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Feb 22, 2024, 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. These are the parameters of the GPIO pins on ***microcontroller A***:

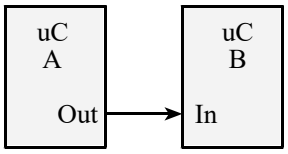
I_{OL} = 1mA, I_{OH} = 1mA, I_{IL} = 1µA, I_{IH} = 1µA,
V_{OL} = 0.3V, V_{OH} = 2.5V, V_{IL} = 0.5V, V_{IH} = 2.0 V

These are the parameters of the GPIO pins on ***microcontroller B***:

I_{OL} = 4mA, I_{OH} = 4mA, I_{IL} = 20µA, I_{IH} = 20µA,
V_{OL} = 0.7V, V_{OH} = 3.2V, V_{IL} = 1.0V, V_{IH} = 2.7 V

Can you directly connect a GPIO output from microcontroller A to a GPIO input on microcontroller B? If yes, prove it. If no, show at least one parameter/equation not satisfied.

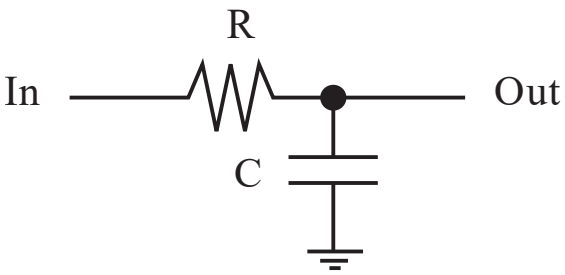
No, V_{OH} (A) =2.5V is less than V_{IH}(B)=2.7V

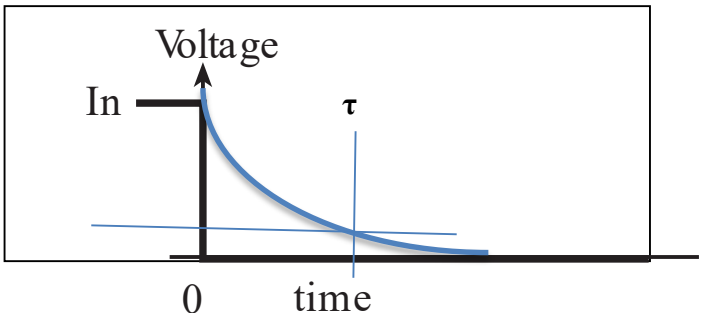


(10) Question 2. Let **x**, **y**, **z** be three fixed-point numbers, with **value1**=**x***2^{-5}, **value2**=**y***2^{-4} and value3=**z***2^{-6}. **x**, **y**, **z** are the integer parts of the fixed-point numbers. Write C code that adds **value1+value2** and stores the sum in integer **z**.

```
// convert both x and y to units z, 2^6
// z=x+y  means
 z =  (x<<1)+(y<<2);
```

(10) Question 3. Consider the following *RC* circuit. At time 0, the input, **In**, instantaneously drops from 3.3V to 0. Sketch the response of **Out** as a function of time. This in essence is what we have on every digital signal where we connect an output pin to an input pin. *R* is the output impedance of the output pin, and *C* is the input capacitance of the input pin. Let **τ**=**R***C. Label **τ** on the sketch.





Out = 3.3 - 3.3*exp(-t/RC)

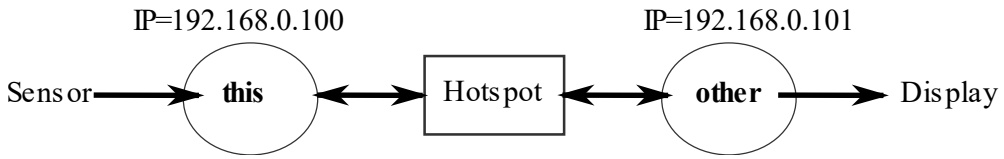
(10) Question 4. Match the scenario with its real-time specification. Answer **hard**, **soft**, or **firm**:

hard real time,
After missed deadline, value goes to very negative

soft real time,
After missed deadline, value decreases monotonically

firm real time
After missed deadline, value is 0

(20) Question 5. Consider an IoT system with two microcontrollers connected to the same wifi hotspot communication with UDP. The IP addresses of each are known as shown in the figure.



this microcontroller is streaming data to the **other** microcontroller. Consider these software tasks that could run on **this** microcontroller (not all tasks may not run):

A) Create a UDP socket, allocates a data structure from the operating system, get SocketID
B) Call DNS to get 192.168.0.101 from **www.ece.utexas.edu/other.html**
C) Connect SocketID in **this** to **other** microcontroller using IP address 192.168.0.100
D) Connect SocketID in **this** to **other** microcontroller using IP address 192.168.0.101
E) Connect to access point
F) Receive UDP message using SocketID
G) Close SocketID socket, returning socket to operating system
H) Disconnect from access point
I) Send a UDP message containing SocketID, data, and 192.168.0.100
J) Send a UDP message containing SocketID, data, and 192.168.0.101
K) Send a UDP message containing SocketID, and data

Part a) Which tasks occur in **this** once at the start. List them in order.

E) Connect to access point
A) Create a UDP socket

Or

E) Connect to access point
A) Create a UDP socket
D) Connect SocketID in **this** to **other** microcontroller using IP address 192.168.0.101

Part b) Which tasks occur every time **this** microcontroller sends data to the **other**. List them in order.

J) Send a UDP message containing SocketID, data, and 192.168.0.101

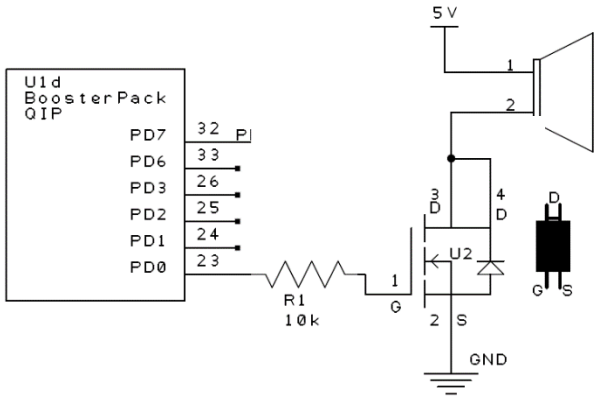
Or

K) Send a UDP message containing SocketID, and data

(10) Question 6. In Little's Theorem, **N=λR**, **R** is response time.

Little's Thm states N=R*λ. N=10, so there are on average 9 elements in FIFO

(10) Question 7. Consider this speaker interface. A squarewave on PD0 will make sound.



(5) Part a) What is the purpose of the 10k resistor?

The 10k slows down the MOSFET, especially when going from on to off.

(5) Part b) What would happen if the 10k resistor were removed and replaced with 0-ohm wire?

V = L dI/dt across the speaker will create a very large voltage which will destroy the circuit

(10) Question 8. Consider the following function. **RunPt** is a global variable.

```
SwitchThread
    PUSH    {R0-R12,LR}
    LDR     R0, =RunPt ; R0=pointer to RunPt
    LDR     R1, [R0]   ; R1=value of RunPt
    STR     SP, [R1]   ; save SP in data structure
    LDR     R1, [R1,#4]; new value for RunPt
    STR     R1, [R0]   ; save RunPt
    LDR     SP, [R1]   ; new SP from data structure
    POP     {R0-R12,LR}
    BX      LR
```

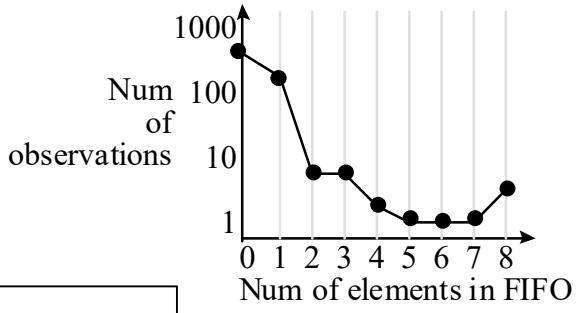
(5) Part a) Prove this function is not reentrant.

There are nonatomic read modify write sequences with two objects: SP itself and the global RunPt

(5) Part b) Explain how to fix the bug

Disable interrupts at beginning and reenable interrupts at the end

(10) Question 9. Consider an output device that uses a FIFO to pass data from main (which puts) to the ISR 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, CPU bound, or neither (circle your answer)

I/O bound *CPU bound* *Neither*

(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.

Yes, because occasionally the FIFO gets full