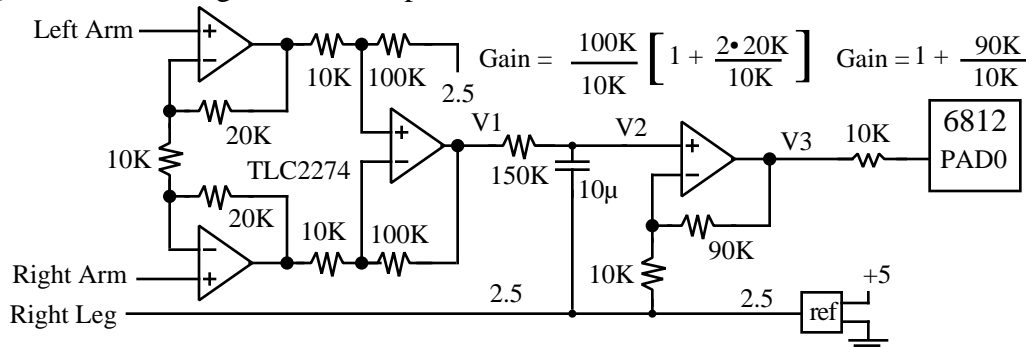


Jonathan W. Valvano July 20, 1998, 2:30pm-3:45pm

Question 1. Design an EKG amplifier interface to a 6812.



Part c) I would sample at 1920 Hz and add a digital 120, 240, 360, 480 Hz reject filter:

6812 is fast enough to process real time data at 1920 Hz

the entire analog system uses a single TLC2274, adding an analog LPF would need another

the digital filter is quite easy to implement (equation 35, in the digital filter chapter)

If there were a lot of other processing for the computer to handle, then a hardware solution would free up some processor time.

Question 2. The objective of this problem is to measure temperature.

Part a) Choose the capacitor value so that $P=125\text{ns}$ matches $T = 0.01^\circ\text{F}$.

The conversion equation is

$$P = 0.28 \cdot R \cdot C = 0.28 \cdot (100 \text{ K} - (T - 90^\circ\text{F}) \cdot 1 \text{K} / ^\circ\text{F}) \cdot C$$

Notice the sensitivity of the 74HC123

$$P / R = 0.28 \cdot C$$

We can also calculate the sensitivity of the thermistor/resistor combination

$$R / T = 1000 / ^\circ\text{F}$$

Consider the sensitivity of the entire hardware system

$$P = P / R \cdot R / T \cdot T$$

Plugging in what we want and know

$$125\text{ns} = 0.28 C \cdot 1000 / ^\circ\text{F} \cdot 0.01^\circ\text{F}$$

$$C = 0.125\mu\text{s} / (.28 \cdot 10^3) = 0.04464\mu\text{F}$$

Part b) Given this value of C, what is the pulse width at 90°F ?

$$P_{90} = 0.28 \cdot R \cdot C = 0.28 \cdot (100,000) \cdot 0.04464\mu\text{F} = 1250 \mu\text{s} = 10000 \text{ cycles}$$

Part c) Given this value of C, what is the pulse width at 110°F ?

$$P_{110} = 0.28 \cdot R \cdot C = 0.28 \cdot (80,000) \cdot 0.04464\mu\text{F} = 1000 \mu\text{s} = 8000 \text{ cycles}$$

Part d) Configures an output compare on PT0 and input capture on PT1.

```
#define Rate 40000    interrupt every 5 ms
#define OC1  0x02
#define IC0  0x01
void ritual(void) {
asm(" sei ");      // make atomic
TIOS|=OC1;        // enable OC1
DDRT|=OC1;        // PT1 is a 100Hz squarewave, interrupt every 5ms
TIOS&=~IC0;       // clear bit 0
DDRT&=~IC0;       // PT0 is input capture
TSCR|=0x80;        // enable
TMSK2=0x30;        // 125 ns clock
TCTL2 = (TCTL2&0xF3)|0x04; // PT1 toggle on each interrupt
TCTL4|=0x03;        // Both edges IC0
TMSK1|=OC1+IC0;    // Arm output compare 1, input capture 0
TFLG1=OC1+IC0;    // Initially clear C1F, C0F
TC1=TCNT+100;      // First one in 100 cycles
asm(" cli "); }

```

Part e) Show the interrupt handler(s) which perform the temperature measurement tasks.

```

unsigned int Temperature; // units 0.01 F
#pragma interrupt_handler TOC1handler()
void TOC1handler(void) { // PT1 is a 100Hz squarewave output
    TFLG1=0C1; // ack C1F
    TC1=TC1+Rate; // Executed every 5 ms

    unsigned int Falling; // TCNT at falling edge of PT0
#pragma interrupt_handler TIC0handler()
void TIC0handler(void) { unsigned int PW; // 10000 to 8000
    TFLG1=IC0; // ack C0F
    if(PORTT&IC0) { // PT0=1 if rising
        PW=TC0-Falling; // the measurement
        Temperature=19000-PW; } // 10000->9000 (90F), 8000->11000 (110F)
    else{
        Falling=TC0; } } // Setup for next
    
```

Question 3.

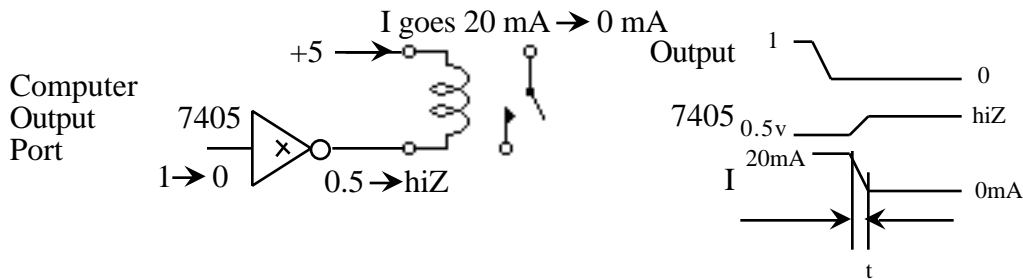
Part a) The back EMF can be calculated using

$$V = L \cdot dI/dt$$

where L is the inductance of the coil and dI/dt is the maximum current slope. To estimate dI/dt we first consider the turn off current (produces positive back EMF).

$$dI/dt = -I/ t$$

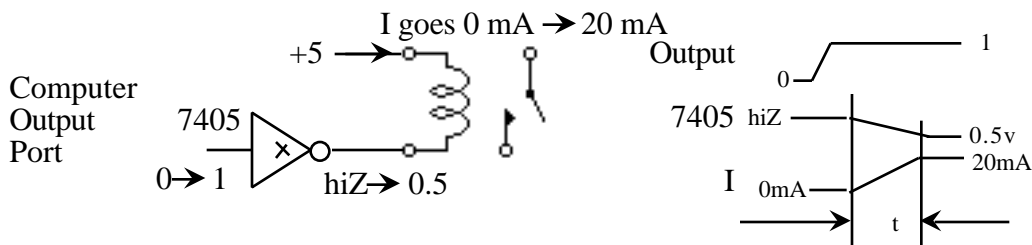
where I is the steady state on-current through the coil (e.g., 20mA) and t is the speed of the 7405 driver (time to go from low to hiZ) (e.g., 10 ns)



If the inductance of the coil is 50μH, then the back EMF will be

$$V = L \cdot I/dt = 50\mu H \cdot 0.020A/0.01\mu s = 100 V$$

Part b) We usually don't add the second diode because the turn on time, t in the figure below, is much longer than the turn off time, t in the above figure. This is usually due to the capacitance in the system.



If it now takes a 1μs to turn on (still pretty fast), then the back EMF will be

$$V = L \cdot I/dt = 50\mu H \cdot 0.020A/1\mu s = 1 V$$