ECE 376 - Homework #6

A/D Converters & Data Collection. Due Monday, February 28th

A/D Converters

1) (10pt) Determine how long it takes to do an A/D conversion with a PIC processor

```
void main(void)
{
   TRISC = 0;
   ADCON1 = 0x0F;

// Turn on the A/D input
   TRISA = 0xFF;
   TRISE = 0x0F;
   ADCON2 = 0x95;
   ADCON1 = 0x07;
   ADCON0 = 0x01;

   while(1) {
      A2D = A2D_Read(0);
      PORTC = PORTC + 1;
      }
   }
```

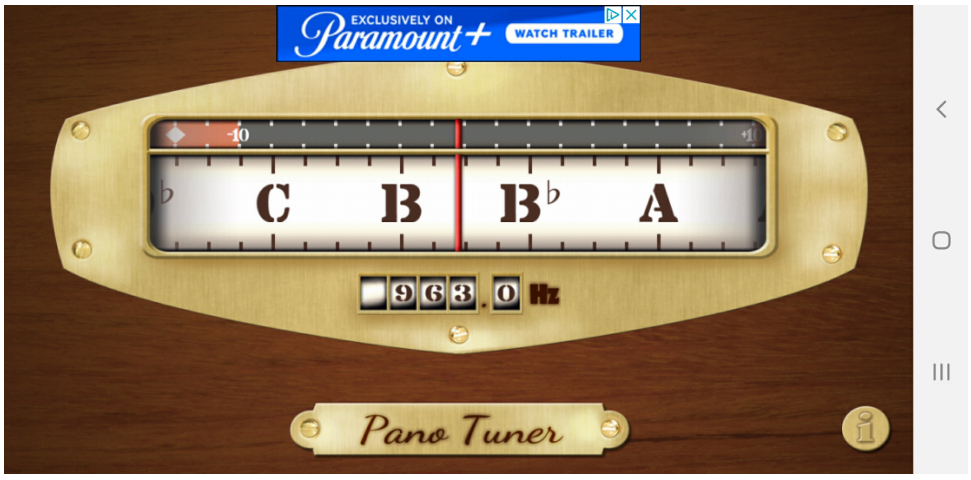
RC4 = 963.0Hz

RC0 = 16 x RC4

RC0 = 15,408Hz

$$N = \left(\frac{10{,}000{,}000}{2 \cdot 15408Hz}\right) = 324.5$$

It takes about 324 clocks (32.4us) to do a single A/D read



2) (10pt) Assume the A/D reads 813 for the following circuit.

- What is the voltage, Vx?
- What is the resitance, Rt?
- What is the temperature?

Assume Rt is a thermistor like the one in your lab kit:

$$R_t = 1000 \cdot \exp\left(\frac{3904}{T+273} - \frac{3905}{298}\right)\Omega$$

where T is the temperature in degrees C

The voltage is...

$$V_x = \left(\frac{813}{1023}\right) \cdot 5.00V = 3.974V$$

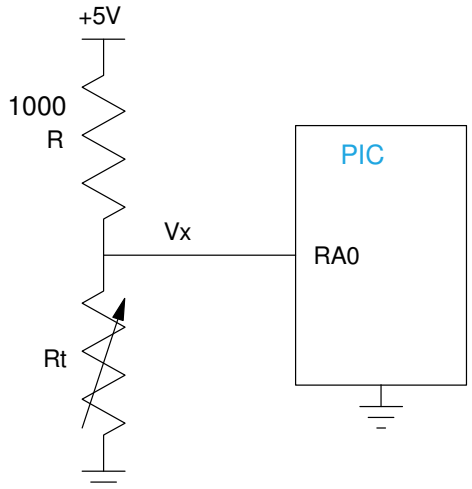
The resistance is (use the voltage or the A/D reading - either one works)

$$R_t = \left(\frac{3.974V}{5.00V - 3.974V}\right) 1000\Omega = 3871.4\Omega$$

$$R_t = \left(\frac{813}{1023-813}\right) 1000\Omega = 3871.4\Omega$$

The temperature is

$$T = -2.901^0 C$$



3-5) Design an embedded sytem which uses the analog input on RA0. Some suggestions are:

Electronic Watering System

3) Requirements: Specity

Input

- Analog Input RA0 (0..5V)
- Button RB0

Output

- LCD Display
- PORTC

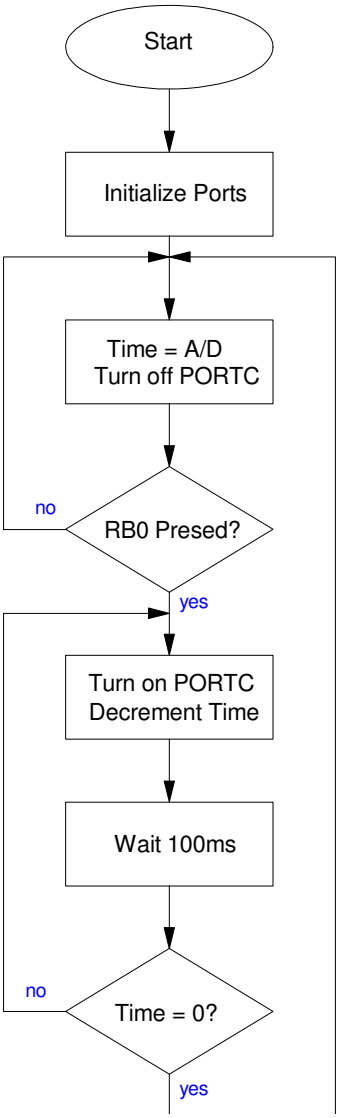
Relationship

- Adjust the analog input from 0 to 1023
- Press RB0
- The lights on PORTC will turn on for N seconds where N = 0.0 to 102.3 seconds
- The time remaining is displayed on the LCD display
- When the time reaches 0.0 seconds, the lights on PORTC turn off and the program repeats

4) C-code and flow chart

```
< include C code >
```

```
Memory Summary:
Program space used   976h (  2422) of 10000h bytes   (  3.7%)
Data space    used    27h (    39) of   F80h bytes   (  1.0%)
EEPROM space  used     0h (     0) of   400h bytes   (  0.0%)
ID Location   used     0h (     0) of     8h nibbles (  0.0%)
Configuration used     0h (     0) of     7h words   (  0.0%)
```



5) Testing and Validation

- Collect data to shot you met the requirements

Analog input reads 000.0 to 102.3

RB0 starts the process

- PORTC turns on
- The timer decreases one count every 100ms
- When the count gets to zero, it stops and PORTC turns off

Using a stopwatch app

- 40.0 seconds takes 40.2 seconds (stopwatch app)
- 71.0 seconds takes 70.66 seconds

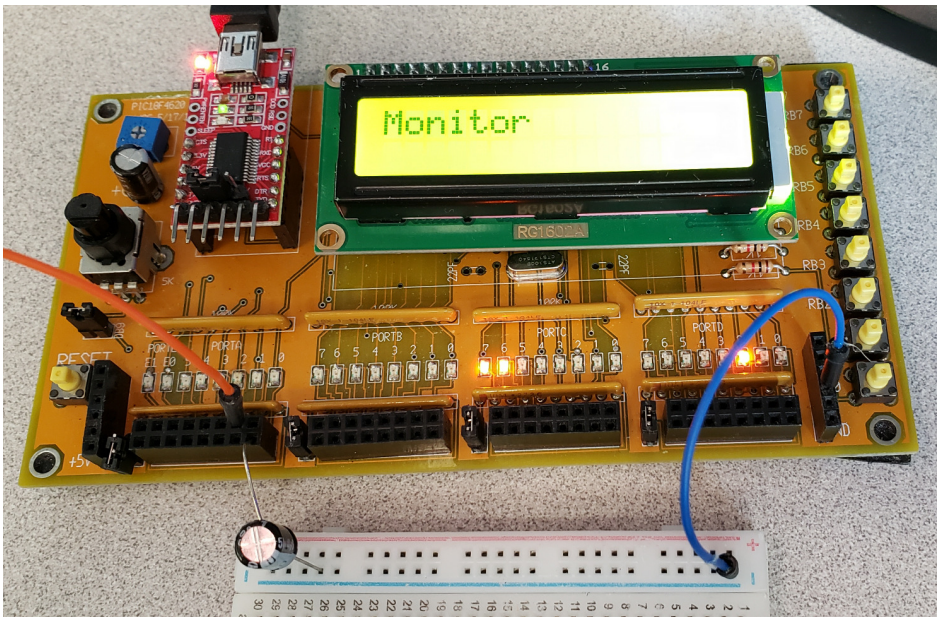
Data Collection

6) Use your PIC board to measure and record via the serial port (pick one)

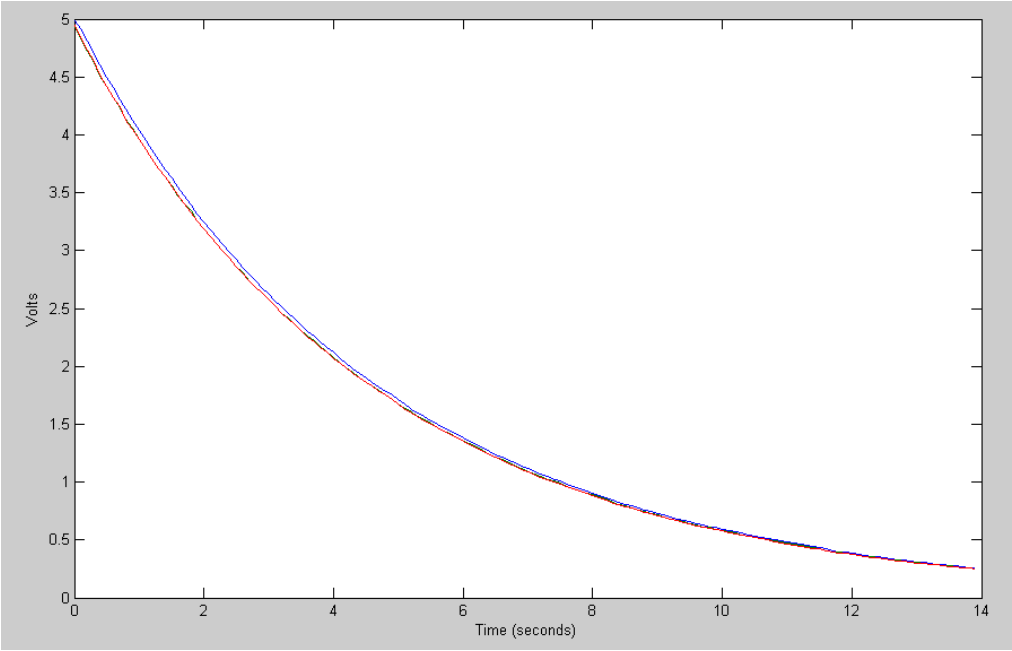
Measure the capacitance of a 47uF capacitor

- Charge it up to +5.00V
- Let it discharge through a 100k resistor
- Measure the voltage as it discharges

Repeat 3 times



Plotting the data in Matlab (three different trials)



7) Convert your data to a number

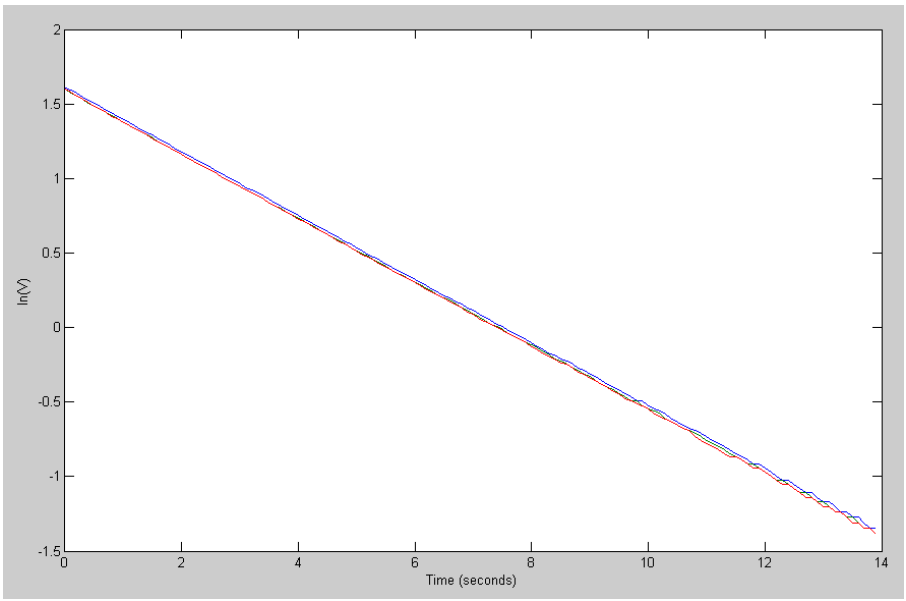
The discharge of the capacitor should be

$$V = V_0 \exp\left(\frac{-t}{RC}\right)$$

Taking the log of both sides

$$\ln(V) = \ln(V_0) - \left(\frac{1}{RC}\right)t$$

Plot ln(V) vs. time



Curve-fit each line as

$$\ln(V) = at + b$$

Using least-squares in Matlab

```
>> B = [t, t.^0];
>> A1 = inv(B'*B)*B'*log(V1)

a   -0.2129
b    1.6033

>> A2 = inv(B'*B)*B'*log(V2)

a   -0.2132
b    1.5859


>> A3 = inv(B'*B)*B'*log(V3)

a   -0.2140
b    1.5868
```

The capacitce is then

$$a = \frac{-1}{RC}$$

$$C = \left(\frac{-1}{a \cdot 100k\Omega}\right)$$

```
>> C1 = -1 / (A1(1) * 100e3)

C1 =  4.6972e-005

>> C2 = -1 / (A2(1) * 100e3)

C2 =  4.6904e-005

>> C3 = -1 / (A3(1) * 100e3)

C3 =  4.6735e-005
```

The measured value of the 47uF capacitor is

- **46.972uF**
- **46.904uF**
- **46.735uF**

With this data you can ask many other questions:

Is capacitnce a function of voltage?

- Is the slope from (4.00V, 5.00V) different than the slope at (2.00V, 3.00V)?

Does capacitance depend upon temperature

- Measure C when it's at room temperature
- Measure C when it's at 0C
- Measure C when it's at 50C

What is the capacitance when used with reverse polarity?

- Measure C with the correct polarity
- Measure C with reverse polarity

What is the variation between capacitors?

- Measure a bunch of 47uF capacitors

Do electrolytic capacitors have tighter tolernces than tantalum capacitors?

- Measure a bunch of 47uF electrolytic capacitors
- Measure a bunch of 47uF tantalum capacitors

etc.