ECE 230 Introduction to Embedded Systems

Module 1 & 2
Project 1 – Assembly Programming, LEDs and Switches

For this project, you will create a program in assembly to toggle a blinking LED with a pushbutton. As an advanced project, you may also toggle which LED is active with a 2nd pushbutton. In this project, you will put into practice the following concepts:

- Assembly programming
- Digital input/output
- Pull-up/down resistors
- LED outputs
- Switch inputs
- Debouncing
- Time measurement in clock cycles
- Measuring signals with an oscilloscope

Circuit

All components needed for the project are included on the MSP432Launchpad board, so you will not need to wire anything for the circuit. The components which will be used in the project are shown in the snippets from the Launchpad schematic below.
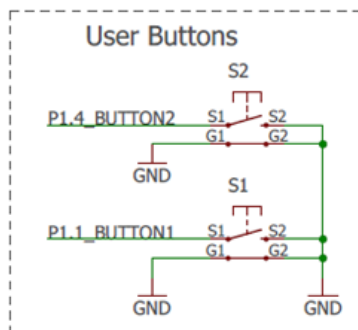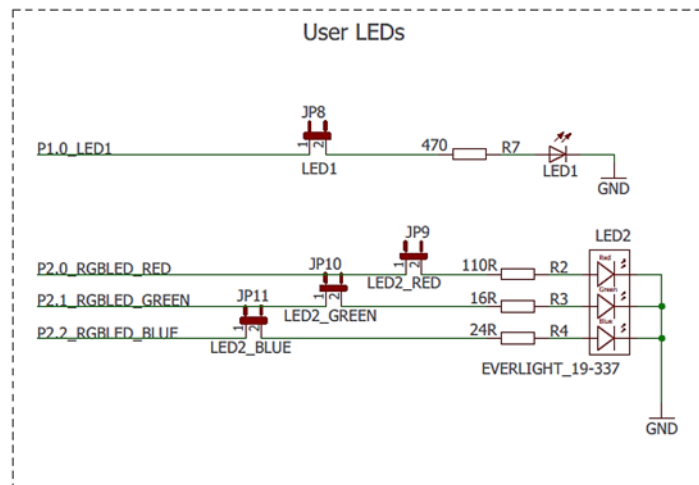

Figure 1: User Buttons

Figure 2: User LEDs

Program

Your program will use LED2 (RGB LED connected to P2.0, P2.1, P2.2), S1 (pushbutton switch connected to P1.1), and S2 (pushbutton switch connected to P1.4). All LEDs should be initially off on system start. Upon press and release of S1, the red LED of LED2 should begin blinking at a rate of 1 Hz (500 ms on and 500ms off). It should continue blinking until S1 is pressed again, then wait until a new press and release before beginning to blink again. Your program should properly debounce on the press and release of the switch input. Toggle which of the RGB LEDs is active (LED which is currently blinking) whenever S2 is pressed. It should initially be the red LED which is active, and with each press of S2 it should toggle red→green→blue→red. It should toggle only once per press of S2 (the switch should be properly debounced). LED2 blink rate requirements should be maintained while S2 is not pressed, but it is okay if pressing S2 impacts blink period (due to debounce handling and waiting for release).

Design constraint: may assume pressed state of S1 and S2 never overlap.

Basic feature requirements (8 points):
- Project implemented in assembly
- LED2 shall be initially *off* on system start
- While LED2 *off*, upon press and release of S1, LED2_red shall begin blinking at a rate of 1 Hz
  - Switch S1 shall be software-debounced on press and release (not less than 5 ms)
  - LED2 shall turn *on* within 10 ms of S1 release
  - LED2 shall blink at 50% duty cycle (*on* for 500 ms and *off* for 500 ms)
    - Accuracy (of pulse widths) shall be within ±2%

Feature 1 requirements (4 points):
- Accuracy (of pulse widths) shall be within ±1%

Feature 2 requirements (4 points):
- Accuracy (of pulse widths) shall be within ±0.2%

Feature 3 requirements (4 points):
- While LED2 blinking, upon press of S1, LED2 shall turn *off* and stop blinking
  - LED2 shall turn *off* within 1 ms of S1 press
  - System shall wait until release of S1 before returning to state of detecting new press and release on S1

Feature 4 requirements (8 points):
- While LED2 blinking, upon press of S2, *active* LED shall toggle in the following cyclic pattern: red→green→blue→red→etc
  - Initial *Active* LED shall be red LED
  - Newly *active* LED shall turn *on* within 1 ms of S2 press, but not prior to former *active* LED turning *off* (should precede handling of switch debounce)
    - Requirement only relevant when S2 pressed while current state of LED2 is *on*
    - LED2 shall maintain state (*on/off*) during current interval of S2 press
  - *Active* LED shall toggle only once per press and release of S2
  - Switch S2 shall be software-debounced on press and release
  - Counter shall be in paused state between press and release of S2 (LED2 blink period counter is not active while S2 is pressed)
    - New *active* LED shall complete remainder of current 500 ms interval (i.e. current interval shall be 500 ms + S2 press time + 5 ms release debounce)
  - *Active* LED shall be maintained through blinking state toggles (press of S1)
- Pressing S2 shall have no effect while LED2 is not blinking

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Verification requirements:
Standard requirement
- LED2 shall blink at 50% duty cycle (*on* for 500 ms and *off* for 500 ms)
  - Accuracy (of pulse widths) shall be within ±2%   (basic feature)
  - **OR** Accuracy (of pulse widths) shall be within ±1%   (feature 1)
  - **OR** Accuracy (of pulse widths) shall be within ±0.2%   (feature 2)

Optional requirements (must complete feature 4)
- While LED2 blinking, upon press of S2, *active* LED shall toggle in the following cyclic pattern: red→green→blue→red→etc
  - Newly *active* LED shall turn *on* within 1 ms of S2 press, but not prior to former *active* LED turning *off* (should precede handling of switch debounce)
    - Requirement only relevant when S2 pressed while current state of LED2 is *on*