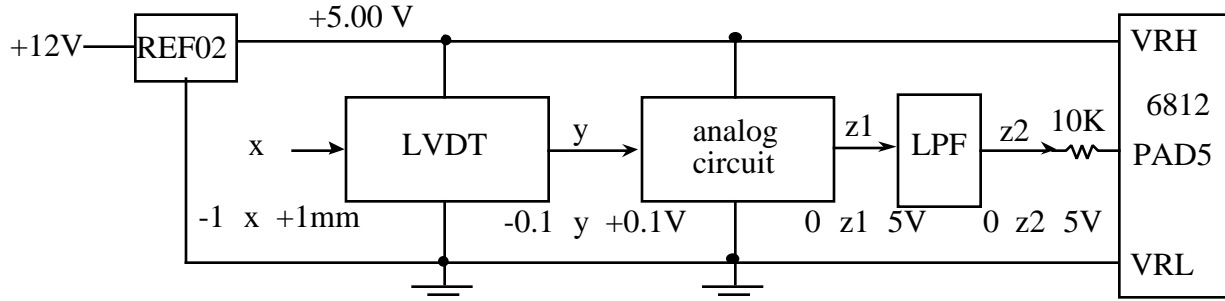


Last Name: _____ First Name: _____

Jonathan W. Valvano March 26, 1999, 11:00 am to 12:50pm

This is an open book, open notes exam. You must put your answers on these pages only, you can use the back. You have 110 minutes, so please allocate your time accordingly.

(50) Question 1. Design a position DAS using a sensor, analog electronics and a 6812. Let x be the position to be measured. The input range is -1mm to $+1\text{mm}$ and the signals of interest are 0 to 1 Hz. A Linear Variable Differential Transformer (LVDT) will be used to convert position, x , into voltage, y . When the input position is -1mm , the LVDT output y is -100mV . When the input position is zero, the LVDT output y is zero. When the input position is $+1\text{mm}$, the LVDT output y is $+100\text{mV}$. In between, the voltage output is linearly related to the position. A REF02 precision reference will provide the constant $+5.00\text{ V}$ for your analog circuit and the 6812 A/D.



(5) Part a) What is the transducer sensitivity? Give units.

(5) Part b) What is the transfer relationship required to convert y into $z1$?

(5) Part c) What is the maximum allowable noise for your analog circuit? Refer the noise to the amplifier input and give units.

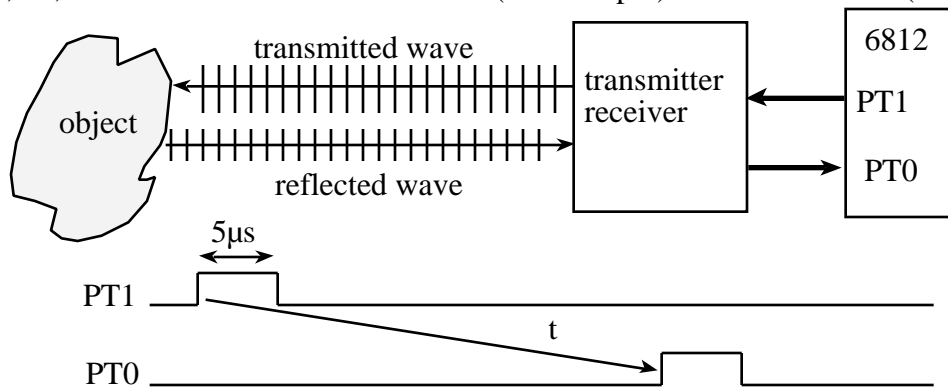
(5) Part d) Choose an appropriate sampling rate.

(15) Part e) Design the pre-amp which has the following characteristics: single input (not differential), gain so that the 0 to +5V A/D is used, high Z_{in} , low Z_{out} , bandwidth >200 Hz. Show resistor values, but not pin numbers. You may use any analog op amps, but please include the chip number.

(10) Part f) The signals of interest are 0 to 1 Hz. There is unwanted noise at 60 Hz. Add a two pole LPF with a cutoff of about 10 Hz.

(5) Part g) What is the system resolution in mm?

(50) **Question 2.** The objective of this problem is to design an underwater ultrasonic ranging system. The distance to the object, d , can vary from 1 to 100 m. The ultrasonic transducer will send a short $5\ \mu\text{s}$ sound pulse into the water in the direction of interest. The sound wave will travel at 1500m/sec and reflect off the first object it runs into. The reflected wave will also travel at 1500m/sec back to the transducer. The reflected pulse is sensed by the same transducer. Your system will trigger the electronics (give a $5\ \mu\text{s}$ digital pulse), measure the time of flight, then calculate the distance to the object. Using periodic interrupts, the software will issue a $5\ \mu\text{s}$ pulse out PT1 once a second. Using interrupting input capture, the software will measure the time of flight, t . The input capture interrupt handler will calculate distance, d , as a decimal fixed point value with units of 0.01m , and enter it into a FIFO queue. The main program will call the ritual, then get data out of the FIFO queue. The main program will call Alarm() if the distance is less than 15 m. You do not have to give the implementation of Alarm(). You may use any of the FIFO's in Chapter 4 without showing its implementation. The following hardware is fixed and can not be changed. As shown in the picture the time of flight, t , is measured from the rise of PT1 (6812 output) to the rise of PT0 (6812 input).



(5) Part a) Derive an equation that relates the distance, d , to the time of flight, t .

(5) Part b) Use this equation to calculate the minimum and maximum possible time of flight, t .

(5) Part c) Choose the TCNT rate that will satisfy the range and resolution requirements of this problem.

(10) Part d) Give the ritual that initializes the interface, including PORTT timer channels 0 and 1. Don't worry about the other 6 timer channels.

(5) Part e) Give the main program that first calls the ritual. The main program will empty the FIFO and call `AI arm()` if the distance drops below 15 m. Decide whether it is better to convert time (TCNT counts) to distance (decimal fixed point, 0.01m) here in the main program or in the interrupt handler.

(10) Part f) Give the `TC1handler()` periodic interrupt handler that issues pulse of about $5\ \mu\text{s}$ duration on PT1 every 1 sec. Good interrupt software has no backward jumps.

(10) Part f) Give the `TC0handler()` interrupt handler that measures the time of flight, and puts the result (either the count or the calculated distance) into the FIFO. Good interrupt software has no backward jumps. There may be additional sonic echoes, so only calculate the range of the first one, and ignore the others.