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This is an open book, open notes exam. You must put your answers on these pages only, you can use the back. You have 50 minutes, so please allocate your time accordingly. ***Please read the entire quiz before starting.***

(25) Question 1. The following is a low-pass FIR digital filter.

y(n) = (x(n)+x(n-1)+x(n-2)+…+x(n-7))/8

If implemented as the above, it would take seven additions and one division. This exact filter can be rewritten as the following, and only require one addition, one subtraction and one division.

sum = sum+x(n)-x(n-8)

y(n) = sum/8

Write a C function that implements this efficient digital filter. No floating point is allowed. Show the MACQ data structure, which you can implement however you wish. The filter function takes an 8-bit ADC input and returns the filter output. The filter prototype is

```
unsigned char filter(unsigned char data);
```

(25) Question 2. Assume a 1 Mbyte by 8-bit RAM is connected to the MC68HC812A4. Chip select CSD is used to activate the RAM, which will be located in the $7000 to $7FFF address window using the DPAGE system.
Part a) The 6812 system comes up out of reset in Special Single Chip Mode. Assume the RAM requires two cycle stretches. The following initialization program is from the book, and was originally designed for a 256 Kbyte wide-mode interface. *Make modifications to this program* so 1) you are running in special expanded narrow mode, 2) you have 20 address lines, and 3) there are 2 cycle stretches.

```
void RAM_Init(void){

  MODE = 0x7B

  PEAR = 0x2C;

  WINDEF = WINDEF|0x80;

  MXAR = 0x03;

 CSCTL0 = CSCTL0|0x10;

 CSCTL1 = CSCTL1&0xEF;

 CSSTR0 = (CSSTR0&0xFC)|0x01;}
```

Part b) Write a memory write access function with the following prototype, such that the 8-bit `data` is stored at the 20-bit `address`. You may assume 0 ≤ `address` ≤ 0x000FFFFF.

```
void RAM_Write(long address, char data);
```

Part c) Write a memory read access function with the following prototype. The function returns the data read from the 20-bit `address`. You may assume 0 ≤ `address` ≤ 0x000FFFFF.

```
char RAM_Read(long address);
```

(25) Question 3. Design an analog circuit that runs on a ±12 V supply. The input range is $-0.1 < V_{in} < +0.1$ V and the output range is $-5 < V_{out} < +5$ V. The input is single ended, i.e., referenced to ground. The output will be connected to a ±5 V ADC. Show the circuit. Label all chip numbers, resistors and capacitors but not pin numbers.

(25) Question 4. Consider the following thread switch system (essentially the initial system used in Lab 17).

```
struct TCB{
  struct TCB *Next;
// *********POSITION A*********** short priority;
  unsigned char *StackPt;
  unsigned char Id;
  unsigned char MoreStack[100];
  unsigned char InitialCCR;
  unsigned char InitialRegB;
  unsigned char InitialRegA;
  unsigned int InitialRegX;
  unsigned int InitialRegY;
  void (*InitialPC)(void);
// *********POSITION B*********** short priority;  or    char priority;
};
typedef struct TCB TCBType;
typedef TCBType * TCBPtr;
TCBType SystemTCB[3];
TCBPtr RunPt;
#pragma interrupt_handler threadSwitchISR()
void threadSwitchISR(void){
asm(" ldx _RunPt\n"
    " sts 2,x");
  RunPt = RunPt->Next;
  PORTJ = RunPt->Id;
  TC3   = TCNT+TimeSlice;
  TFLG1 = 0x08;
asm(" ldx _RunPt\n"
    " lds 2,x");
}
```

Part a) Explain why the system crashes if a `short priority;` entry is added into POSITION A.

Part b) Assume the `short priority;` entry is placed in POSITION A. Without moving the position of the entry (leaving it there in POSITION A), make other changes to the above program to fix the bug.

Part c) Consider the case where an entry is added at POSITION B. Which of the following statements is true?

- No fields can be added at POSITION B.
- Only 8-bit fields can be added at POSITION B.
- Only 16-bit fields can be added at POSITION B.
- It is OK to add either 8-bit or 16-bit fields at POSITION B.