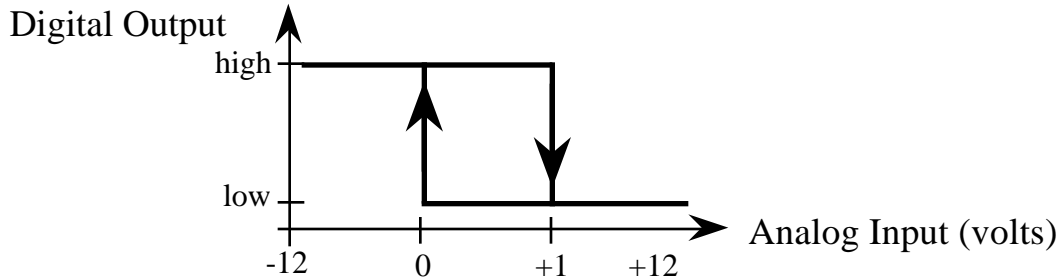


Jonathan W. Valvano March 13, 1998, 11:00 am-12:30pm

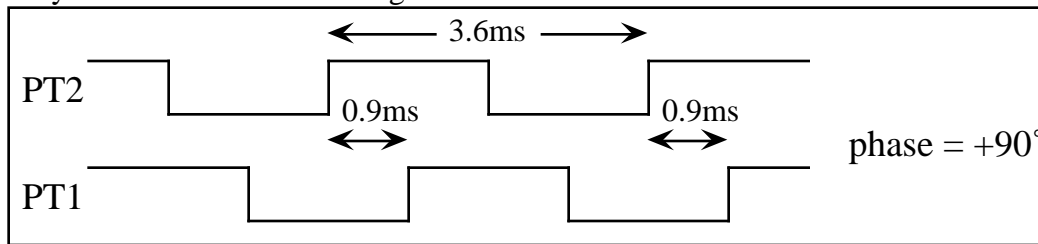
This is an open book, open notes exam. You must put your answers on the special answer sheets only. You have 90 minutes, so please allocate your time accordingly.

(20) **Question 1.** Design an analog to digital converter with the following transfer function.

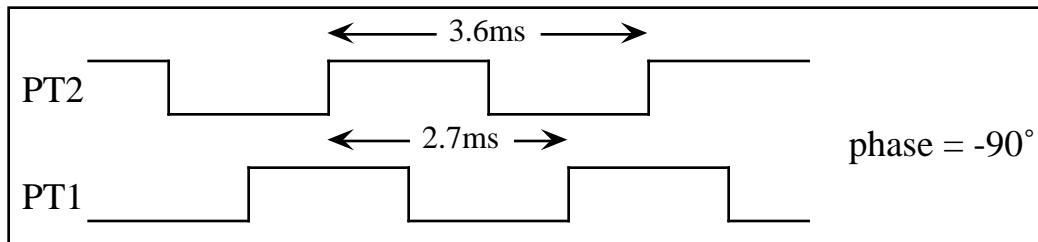


Label all chip numbers (but not pin numbers). Specify all +12, -12, and +5 v power supply connections, resistor values and capacitor values. Offset null potentiometers are not required.

(30) **Question 2.** The objective of this problem is to measure the phase angle between two squarewaves. They are connected to the input capture pins 1 and 2 (6812 PT1 and PT2 respectively). The range is  $-179^\circ$  to  $+180^\circ$  and the resolution should be  $1^\circ$ . You may assume without measuring that both squarewaves have a period of exactly 3.6ms (277.8 Hz.) In this first example, PT2 leads PT1 by  $90^\circ$ , and your measurement should give an answer of  $+90$ .



In this second example, PT2 leads PT1 by  $-90^\circ$  (same as  $+270^\circ$ ), and your measurement should give an answer of  $-90$ .

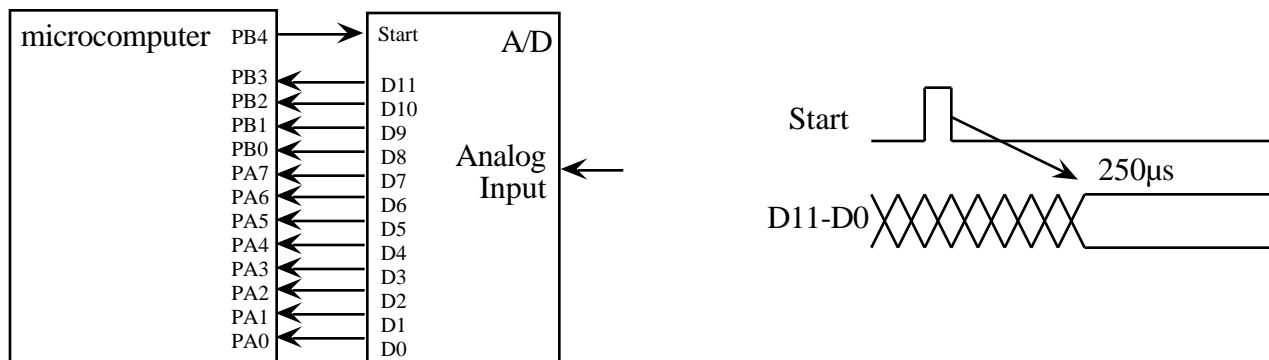


Part a) What is the desired precision? Give units.

Part b) The ritual which initializes the measurement software. Your solution will perform phase measurements every 3.6ms, and update a global variable, Phase, with the most recent phase measurement. Show the appropriate definition of Phase. Other globals are allowed only if they are essential to the measurement system. You should assume that there are other uses of the input capture/output compare system, but PT2 and PT1 are dedicated to this task. You may write in C or assembly.

Part c) Show the interrupt handler(s) which perform the phase measurement tasks in the background and sets the global, Phase, every 3.6ms. You may assume the interrupt vectors are properly established, but please use simple interrupt handler names like TIC1handl er() .

(50) **Question 3.** The objective of this problem is to interface a 12 bit signed A/D, and implement a real time data acquisition system. The 12 bit A/D is connected to Ports A and B. A pulse on the A/D **Start** signal will begin a conversion which takes 250 μs to complete.



This hardware is fixed and can not be changed. Ports A and B have direction registers (DDRA, DDRB), but can not generate interrupts. The 12 bit A/D sample is 2's complement signed.

Voltage	D11- D0
- 5v	%1000, 0000, 0000
- 2. 4mV	%1111, 1111, 1111
0v	%0000, 0000, 0000
2. 4mV	%0000, 0000, 0001
+5v	%0111, 0000, 0000

You will use Output Compare 5 interrupts to implement the real time data acquisition system with a sampling rate of 200 Hz (5 ms period). Implement the following FIR digital filter.

$$y(n) = \frac{x(n) + x(n-24)}{2}$$

```
int yn; // FIR filter output, calculated at 200 Hz
```

You will implement a MACQ to store the most recent 25 A/D samples. Your MACQ should use an index or pointer scheme rather than the shifting data mechanism used in the examples of the book.

Part a) Show the ritual which initializes the hardware and data structures. You may write in C or assembly.

Part b) Show the OC5 interrupt handler which collects the A/D samples (at 200Hz), implements the FIR digital filter, and stores the result in a signed 16 bit global called yn. You are NOT allowed to wait the 250 μs A/D conversion delay from within the OC5 handler. You may NOT have any backwards jumps in the interrupt handler. (Hint, there is an answer which uses a single 200 Hz OC5 interrupt thread, but if you can't think of it, you are allowed to create a second OC thread using one of the other output compare channels.) You may assume the interrupt vector(s) is properly established, but please use simple interrupt handler name like TOC5handl er() .