PROJECT #1 VERIFICATION

ASSEMBLY PROGRAMMING, LEDS, AND SWITCHES

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ECE230-03

REQUIREMENTS

- Project implemented in assembly
- LED2 shall be initially *off* on system start
- While LED2 is *off*, upon press and release of S1, LED2 shall begin blinking at a rate of 1Hz
    - Switch S1 shall be software-debounced on press and release
    - LED2 shall turn *on* within 10ms of the release of S1
    - LED2 shall blink at 50% duty cycle (*on* for 500ms and *off* for 500ms)
- While LED2 is blinking, upon press of S1, LED2 shall turn *off* and stop blinking
    - LED2 shall turn *off* within 1ms of S1 press
    - System shall wait until S1 has been released before returning to a state of detecting a new press and release of S1

ADVANCED REQUIREMENTS

- For all requirements, accuracy shall be within ±10µs
- Initially on system start, the red LED of LED2 shall be the *active* LED whose state is toggled by S1
- While LED2 is blinking, upon press of S2, the *active* LED shall toggle in the following cyclic pattern: red → green → blue → red → etc.
    - The newly *active* LED shall turn *on* within 1ms of the press of S2, but not prior to the former *active* LED turning *off*
    - The *active* LED shall toggle only once per press and release of S2
    - Switch S2 shall be software-debounced on press and release
    - The system shall be in a paused state between the press and release of S2

TEST PLAN

The following details a plan for testing the specifications

Test	Procedure	Pass/Fail Criteria
1	On start, verify LED2 is off	LED2 is off at t=0
2	On start, verify the active LED is red	The red LED activates on the first press and release of S1
3	Verify LED2 turns on within spec	LED2 turns on within 0<t<10.01ms after S1 is released
4	Verify S1 and S2 are debounced on both press and release	S1 and S2 have software debouncing on every press and release
5	Use an oscilloscope to verify LED2 has a frequency of 1Hz and a 50% duty cycle	LED2 toggles every 499.99<t<500.01ms
6	Verify LED2 turns off and stops blinking after S1 is pressed within spec	LED2 turns off and stops blinking within 0<t<1.01ms after the press of S1
7	Verify the system waits until S1 has been released before waiting for a new S1 press	The system waits until S1 has been released before detecting a new S1 press and release
8	Verify S2 toggles which LED is active and toggles in the correct cyclic pattern	S2 toggles the active LED and goes red → green → blue → red
9	Verify the next active LED turns on after S2 is pressed within spec	The former active LED turns off and the next active LED turns on within 0<t<1.01ms after the press of S2
10	Verify the active LED toggles only once per S2 press and release	The active LED changes only once when S2 is pressed and released
11	Verify the system is paused while S2 is being held	The LED does not blink nor react to switch inputs while S2 is being held

VERIFICATION

TEST 1

On start, LED2 is completely off.

Meets criteria.

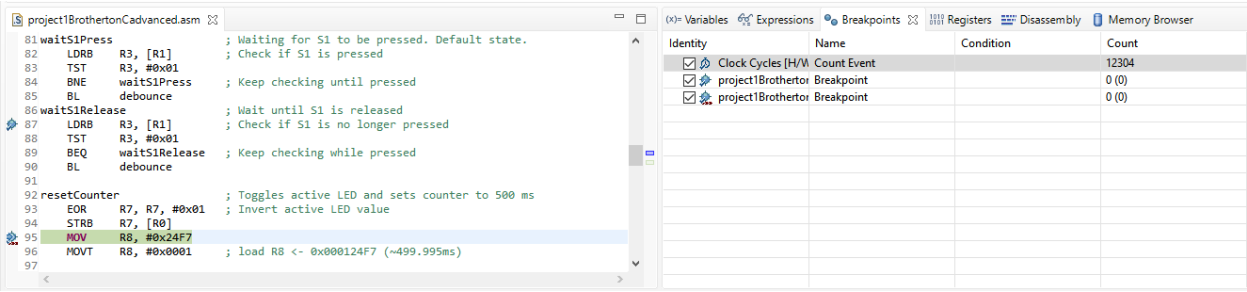
TEST 2

When S1 is pressed and released, the red LED begins blinking.

Meets criteria.

TEST 3

The following code analysis depicts the code between S1 being released (breakpoint at line 47) and the LED turning on (breakpoint at line 95). By looking at the clock cycle counter, it can be determined how long it took.



The following calculation shows how long the process took given that the MSP432P401R clock rate is 3MHz:

$$t = \frac{12304\ clock\ cycles}{3 \times 10^6 cycles\ per\ second} = 4.101ms$$

Meets criteria.

TEST4

The following code displays the part of the program with the state machine that checks for switches being pushed.

project1BrothertonCadvanced.asm

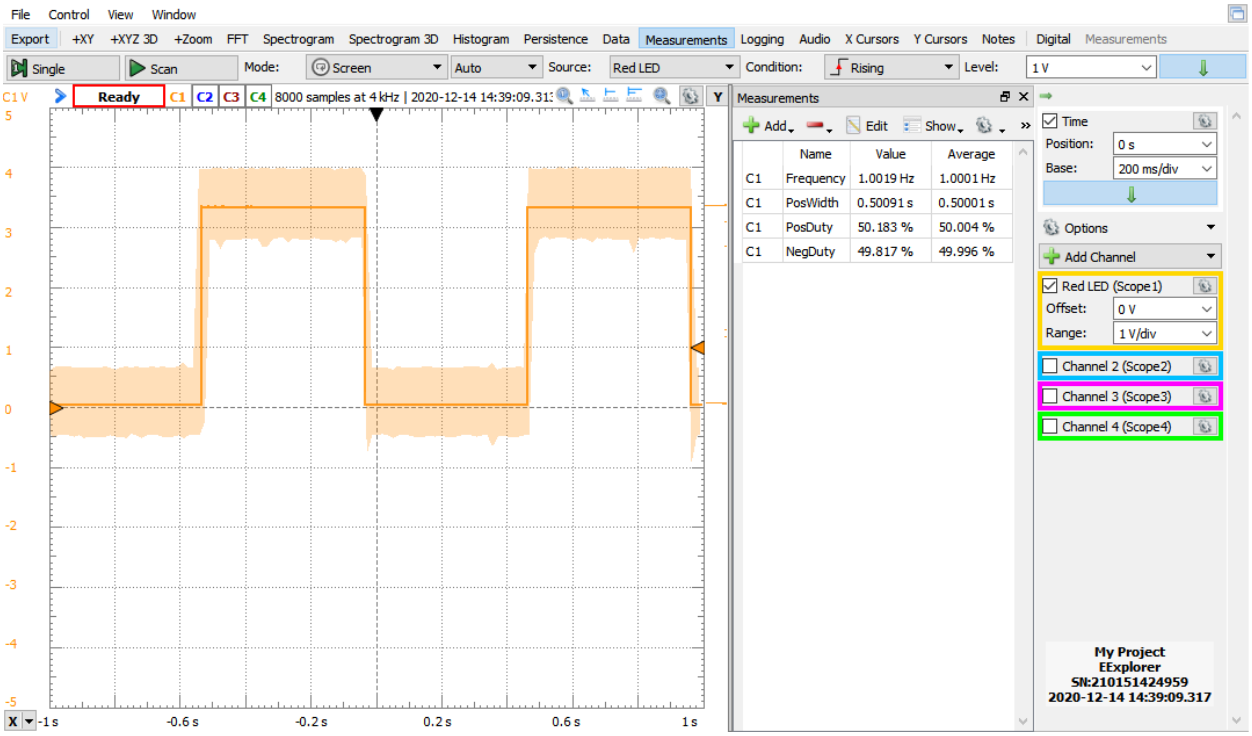
```
74 debounce                 ; Software debouncing via delay
75     MOV     R3, #0x1000  ; Load R3 <- 0x1000 (~4.096ms)
76 delay
77     SUBS    R3, #01
78     BNE     delay
79     BX      LR
80
81 waitS1Press              ; Waiting for S1 to be pressed. Default state.
82     LDRB    R3, [R1]     ; Check if S1 is pressed
83     TST     R3, #0x01
84     BNE     waitS1Press  ; Keep checking until pressed
85     BL      debounce
86 waitS1Release            ; Wait until S1 is released
87     LDRB    R3, [R1]     ; Check if S1 is no longer pressed
88     TST     R3, #0x01
89     BEQ     waitS1Release ; Keep checking while pressed
90     BL      debounce
91
92 resetCounter             ; Toggles active LED and sets counter to 500 ms
93     EOR     R7, R7, #0x01 ; Invert active LED value
94     STRB    R7, [R0]
95     MOV     R8, #0x24F7
96     MOVT    R8, #0x0001  ; load R8 <- 0x000124F7 (~499.995ms)
97
98 LEDToggle                ; State for LED blinking while it waits for switch press
99     LDRB    R3, [R1]     ; See if S1 is pressed
100    TST     R3, #0x01
101    BEQ     LEDOff       ; if S1 pressed, turn off LED
102    LDRB    R3, [R2]     ; See if S2 is pressed
103    TST     R3, #0x01
104    BEQ     updateLED    ; Change the active LED
105    SUBS    R8, R8, #0x01
106    BEQ     resetCounter ; if counter == 0, reset counter and toggle LED
107    B       LEDToggle
108
109 updateLED                ; Update which LED is active. R->G->B->R
110    MOV     R7, #0       ; turn off LED
111    STRB    R7, [R0]
112    ITTE    EQ           ; if blue LED is active, set it to red
113    CMPEQ   R0, R6
114    MOVEQ   R0, R4
115    ADDNE   R0, R0, #0x4 ; else set it to next LED
116    MOV     R7, #1       ; turn on LED
117    STRB    R7, [R0]
118    BL      debounce     ; debounce S2
119 waitS2Release            ; Wait until S2 is released
120    LDRB    R3, [R2]     ; Check if S2 is no longer pressed
121    TST     R3, #0x01
122    BEQ     waitS2Release
123    BL      debounce
124    B       LEDToggle
125
126 LEDOff                   ; State after LED toggle and S1 has been pressed
127    MOV     R7, #0       ; turn off LED
128    STRB    R7, [R0]
129    BL      debounce
130 waitS1Release2           ; Wait for S1 to be released
131    LDRB    R3, [R1]
132    TST     R3, #0x01
133    BEQ     waitS1Release2 ; keep checking while pressed
134    BL      debounce
135    B       waitS1Press  ; back to initial state
```

After every single switch press or release and before any check for switch input (lines 85, 90, 118, 123, 130, 135), the software branches and links to a procedure which causes a delay and acts as a software debounce.

Meets criteria.

TEST 5

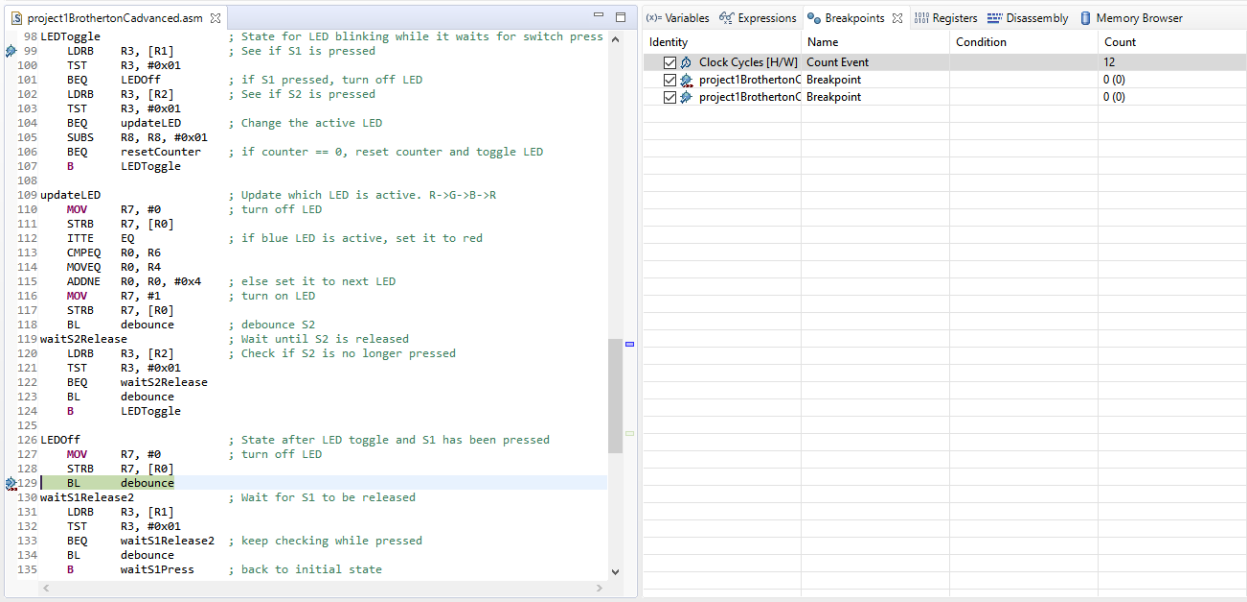
In order to verify the LED follows the blinking pattern, an oscilloscope was used. The following is a snapshot of the oscilloscope and the LED output. Due to slight inconsistencies, how long the LED blinks (PosWidth) and the frequency varies. However, on average the LED blinks for 500.01ms and nearly has a 50% duty cycle.



Meets criteria.

TEST 6

The following code analysis depicts the code between S1 being pressed (breakpoint at line 99) and the LED turning off (breakpoint at line 131). By looking at the clock cycle counter, it can be determined how long it took.



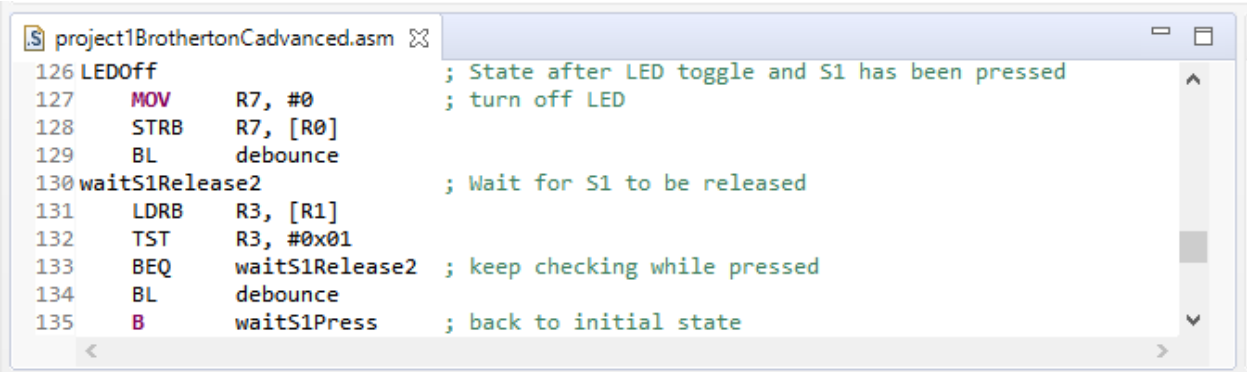
The following calculation shows how long the process took given that the MSP432P401R clock rate is 3MHz:

$$t = \frac{12\ clock\ cycles}{3 \times 10^6 cycles\ per\ second} = 4\mu s$$

Meets criteria.

TEST 7

The following code shows that the program will wait until S1 is released until it will detect another S1 press.



Meets criteria.

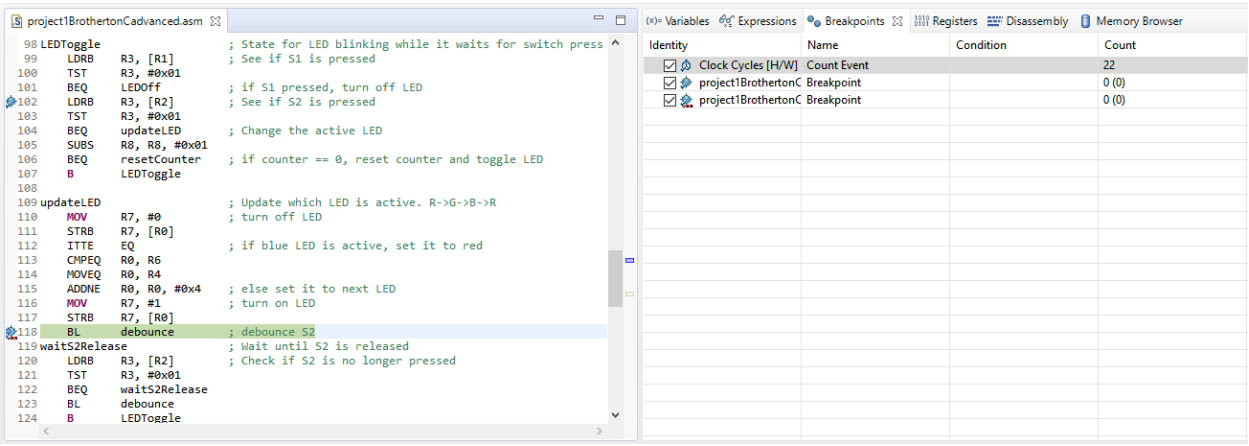
TEST 8

When S2 is pressed while LED2 is in the blinking cycle, the system cycles between the red, green, and blue LED.

Meets criteria.

TEST 9

The following code analysis depicts the code between S2 being pressed (breakpoint at line 102) and the former active LED turning off and the new active current LED turning on (breakpoint line 114). By looking at the clock cycle counter, it can be determined how long it took.



The following calculation shows how long the process took given that the MSP432P401R clock rate is 3MHz:

$$t = \frac{22\ clock\ cycles}{3 \times 10^6 cycles\ per\ second} = 7.\overline{3}\mu s$$

Meets criteria.

TEST 10

The LED only changes once per press of S2. Regardless if S2 is pressed or held.

Meets criteria.

TEST 11

While S2 is being held, the active LED remains on and the S1 does not change the system.

Meets criteria.

CONCLUSION

All the tests met the criteria for both the basic and advanced requirements.

DEMO LINK

The following a YouTube link demonstrating the project:

https://www.youtube.com/watch?v=uPxH2E80UFQ