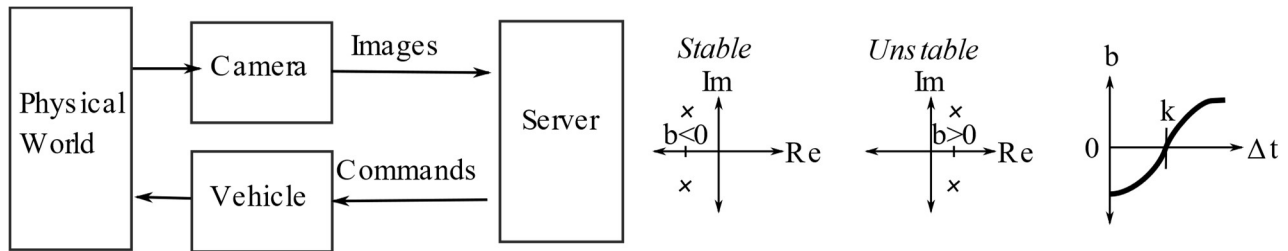


Jonathan W. Valvano

First: _____ Last: _____

Feb 16, 2023, 12:30-1:45pm. This is a closed book exam, with one 8.5 by 11-inch crib sheet (double sided). You have 75 minutes, so please allocate your time accordingly. No calculators allowed. **Please read the entire quiz before starting.**

(10) Question 1. Consider a self-driving vehicle. The control system samples images with cameras located on the vehicle, sends the images via TCP packets to a central server, the central server analyzes the images, and sends motor commands to the vehicle, which then adjusts power and steering as needed. Let Δt be the total delay to go from the physical world to the server and back to the physical world. k is a constant. This classical control system where the value of the delay determines if the system is stable or unstable. $\Delta t < k$ means the poles are in the left plane, and the system works. $\Delta t > k$ means the poles are in the right plane, and the vehicle crashes.

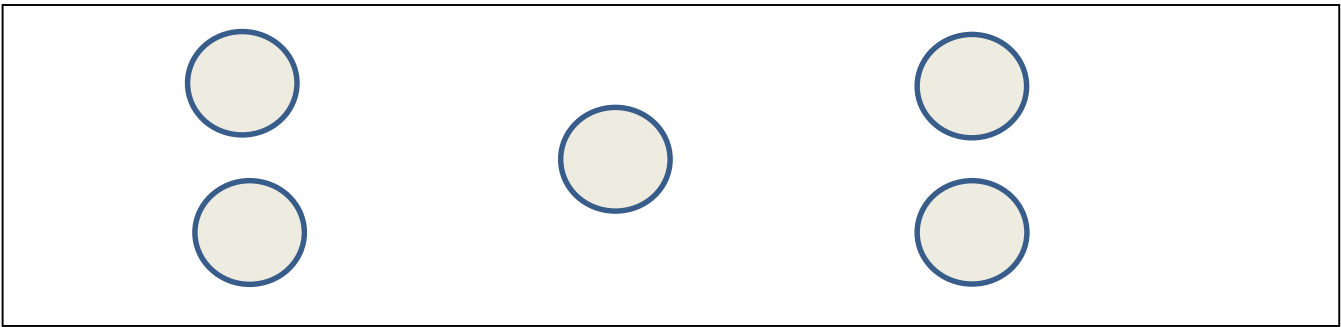


How would you classify this real time system: hard, firm, soft? Justify your answer

(10) Question 2. Consider an internet video conferencing system like zoom. Should you implement it using TCP or UDP? Justify your answer.

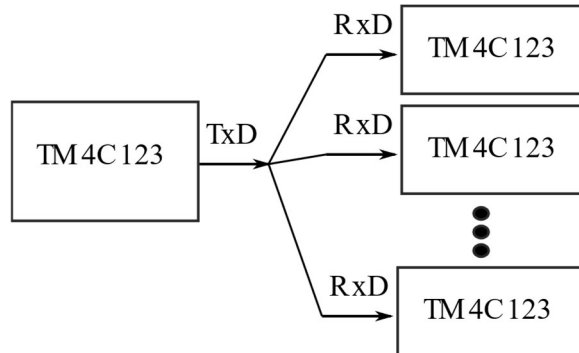
(10) Question 3. Consider an IoT system implementing a network of 5 sensor nodes. The network implements a **mesh** topology.

(5) Part a) This network has 5 nodes. Add lines representing possible communication paths.



(5) Part b) List one advantage a mesh topology would have over a star topology

(10) Question 4. Consider a master slave system where one master TM4C123 broadcasts over UART commands to multiple slave TM4C123s. There is no addressing, all slaves respond in the same way. The baud rate is fixed at 115200 bits/sec. Communication is one way (master to slave). Consider this system from a circuit level perspective: voltage, current, resistance, capacitance, inductance. Qualitatively, what one factor will determine the maximum number of slaves allowed?

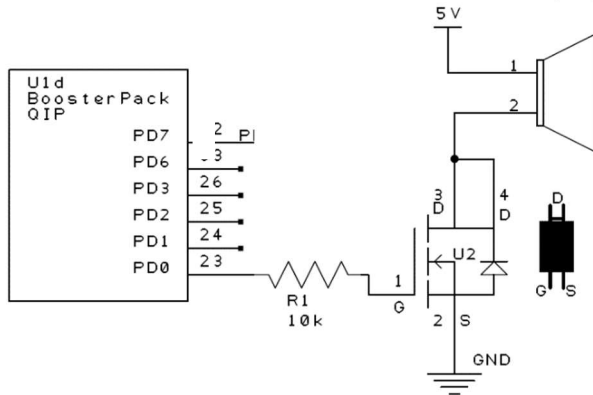


Parameters for the TM4C123 microcontroller (with 8mA mode selected)

$$I_{OL} = 8\text{mA}, \quad I_{OH} = 8\text{mA}, \quad I_{IL} = 2\mu\text{A}, \quad I_{IH} = 2\mu\text{A}, \quad C_{in} = 8 \text{ pF}$$
$$V_{OL} = 0.4\text{V}, \quad V_{OH} = 2.4\text{V}, \quad V_{IL} = 1.3\text{V}, \quad V_{IH} = 2.0 \text{ V}$$

(10) Question 5. Most instructions on the CortexM will run to completion if an interrupt is triggered during its execution. However, there are some instructions such as LDM STM PUSH POP IDIV and SDIV that will be terminated and abandoned if an interrupt is triggered during its execution. After the ISR is complete, the instruction will be restarted from its beginning. Why are these instructions not allowed to complete?

(10) Question 6. Consider this speaker interface. One system has a speaker resistance, R of 8Ω , and another system has a speaker resistance of 32Ω . V_{GS} is $2V$, and V_{DS} is $0.5V$. The MOSFET could be either IRLD024 or IRLD120. PD0 is a 50% duty cycle square-wave at 1 kHz .



Derive an equation for the electrical power delivered to the speaker. Show your work, and give your equation in terms like V_{OH} , V_{OL} , V_{CC} ($3.3V$), V_{BUS} ($5V$), R_I ($10k\Omega$), R (8Ω or 32Ω), V_{GS} , and V_{DS} . Use the equation to determine how much louder the sound will be using $R = 8\Omega$ as compared to using $R=32\Omega$.

(10) Question 7. Consider this system with two timer interrupts. The priority level of both interrupts is 7, lowest possible level. There are no other accesses to Port F.

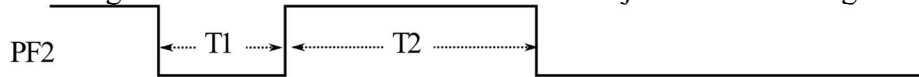
```

void Timer0A_Handler(void) {
    TIMER0_ICR_R = 1;
    GPIO_PORTF_DATA_R ^= 0x02;
    GPIO_PORTF_DATA_R ^= 0x02;
    Task0();
    GPIO_PORTF_DATA_R ^= 0x02;
}

void Timer1A_Handler(void) {
    TIMER1_ICR_R = 1;
    GPIO_PORTF_DATA_R ^= 0x04;
    GPIO_PORTF_DATA_R ^= 0x04;
    Task1();
    GPIO_PORTF_DATA_R ^= 0x04;
}
    
```

(5) Part a) Do these ISRs have a critical section? Justify your answer.

(5) Part b) The following measurement was made on PF2. T2 is just a little bit larger than T1.



What does the time T1 mean? What does the time T2 mean? Derive an equation to calculate the time to execute Task1.

(10) Question 8. We will store the value 0.00 cm with the integer 0 and store the value +2.00 cm with the integer +8. Assuming the integer is stored as an 8-bit unsigned number, what are the minimum, maximum, precision and resolution of this fixed point number system? Give units for each.

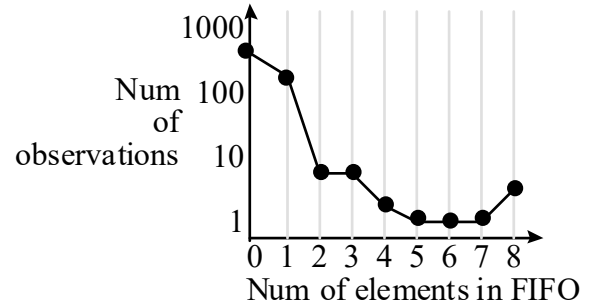
Minimum value =

Precision =

Maximum value =

Resolution of the value =

(10) Question 9. Consider an input device that uses a FIFO to pass data from ISR (which puts) to the main program (which gets). The FIFO can hold up to 8 elements. If it has 0 elements the FIFO is empty. If it has 8 elements the FIFO is full. The size of the FIFO was measured periodically resulting in the following histogram.



(5) Part a) Is this I/O bound or CPU bound (circle your answer)

<i>I/O bound</i>
<i>CPU bound</i>

(5) Part b) Should you increase the size of the FIFO? If yes, explain why the FIFO size should be increased. If no, explain why this FIFO size is ok.

(10) Question 10) Consider a producer-consumer problem with a FIFO, and the FIFO never becomes full. You know the maximum input rate was measured to be 1000 values per second. The maximum number of elements in the FIFO was measured to be 10 elements. What can you tell me about the average response time? Justify your answer.