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May 13, 2014, 9am-12n
Closed book part

(5) Question 1. Draw the circuit symbol for an NPN MOSFET transistor, like an IRF540. Label all the pins of this transistor. If you think the MOSFET is current-controlled, specify into which pin the current must flow to place the transistor into saturation. If you think the MOSFET is voltage-controlled, define across which two pins the voltage must be applied to place the transistor into saturation.

(5) Question 2. Consider the following circuit with an ideal resistor, ideal inductor, and ideal switch. Assume the switch has been closed for a long time. At time equals 0, the switch is opened. Roughly sketch the voltage, V_1, and the current, I, as a function of time, before and after time equals 0.
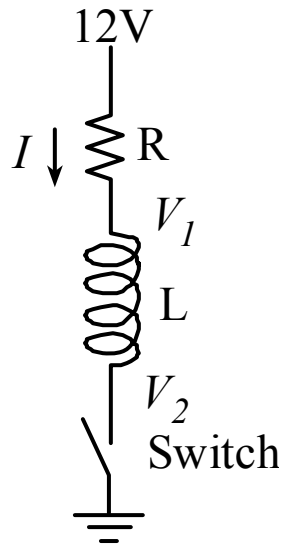
(5) Question 3. What is the purpose of the two 120 Ω resistors used in a CAN network, shown as 60 Ω in the above circuit? You used two 100 Ω resistors in Lab 6. *Hint*: these resistors were not actually needed for our Lab 6.
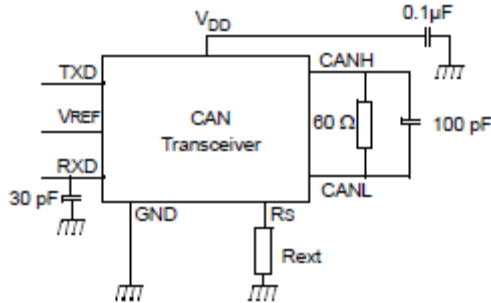
(5) Question 4. In what form is data transferred across UART, SSI, I2C, CAN, ZigBee, IEEE802.11, fiber optic cables, and Ethernet? I.e., what moves from transmitter to receiver?
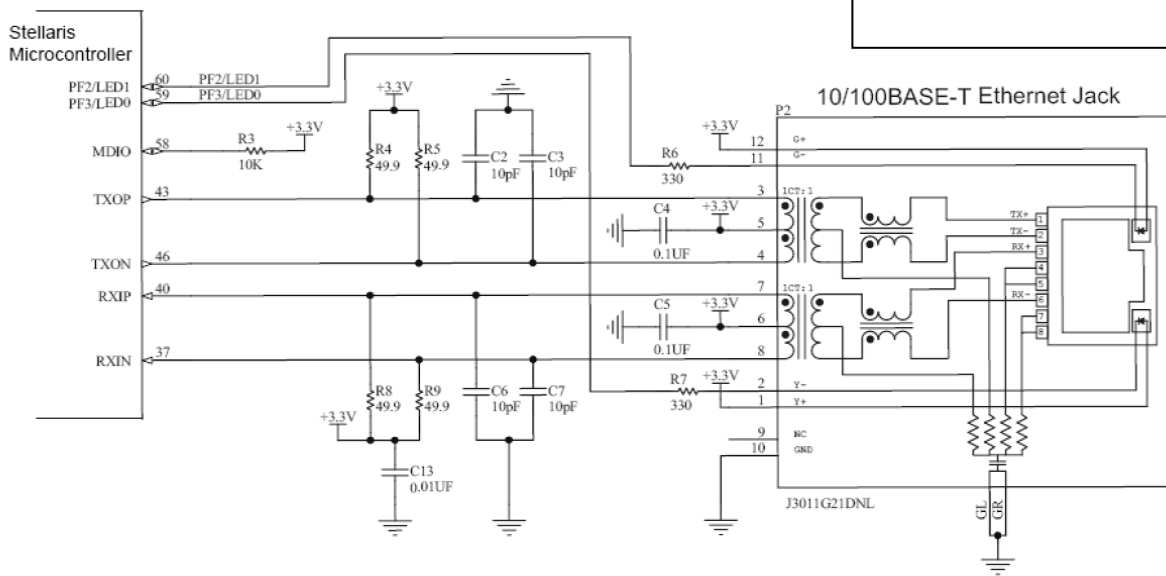
(5) Question 5. Consider Ethernet at its lowest level, i.e., the physical channel. Is Ethernet full duplex or half duplex?

(5) Question 6. Consider CAN at its lowest level, i.e., the physical channel. Is CAN synchronous or asynchronous?

(5) Question 7. The following friendly code is used for thread profiling in a preemptive scheduler like Lab 2. Assume Port A pins 5 and 6 are initialized to outputs and connected to a logic analyzer. The preemptive scheduler periodically runs these two threads. There is a bug in the way the profile is configured. Edit the code to remove the bug. Full credit given to the best answer.

```
#define GPIO_PORTA_DATA_R (*((volatile unsigned long *)0x400043FC))
```

```void Thread1(void){```
 	
` Init1();`
 	
` while(1){`
 	
`  GPIO_PORTA_DATA_R |= 0x40;`
 	
`  Body1();`
 	
`  GPIO_PORTA_DATA_R &= 0xFFFFFFBF;`
 	
` }`
 	
`}`
	```void Thread2(void){```
	
	` Init2();`
	
	` while(1){`
	
	`  GPIO_PORTA_DATA_R |= 0x20;`
	
	`  Body2();`
	
	`  GPIO_PORTA_DATA_R &= 0xFFFFFFDF;`
	
	` }`
	
	`}`

(5) Question 8.
Part a) Under what conditions should you use cycle steal DMA rather than burst DMA?

Part b) Under what conditions should you use burst DMA rather than cycle steal DMA?

(5) Question 9. A Fuzzy Logic system employs a "false equals 0", and a "true equals 255" definition. Consider the following Fuzzy Logic definition for **not**

$\sim A \equiv 255 - A$ where – is regular subtraction

Prove or disprove the following property in Fuzzy Logic

$A \mid (\sim A) = $ true

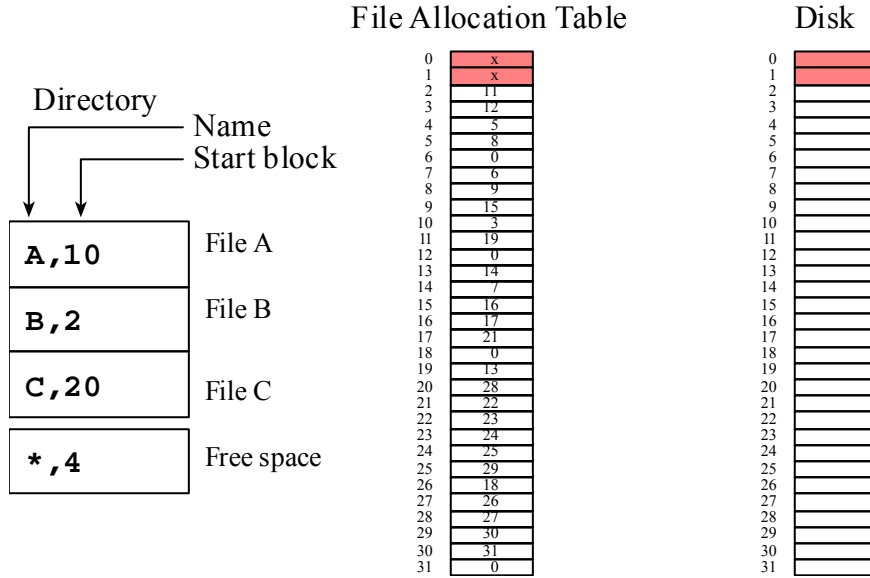**(15) Question 10.** Consider the following IIR digital filter

$$y(n) = 2*x(n) + 2*x(n-4) - y(n-4)/16$$

Part a) Find all the poles and find all the zeros for this digital filter. Clearly state how many poles and zeros there are.

Part b) At what sampling rate does this IIR filter reject 60 Hz?

Part c) Redesign this filter so the DC gain is 1, keeping the placement of the poles and zeros

(5) Question 11. Consider this file system that uses a FAT. Each disk block contains 32 bytes. The directory is in block zero, the FAT is in block 1. Each directory entry contains a file name and an index to the first FAT entry for that file. The last entry in the directory contains an index to the first FAT entry for the free space. Entire blocks are allocated to a file, so there is no internal fragmentation.

File Allocation Table   Disk

Directory
— Name
— Start block

Directory	
A,10	File A
B,2	File B
C,20	File C
*,4	Free space

File Allocation Table:

Index	Value
0	x
1	x
2	11
3	12
4	5
5	8
6	0
7	6
8	9
9	15
10	3
11	19
12	0
13	14
14	7
15	16
16	17
17	21
18	0
19	13
20	28
21	22
22	23
23	24
24	25
25	29
26	18
27	26
28	27
29	30
30	31
31	0

Part a) How many free blocks are there?

Part b) Does this file system have external fragmentation? Simply answer yes or no

Part c) How many blocks are allocated to File A?

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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.

(20) Question 12. You are given a CAN network connecting two computers A and B, like the one developed in Lab 6. The CAN will be dedicated for the sole purpose of implementing one distributed spinlock counting semaphore. I.e., the CAN will not be used for purposes other than implementing this one semaphore. You may assume the CAN is initialized on both computers, and computer B has access to the CAN via the **CAN0_Setup_Message_Object** function. To send a 4-byte message you call
    CAN0_Setup_Message_Object(ID, NULL, 4, data, ID, MSG_OBJ_TYPE_TX);
The starter file CAN programs send 4 bytes of data. Feel free to increase or decrease the amount of data as you wish. You may assume only one thread in computer A calls **OS_DistributedWait** and only one thread in computer B calls **OS_DistributedSignal**. You are allowed to make additional simplifying assumptions if you need to. You may use, without showing implementation, any OS function you implemented in your Lab 2 or Lab 3 OS. It is important not to introduce critical sections.
(5) Part a) Edit the following ISR that runs on Computer A.

```
#define RCV_ID 4
void CAN0_Handler(void){ unsigned char data[4];
  unsigned long ulIntStatus, ulIDStatus;
  int i;
  tCANMsgObject xTempMsgObject;
  xTempMsgObject.pucMsgData = data;
  ulIntStatus = CANIntStatus(CAN0_BASE, CAN_INT_STS_CAUSE); // cause?
  if(ulIntStatus & CAN_INT_INTID_STATUS){  // receive?
    ulIDStatus = CANStatusGet(CAN0_BASE, CAN_STS_NEWDAT);
    for(i = 0; i < 32; i++){    //test every bit of the mask
      if( (0x1 << i) & ulIDStatus){  // if active, get data
        CANMessageGet(CAN0_BASE, (i+1), &xTempMsgObject, true);
        if(xTempMsgObject.ulMsgID == RCV_ID){
          RCVData[0] = data[0];
          RCVData[1] = data[1];
          RCVData[2] = data[2];
          RCVData[3] = data[3];
          MailFlag = true;   // new mail
        }
      }
    }
  }
  CANIntClear(CAN0_BASE, ulIntStatus);  // acknowledge
}
```

(5) Part b) Implement `OS_InitNetSem` on the computer containing the official copy of the counter. Clearly specify on which computer `OS_InitNetSem` runs.

```
long Counter;  // official copy of semaphore
// ******** OS_InitNetSem ************
// initialize network semaphore
// inputs:  initial Counter value
// output: none
void OS_InitNetSem(long value){
```

(5) Part c) Implement the wait function that runs on Computer A.
```
// ******** OS_DistributedWait ************
// input:  none
// output: none
void OS_DistributedWait(void){
```

(5) Part d) Implement the signal function that runs on Computer B.
```
// ******** OS_DistributedSignal ************
// increment Counter
// input:  none
// output: none
void OS_DistributedSignal(void){
```

(15) Question 13. The goal is to design an FIR filter using the inverse discrete Fourier transform. The process is similar to Lab 4, except the size of the DFT is N=16 points (instead of 51 points), and the sampling rate is 1000 Hz. This FIR will have a linear phase response. The k column is the index from 0 to 15. The magnitude $|H(k)|$ and phase θ (in radians) columns are the magnitude and phase of $H(k)$. $H(k)$ is the complex representation of gain and phase. $h(n)$ is the inverse discrete Fourier transform of $H(k)$.

k	$|H(k)|$	θ	$H(k)$	$h(n)$
0	**0**	0.00	0	0.0124
1	**0**	9.82	0	-0.0625
2	**0**	19.63	0	-0.0418
3	**0**	29.45	0	0.0625
4	**1**	39.27	+i	0.0935
5	1	49.09	0.382683432365092-0.923879532511286i	-0.0625
6	1	58.90	-0.707106781186545+0.70710678118655i	-0.3142
7	1	68.72	0.923879532511289-0.382683432365084i	0.5625
8	1	78.54	-1	-0.3142
9	1	-68.72	0.923879532511289+0.382683432365084i	-0.0625
10	1	-58.90	-0.707106781186545-0.70710678118655i	0.0935
11	1	-49.09	0.382683432365092+0.923879532511286i	0.0625
12	1	-39.27	-i	-0.0418
13	0	-29.45	0	-0.0625
14	0	-19.63	0	0.0124
15	0	-9.82	0	0.0625

Part a) Let $G = |H(k)|$. Give an equation relating $H(k)$ as a function of G and θ. The units of θ are radians.

Part b) Why is $H(k)$ the complex conjugate of $H(16-k)$ for $k = 1$ to 7?

Part c) What type of filter is this? HPF, LPF or BPF? What is the cutoff frequency(s)?

Part d) Show the equation for this FIR filter using decimal fixed-point math. (no software required)