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SENG 5831 Embedded Systems Prof. Amy Larson

1. Use your original version of toggling the red LED that uses for-loops. Toggle all 3 at 1Hz. (Do not type in any menu options while you are toggling until the 1 minute is up). How good was your WCET analysis of the for loop? If it is very far off, adjust it. Why did I not want you to use the menu while running the experiment?

My original estimation was off by about 25%. I adjusted it and now the LEDs are blinking 60 times per minute and off by 2 after 10 minutes. It seems that processing the commands from the menu robs execution cycles and over time causes the blinking rate of the LEDs to be incorrect.

2. Use your software timer to toggle the red LED. Toggle all 3 at 1Hz. Simply observe the final toggle count. All should be about 60 (maybe the red is off by 1). If this is not the case, you probably set something up wrong, and you should fix it.

Yes, They're all within 1-2 toggles at 60. At 600, they're all within 1-2 toggles

3. Set all LEDs to toggle at 2Hz (500ms). Place a 90ms busy-wait for-loop into the ISR for the green LED. Toggle for 1 minute and record results. Now move the 90ms busy-wait for-loop from the green into the ISR for the yellow LED. Toggle for 1 minute and record results. What did you observe? Did the busy-wait disrupt any of the LEDs? **Explain your results.**

R:100 G:121 Y:121 with the busy-wait inside the green ISR

R:14 G:121 Y:120 with the busy-wait inside the yellow ISR

Yes, the busy wait seemed to disrupt the Red LED even though the busy wait was placed in the Green and the Yellow ISR functions. The Red LED was delayed more when the busy-wait loop was placed inside the yellow ISR because the yellow ISR is called 10 times more frequently than the Green LED ISR. The yellow ISR is being called 20 times per second while the green ISR is being called 2 times per second.

4. Repeat #3, except use a 110ms busy-wait. You probably won't be able to use the menu functions. If not, report that, and discuss what you observed from the blinking. **Explain your results.**

R: 95 G:121 Y:121 with the busy-wait inside the green ISR

When placing the 110 ms busy-wait loop in the Yellow ISR, the menu stopped responding. This is because 100% of the execution time is being used inside the Yellow ISR for the busy-wait loop. The Red LED also stopped blinking

5. Repeat #3, except use a 510ms busy-wait. **Explain your results.**

With the busy-wait loop inside of the Green ISR, the Red LED stopped flashing all together. The Green LED is flashing slightly faster than the Yellow LED. Or rather it looks like the Yellow LED is flashing slightly slower than the Green LED. The menu is also not responding. The causes are the same as what was observed in the #4 experiment. I think the reason that it is only slightly slower is because the Green ISR is being triggered every half second which is close to the frequency that the ISR is supposed to be firing at.

With the busy-wait loop in the Yellow ISR, the Red LED is not blinking at all and the Yellow LED is drastically slower than the Green LED. Menu is still not responding. Again, I believe this is because the Yellow ISR is spending too much time inside the busy-wait loop which is compounded by the fact that the Yellow ISR is called 20 times per second. Every toggle of the Yellow LED requires 5 passes through the Yellow ISR. However, because each of the 5 passes through the Yellow ISR now takes 510ms, the toggling of the Yellow LED is occurring every ~2.5 seconds.

6. Repeat #5 (i.e. 2Hz toggle with 510ms busy-wait), except place an sei() at the top of the ISR with the for-loop in it. **Explain your results.**

With the busy-wait loop and the sei() command in the Green ISR, the Red LED has stopped blinking completely. The Green and Yellow LEDs have continued blinking at their normal rate. The menu is non-responsive. I'm not sure why the Green and Yellow LED are blinking at the same rate whereas during experiment #5 the Yellow LED was flashing at a slightly slower rate. Again, because the Green ISR is being triggered every half second, which is close to 510ms, which is close to the frequency that the Green ISR is supposed to be triggered at, there's not really any perceived delaying of the Green LED.

With the busy-wait loop and the sei() command in the Yellow ISR, the Red and Yellow LEDs have stopped blinking completely. The Green LED has continued blinking at it's normal rate. The menu is non-responsive. It appears that the sei() command is allowing the Yellow ISR to be interrupted by the ATMEGA chip triggering another interrupt event on the Yellow LED. Because the busy-wait loop is before the action to toggle the Yellow LED, the program counter is essentially being reset back to the beginning of the Yellow ISR before it can finish running through the busy-wait loop. The result is that the Yellow LED never flashes.