

# CPE 390: Microprocessor Systems

## HW5

Due: 4/5/18

- What does it mean to say that the HCS12 microcontroller uses memory-mapped I/O?  
  
(b) If you were adding 4kB of external RAM to an HCS12 microcontroller, what is the lowest physical address range that this RAM could occupy?
- A square wave signal (even periods of '1's and '0's) is applied to pin PA6. Write a program starting at address \$4000 to output a square wave on pin PA1 which is exactly one half the frequency of the input signal on pin PA6. Do not use interrupts. (*Hint: PA1 should change state (0 → 1 or 1 → 0) every time PA6 goes from a '0' to a '1'. Use brset and brclr instructions to test Port A*)

If you like, you can try running this on the simulator. You will need to change from Port A to Port T. The Port T data register PORTT is at address \$AE. The Port T direction register DDRT is at address \$AF. Also, you must run `DEBUG12.S19` first for this to work correctly. The simulator has a signal generator that can be used to drive a single bit of Port T. You can access it via the *View* pull-down menu. Set the frequency to something around 100 Hz, select port PT6 and click *Enable*. When you run your program, click the *Display Updates* button in the main simulator window. This will cause the inputs and outputs of Port T to be continuously updated while your program is running. Adjust the frequency of the signal generator to suit the speed of the simulator on your computer.

- What is the difference between the RTI and RTS instructions?
  - What would the stack look like (address and data, where known) in the interrupt service routine if an interrupt occurred during the *subd* instruction in the sequence below? (Assume bits S and X of CCR are set to '1')

```
lds      #$5900
cli
ldd      #$200
pushd
ldx      #$2286
ldy      #$4567
jsr      sub1
...
sub1:    psha
subd     #$201
...
```

4. An HCS12 microcontroller is being used to control a coffee maker. One of the tasks it must perform is periodically monitor and record the maximum temperature of the hotplate in a memory location labeled HOTT. A digital temperature sensor is connected to Port A. The temperature sensor outputs an unsigned 8-bit word which is the temperature of the hotplate in degrees Celsius.
- (a) Write an interrupt service routine for the real-time interrupt (RTI) that checks the temperature of the hotplate and updates HOTT if necessary.
- (b) Write a main program to initialize HOTT to zero, set up Port A for input and then set up the RTI to perform its check every 100ms (approx.). Once the interrupts have been set up, the main program should branch to a coffee making control program (that somebody else wrote) located at location CMC. Assume the crystal oscillator clock is running at 4MHz.

You can assume the following labels have already been set in your program:

PORTA:	EQU	\$00	; Port A Data
DDRA:	EQU	\$02	; Port A Direction Register
CRGFLG:	EQU	\$37	; CRG Flag Register
CRGINT:	EQU	\$38	; CRG Interrupt Register
RTICTL:	EQU	\$3B	; RTI Control Register
UserRTI:	EQU	\$3FF0	; RTI entry in Interrupt Vector Table
HOTT:	EQU	\$6000	; Maximum temperature variable
CMC:	EQU	\$7000	; Address of coffee making program