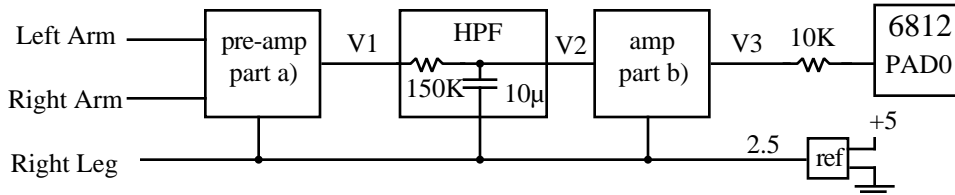


Jonathan W. Valvano July 20, 1998, 2:30pm-3:45pm

This is an open book, open notes exam. You must put your answers on these pages only, you can use the back. You have 90 minutes, so please allocate your time accordingly.

**(40) Question 1.** Design an EKG amplifier interface to a 6812. The biopotential is a  $\pm 5mV$  signal measured between the left and right arms using Silver-Silver Chloride electrodes. A third electrode is placed on the right leg and is used as a reference. In order to make the entire system battery operated low-power rail-to-rail TLC2274 op amps will be used, each powered with +5 and ground. Notice that the analog system uses the 2.5v signal as its reference.



(10) Part a) Design the pre-amp which has the following characteristics: differential input, gain=50, good CMRR, high  $Z_{in}$ , low  $Z_{out}$ , bandwidth  $>200$  Hz. Show resistor values, but not pin numbers.

(10) Part b) Show the amplifier stage which has the following characteristics: single input, gain=10, high  $Z_{in}$ , low  $Z_{out}$ , bandwidth  $>200$  Hz. Show resistor values, but not pin numbers.

(10) Part c) The signals of interest are 0.1 to 100 Hz. There is unwanted noise at 120, 240, 360, and 480Hz. Discuss the tradeoffs between the following two options:

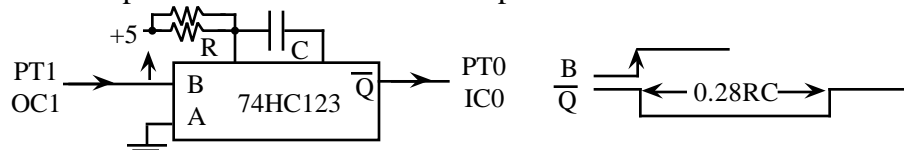
- 1) add an active analog low pass filter with a 100 Hz cutoff , and sample at 200 Hz.
- 2) sample at 1920 Hz and add a digital 120, 240, 360, 480 Hz reject filter.

Which approach would you take and why? Under what conditions would the other choice be better?

**(50) Question 2.** The objective of this problem is to measure body temperature using input capture (pulse width measurement). A shunt resistor is placed in parallel with a thermistor. The thermistor-shunt combination, R, has the following linear relationship for temperatures from 90 to 110 °F.

$$R = 100K - (T - 90^\circ F) \cdot 1K / ^\circ F \quad \text{where } R \text{ is the resistance of the thermistor-shunt}$$

In other words, the resistance varies from 100K to 80K as the temperature varies from 90 to 110°F. The range of your system is 90 to 110 °F and the resolution should be better than 0.01°F. You will use a 74HC123. On the rise of the B trigger input, the '123 creates a negative logic pulse on its output. The width of the pulse is about  $0.28 \cdot R \cdot C$ . Temperature will be measured 100 times a second.



Part a) The pulse width measurement resolution will be 125ns. Choose the capacitor value so that this 125ns pulse width measurement resolution matches the desired temperature resolution of 0.01°F.

Part b) Given this value of C, what is the pulse width at 90 °F? Give the answer both in  $\mu s$  and E clock cycles.

Part c) Given this value of C, what is the pulse width at 110 °F? Give the answer both in  $\mu s$  and E clock cycles.

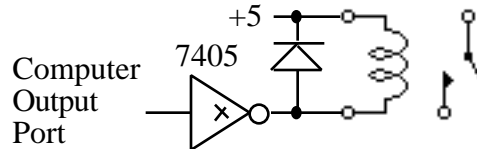
Part d) Write the ritual which configures an output compare on PT1 as a periodic interrupt. A rising edge should occur every 10 ms. Configure an input capture on PT0 to measure the pulse width.

Part e) Show the interrupt handler(s) which perform the temperature measurement tasks in the background and sets a global, `Temperature`, 100 times a second. The units of this unsigned decimal fixed point number are 0.01 °F. E.g., `Temperature` will vary from 9000 to 11000 as temperature varies from 90 to 110 °F. The output compare interrupt will start the pulse (You may assume the interrupt vectors are properly established, but please use simple interrupt handler names like `TOC1handler()` and `TIC0handler()`).

**(10) Question 3.** This question considers the concept of back EMF which can occur on a DC motor, stepper motor coil, relay coil, or solenoid coil when switched with a digital gate. A snubber diode is used to eliminate the back EMF. The choice of which diode to use depends on the magnitude of the back EMF voltage. The circuit configuration depends on the presence of either positive and/or negative amplitude back EMF's.

diode	maximum voltage
1N4001	50V
1N914	75V
1N4002	100V
1N4003	200V
1N4004	400V
1N4005	600V
1N4006	800V
1N4007	1000V

Part a) Aside from empirical (experimental) techniques, develop a procedure to select the proper diode in the following circuit. I am looking for different answer than the obvious method of measuring it in the lab with a scope. I.e., develop theoretical equations. Be as detailed as possible.



Part b) Why don't we usually add the second diode? I.e., what usually prevents negative amplitude back EMF?

