OREGON INSTITUTE OF TECHNOLOGY

**Computer Systems Engineering Technology Department**

***CST 204 - Introduction to Microcontrollers***

**Lab 5 – Interrupt Service With Timer 1 and Timer32**

This lab has two parts.

* Part 1 will configure the interrupt system. It will also configure and use Timer 1 as a continuously running timer (NEVER stops) to create the 10 ms real-time executive loop time. All previous functions should operate correctly once the “lab1\_libx.X.a” library file is removed.
* Part 2 will use Timer 2 and Timer 3 (“Timer32”) as a single 32-bit timer. It will be configured and used in interrupt-driven fashion as well. The Interrupt Service Routine will toggle (invert) the LED at RA6. An application “app\_test\_timer32” will inform the ISR when to toggle or turn off. When toggling, the LED will flash at a rate of 0.5 Hz (500 ms cycle time – 250 ms ON, 250 ms OFF).
* NOTE: Use the following as operands for coprocessor instructions mfc0, mtc0
  + EPC register **\_CP0\_EPC**
  + Status register **\_CP0\_STATUS**
  + Cause register **\_CP0\_CAUSE**

All of the *Lab 5 functions* will build off of the **Lab 3 framework**.

* Carefully copy the **cst204:\labs\lab3\lab3.X** project project into a new **cst204:\labs\lab5\lab5.X** project.
* The following files should have been ported into the **cst204:\labs\lab5\lab5.X\source** folder (Added to **Source Files** Project Folder)
  + app\_clock.c
  + app\_heartbeat.S
  + app\_test\_keypad.c
  + config\_bits.S
  + data.S
  + hardware.S
  + keypad.S
  + lcd.S
  + main.S
  + svc\_keypad.c
* New files will be:
  + isr\_timer1.S
  + isr\_timer32.S
  + app\_test\_timer32.c
* Previous files that will be modified are:
  + data.S
  + hardware.S
  + main.S

**Part 1**

* Modify the following files to add the required items.
  + **hardware.S**
    - **intsys\_config** – Add configuration to configure and enable the interrupt system. Use only the following two configurations. Use class notes as a guide.

1) **\_CP0\_CAUSE** to set IV bit,

2) **INTCON** to set MVEC bit

* + - timer1\_config – Add configuration to configure Timer 1.

1) Clear T1IF (IFS0),

2) Set PRIORITY = 6 and Subpriority = 0 (IPC1),

3) Set T1IE (IEC0),

4) Clear TMR1

5) Load PR1 = 25000 (10 ms at PBCLK = 2.5 MHz)

6) Turn on Timer 1 (T1CON).

* Add the following files to add the required items.
  + **isr\_timer1.S**
    - **isr\_timer1** – Add prologue and epilogue code. In the “middle” do:

1) Clear **T1IF** (**IFS0**),

2) Set global variable **FLAG\_10MS**

3) Include the “real” ISR in the vector\_4 section below the **isr\_timer1** code.

**.section .vector\_4, code**

**j isr\_timer1**

**nop**

**Part 2**

* Modify the following files to add the required items.
  + **hardware.S** will add the assembly code to configure the GPIO pins that interface to the LCD.
    - **gpio\_config** – Configure RA6 as digital OUTPUT, non-open drain
    - **timer32\_config** – Add configuration to configure Timer 2 and 3.

1) Clear T3IF,

2) Set T32 in T2CON,

2) Set Timer 3 PRIORITY = 5 and Subpriority = 0,

3) Set T3IE.

* + **data.S** will add the following global variables used by **isr\_timer32.S** and **app\_test\_timer32.c**.
    - **FLASHER**
    - **app\_timer32\_state**
* Add the following files to add the required items.
  + **isr\_timer32.S** is the Timer 3 ISR.
    - **isr\_timer32** – Add prologue and epilogue code. In the “middle” do:

0a) Stop Timer 2

0b) Clear T3IF

1) Check global variable **FLASHER**

If **FLASHER** = 0,

i) Clear RA6

If **FLASHER** = 1

i) Toggle RA6

ii) Clear TMR2

iii) Load PR2 = 625000 (250 ms at PBCLK = 2.5 MHz)

iv) Start Timer 2

2) Include .section code using**.vector\_12** (vector 12) to call **isr\_timer32**

* + **app\_test\_timer32.c** is a test application per the description below.
    - **app\_test\_timer32** – Two-state state machine to wait for the “1” key press and respond by: 1) Setting **FLASHER** = 1 and setting T3IF, or 2) Clearing **FLASHER** = 0.

**KEY\_PRESSED = 1 / FLASHER = 1**

**/ IFS0SET = 0x1000 (T3IF = 1)**

1

0

**KEY\_PRESSED = 0 / FLASHER = 0**

**KEY\_PRESSED = 1**

**KEY\_PRESSED = 0**

**Completion of Part 1 and Part 2.**

* Demonstrate operation to the instructor.
* Zip the **cst204:\labs\lab5** folder and rename it **cst204:\labs\lab5.zip** and upload.