Q1 [40 Points]. For a daisy-chained SPI with 4 devices ($\mu C \rightarrow$ Device #1 $\rightarrow$ Device #2 $\rightarrow$ Device #3 $\rightarrow$ Device #4 $\rightarrow$), the SPI master intends to send the following bytes to the devices in sequence:

- `0x5A` to Device #1
- `0x6B` to Device #2
- `0x7C` to Device #3
- `0x8D` to Device #4

Additionally, at the start of communication, all devices hold the byte `0xFF` in their SPI shift registers.

(Part 1) After 32 clock cycles, what will be the contents of the SPI shift registers of devices?

(Part 2) If the SPI clock operates at 500 kHz, how long (in milliseconds) will it take for the SPI master to complete the transmission to all devices and receive back the first byte sent?

(Part 3) Suppose the master sends the byte sequence with an incorrect clock frequency of 250 kHz, but the devices expect 500 kHz. What would be the potential impact on the data received by Device #4, and why?

(Part 4) If Device #2 is configured to reverse the bits of the data it receives before passing it on, what will be the final byte received by the master after 32 clock cycles?

Q2 [40 Points]. You are designing a system to control the brightness of an LED using timer-based Pulse Width Modulation (PWM) on a microcontroller.

(Part 1) Calculate the period of a PWM signal with a frequency of 1 kHz in microseconds. The microcontroller's clock frequency is 16 MHz, and the timer uses a prescaler of 64. Calculate the value to be loaded into the timer's register (TA0CCRx value) to achieve a 1 kHz PWM frequency.

(Part 2) Given the calculated TA0CCRx value from part (1), compute the TA0CCRx for the 50% and 75% duty cycle.

(Part 3) Assume the timer is in 8-bit mode (255 max). Calculate the minimum and maximum achievable PWM frequencies using the 16 MHz clock and a prescaler of 64. Determine the resolution of the duty cycle as a percentage.

(Part 4) Suppose you switch to a 16-bit timer with the same 16 MHz clock and a prescaler of 64. Calculate the maximum TA0CCRx value. Calculate the minimum achievable PWM frequency.

Q3 [20 Points]. A push button is used to control an LED based on these rules: (1) Every time the push button is pressed, the LED turns ON for 5 seconds; (2) If the button is pressed again within the 5-second window, the timer resets, and the LED stays ON for another 5 seconds from the latest press. A user interacts with the button as follows:

- **Press 1:** Time = 0 seconds
- **Press 2:** Time = 3 seconds
- **Press 3:** Time = 8 seconds
- **Press 4:** Time = 12 seconds

(Part 1) Calculate the total time the LED stays ON based on the button press sequence. Provide a timeline showing the ON and OFF states of the LED.

(Part 2) Explain if there are any periods where pressing the button has no effect and why that happens.

(Part 3) Consider a scenario where the button is pressed every 4 seconds starting at Time = 0 seconds. How long would the LED remain ON by the 20th press?

Homework Policies

(I) Homework 5 is due by 11:59PM on Sunday 11/23/2024. Late submissions WILL NOT BE ACCEPTED, as the solution will be released immediately after the deadline to aid in your preparation for the final exam.
(II) All homework must be submitted electronically (PDF) via Webcourses. Ensure that your file is properly named (e.g., "Lastname_Firstname_EEL4742_HW5.pdf"). If you encounter technical issues during submission, you must notify the instructor before the due date by email.
(III) All submitted work must be your own. Plagiarism, including copying from other students, online sources, or using GPTs, is strictly prohibited. Any instances of plagiarism will result in a zero for the assignment.
(IV) If you believe there has been a grading error, you may request a regrade within one week of receiving your graded assignment.
(V) For certain assignments, you may be required to attend a check-off meeting (in-person or online) with the instructor after submission. During this meeting, you will discuss your solution, explain your approach, and answer questions about your work. Failure to attend a required check-off meeting, or inability to explain your solution, may result in a reduction of your grade for that assignment.