” determine the state of output pin “OCx” when the free running counter matches the “TOCx” counter. Refer to Table 10-6 on page 413 of the 68HC11 reference manual for details.

You will be learning how to program the output-compare channels to generate a waveform of the following characteristics at pin “OCx “.
Period = 2.5 ms
High = 1.5 ms
Low = 1.0 ms
Duty Cycle = High/Period = 60%

You need to program the “TMSK1” and “TCTL1” registers with the appropriate values to generate the waveform. The program given to you shows how to use the output compare 3. The Output Compare 3 Interrupt is enabled in the “TMSK1” register, and all other interrupt enable bits in the register are disabled. Similarly you have to program other output compares to generate a waveform. Also you should be able o generate waveforms of different duty cycles. Program the appropriate bits in the “TCTL1” register to generate the required waveform at the relevant pins.

TCTL1 $1020
    OM2 OL2 OM3 OL3 OM4 OL4 OM5 OL5

TMSK1 $1022
    OC1I OC2I OC3I OC4I OC5I IC1I IC2I IC3I

The following method to generate the waveform is suggested.
- Allocate 3 memory locations for High, Low and the Period.
- Initialize these locations to the appropriate values.
- Enable Output Compare Interrupts.
- Within the interrupt service routine, change the value of the “TOCx” counter, so
  - Remember to clear the flag bits in the TFLG1 register after the interrupt is serviced.

The required subroutines for this program (stud_OC.RTF) are provided on the website. Follow the given hints and complete the given code and run it on the board. Check the output at pin PA5/OC3 on the board.

T. A. Initials:______________________