Jonathan W. Valvano First Name: _______________ Last Name:_____________________
May 10, 2013, 2-5pm
Closed book part

(20) Question 1. For each term, give a short definition (less than 20 words). Equations are good.
Part a) Aging

Part b) Board Support Package

Part c) Crisp Input

Part d) External Fragmentation

Part e) Internal Fragmentation

Part f) Path Expression

Part g) Reentrant

Part h) Stabilization

Part i) Stuff Bits

Part j) CAM. Use a figure and an example to explain how it works.

(5) Question 2.

Part a) Give the equation specifying the complex impedance of an ideal inductor. Give your answer in terms of inductance L and s, where $s = 2\pi f$j.

Part b) Give the equation specifying the complex impedance of an ideal capacitor. Give your answer in terms of capacitance C and s, where $s = 2\pi f$j.

Part c) Draw an equivalent circuit describing a DC motor and label each of the components.

Part d) For each component in part c) give a physical justification of its existence. For example, the motor is made with copper wire, and the resistance of that wire results from the ohmic property of copper wire: $R = \rho\ L/A$ (ρ is resistivity, L is length of the wire, A is the cross sectional area)

(5) Question 3. Explain how you could use both PSP and MSP to make a better OS. In particular, how would you use MSP? How would you use PSP?

(5) Question 4. Consider Ethernet at its lowest level

Part a) Is Ethernet full duplex or half duplex? Justify you answer by illustrating the wires in an Ethernet cable.

Part b) Is Ethernet synchronous or asynchronous? Justify you answer by illustrating the wires in an Ethernet cable.

(5) Question 5. Give the equation defining the Discrete Fourier Transform (DFT). Let x(n) be the sampled data, and let X(k) be the DFT output. Show equation of X(k) as a function of x(n).

(15) Question 6. Write C code for a FIFO queue that can be used to pass 32-bit data between foreground threads. None of the FIFO functions will be called from an interrupt service routine. You must write all of the FIFO code. There will be multiple producers and multiple consumers running in the foreground using a preemptive scheduler accessing this one FIFO. You can define and initialize semaphores by adding globals:

```
long semaphore=0;
```

You may call the following two blocking semaphore functions without showing their implementation.

```
void OS_Wait(long *semaPt);
void OS_Signal(long *semaPt);
```

Add the **`static`** qualifier to private components, and no **`static`** for public components. A producer thread should block on full, and a consumer thread should block on empty.

(5) Question 7. We defined time-jitter, δt, as the difference between when a periodic task is supposed to be run, and when it is actually run. The goal of a real-time DAS is to start the ADC at a periodic rate, Δt. Let t_n be the nth time the ADC is started. The goal is to make $t_n - t_{n-1} = \Delta t$. The jitter is defined as the constant, δt, such that

$$\Delta t - \delta t < t_i - t_{i-1} < \Delta t + \delta t \qquad \text{for all } i.$$

Assume the input to the ADC can be described as $V(t) = A + B\mathbf{cos}(2\pi ft)$, where A, B, f are constants. Assume the input is not clipped by the finite range of the ADC ($0 < V(t) < 3$V). Derive an estimate of the maximum voltage error, δV_{max}, caused by time-jitter. Basically, solve for δV_{max} as a function of δt, A, B, and f**.** Use calculus, not discrete time math.

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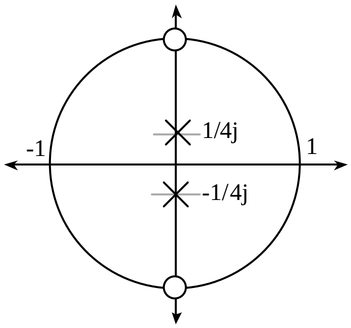
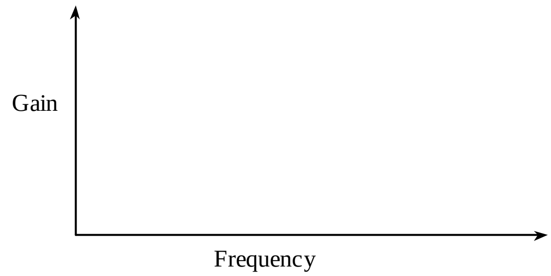
Open book part

Open book, open notes, calculator (no laptops, phones, devices with screens larger than a TI-89 calculator, devices with wireless communication). Please don't turn in any extra sheets.

(10) Question 8. The sampling rate of a real-time data acquisition system is 1000 Hz.

Part a) Make a rough sketch of the gain versus frequency response of a digital filter with this pole-zero plot. You should label the **Frequency** axis with specific values like 250, 500, but you need not quantitatively label the **Gain** axis.





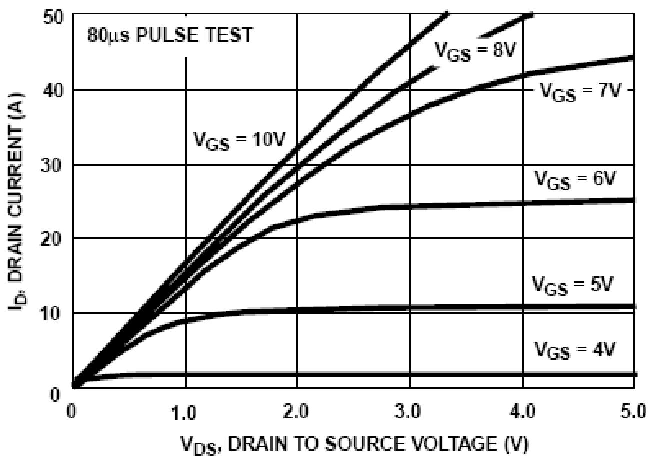
Part b) Derive the equation for the digital filter.

Part c) Write a C function using integer math to implement this digital filter. The function prototype is

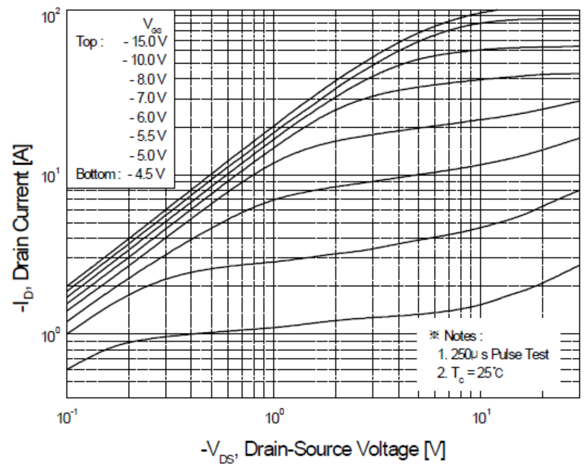
```
short Filter(short input);
// input is the new sampled data (0 to 1023), and
// the return parameter is the output of the filter
```

(10) Question 9. Consider a file system with FAT allocation. The disk size is 2^{29} bytes, and there is one FAT for the entire disk. Don't pack the bits into the FAT; let each block number be an 8-bit char, a 16-bit short, or a 32-bit long as needed. Assuming you wish to have no external fragmentation, what is the smallest block size that allows the FAT to exist completely in a one block?

(10) Question 10. Design a full H-bridge using two n-channel and two p-channel MOSFETs that will be used to drive a DC motor. The available power supply is +8.4V. The V_{OH} of the microcontroller is 3V. The goal is to run the motor as fast as possible (largest voltage across the motor, or the largest drain current). You can use other transistors and resistors (specify part numbers and resistor values).



n-channel



p-channel

The microcontroller has two digital outputs that control the motor speed and direction.

(15) Question 11. PendSV will be used to implement a cooperative thread switcher. Implement a round robin scheduler. The TCB structure is different from the one in the book.

```
struct tcb{
  struct tcb *next; // linked-list pointer
  long *sp;         // pointer to stack, valid for threads not running
};
typedef struct tcb tcbType;
tcbType *RunPt;
```

All active threads exist in a circular linked list with `RunPt` pointing to the thread currently running. There are NO interrupts in this operating system and SysTick is not used.

Part a) Write the PendSV handler in assembly language that implements a thread switch.

Part b) Show C or assembly code used to trigger a PendSV. This code will be used to invoke a cooperative thread switch.