ECE 376 - Homework #1

PIC Background
Due Wednesday, September 4th

Problem	Answer
1) How many clocks does it take to do a floating point opeation in C? • Check Homework #9 solutions for Spring 2024	**3409 clocks**
2) A PIC's output is limited to 25mA. Assuming V2 is 5V, what is the smallest resistance youcan connect to the output? (how small can R3 be?)	**200 Ohms**
A PIC can measure voltage to 4.88mV. To give an idea of how small this is....	
3) What is the smallest change in R2 a PIC can measure if R2 = 500 Ohms nominally? • How much does R2 have to change from 500 Ohms for V1 to change by 4.88mV?	**1.96 Ohms**
4) Assume R2 is a thermistor. • What temperature is it if R2 = 500 Ohms? • How much does the temperature have to change for V1 to change by 4.88mV?	**T = 41.6433 C** **dT = 0.0989C**
A PIC can measure time to 100ns. To give an idea of how small this is....	
5) The fastest animal is the Peregrine falcon - able to fly up to 389 km/h (242 mph). How far can a Peregrine falcon fly in 100ns?	**10.8 um**
6) Assume for the 555 timer • R1 = 500, R2 = 500, C = 0.22uF • What frequency does the 555 timer output on pin #3?	**f = 4371.8 Hz**
7) What is the smallest change in frequency a PIC can detect? • i.e. how much does the frequency have to change for the period to change by 100ns?	**df = 1.91Hz**
8) With this circuit, you can build an Ohm-meter (replace R2 with the resistance to be measured.) Assume R2 = 500 Ohms (nominally). How much does R2 have to change for the period to change by 100ns? • i.e. What is the resolution of this circuit when used as an Ohm-meter?	**dR = 0.328 Ohms**
9) Replace R2 with a thermistor which reads 500 Ohms nominally. How much does the temperature have to change for the period to increase by 100ns? • i.e. what is the resolution in degrees C?	**dT = 0.0166C**

Problem 1) How many clocks does it take to do a floating point opeation in C?

- Check Homework #9 solutions for Spring 2024

ans: 3409 clocks (340.9us)

Problem 2) A PIC's output is limited to 25mA. Assuming V2 is 5V, what is the smallest resistance youcan connect to the output? (how small can R3 be?)

$$V = IR$$

$$R = \left(\frac{5V}{25mA}\right) = 200\Omega$$

What this means is you can't connect an 8-Ohm speaker to a PIC's output: it will draw too much current. If you want to drive a speaker from a PIC

- Add a 200 Ohm resistor in series to limit the current to 25mA,
- Use a transistor as a switch to turn on and off the speaker, or
- Use an h-bridge to drive the speaker

Problem 3) A PIC can measure voltage to 4.88mV. To give an idea of how small this is....

What is the smallest change in R2 a PIC can measure if R2 = 500 Ohms nominally?

At 500 Ohms,

$$V = \left(\frac{R_2}{R_1+R_2}\right)5V$$

$$V = \left(\frac{500}{500+500}\right)5V = 2.500V$$

If V changes by 4.88mV, R2 is then

$$\left(\frac{R_2}{R_2+500}\right)5V = 2.50488V$$

Doing some algebra

$$R_2 = \left(\frac{2.50488V}{5V-2.50488V}\right)500\Omega$$

$$R_2 = 501.96\Omega$$

R2 has to change by 1.96 Ohms for the PIC to see the change

The resolution is 1.96 Ohms

Problem 4) Assume R2 is a thermistor.

What temperature is it if R2 = 500 Ohms?

$$R = 500 = 1000 \cdot \exp\left(\frac{3905}{T+273} - \frac{3905}{298}\right)\Omega$$

Solving

$$T = 41.6433C$$

If R changes to 501.96 Ohms (from problem #3)

$$T = 41.5443C$$

for a difference of 0.0989C

A PIC can detect a change in temperature of 0.0989C

Problem 5) A PIC can measure time to 100ns. To give an idea of how small this is....

The fastest animal is the Peregrine falcon - able to fly up to 389 km/h (242 mph). How far can a Peregrine falcon fly in 100ns?

$$\left(\frac{389km}{h}\right)\left(\frac{1000m}{km}\right)\left(\frac{1hr}{3600s}\right)(100ns) = 10.806\mu m$$

The world's fastest animal moves 10 microns in one clock. 10 microns is

- 10x the size of a bacteria
- 1/18th the size of human hair

Problem 6) Assume for the 555 timer

- R1 = 500, R2 = 500, C = 0.22uF
- What frequency does the 555 timer output on pin #3?

The period is

$$T = (R_1 + 2R_2) \cdot C \cdot \ln(2)$$

$$T = 228.739\mu s$$

The frequency is

$$f = \frac{1}{T} = 4371.8Hz$$

Problem 7) What is the smallest change in frequency a PIC can detect?

- i.e. how much does the frequency have to change for the period to change by 100ns?

The period has to change by 100ns

$$T_2 = 228.739\mu s + 100ns$$

$$T_2 = 228.839\mu s$$

The frequency is

$$f_2 = \frac{1}{T_2} = 4369.89Hz$$

for a difference of

$$\delta f = f - f_2 = 1.91Hz$$

A PIC can detect a change of 1.91Hz

Problem 8) With this circuit, you can build an Ohm-meter (replace R2 with the resistance to be measured.) Assume R2 = 500 Ohms (nominally). How much does R2 have to change for the period to change by 100ns?

i.e. What is the resolution of this circuit when used as an Ohm-meter?

The period is

$$T = (R_1 + 2R_2) \cdot C \cdot \ln(2)$$

The nominal period (R1 = R2 = 500, C = 0.22uF) is

$$T = 228.739\mu s$$

If the period is 100ns longer, solve for R2

$$228.839\mu s = (500 + 2R_2) \cdot (0.22\mu F) \cdot \ln(2)$$

$$R_2 = 500.328\Omega$$

You can detect a change in resistance of 0.328 Ohms

Problem 9) Replace R2 with a thermistor which reads 500 Ohms nominally. How much does the temperature have to change for the period to increase by 100ns?

Nominal:

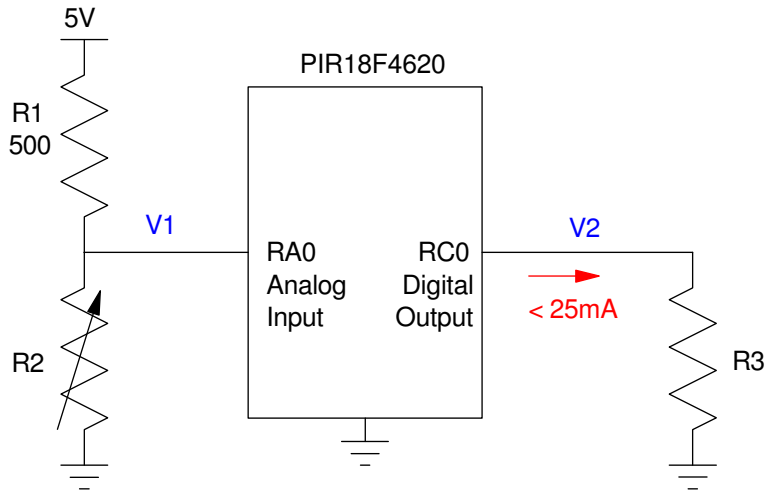
- R2 = 500 Ohms
- T = 41.6433 C (problem #4)

Change:

- R2 = 500.328 Ohms
- T = 41.6267 C

Change = 0.0166 degrees C

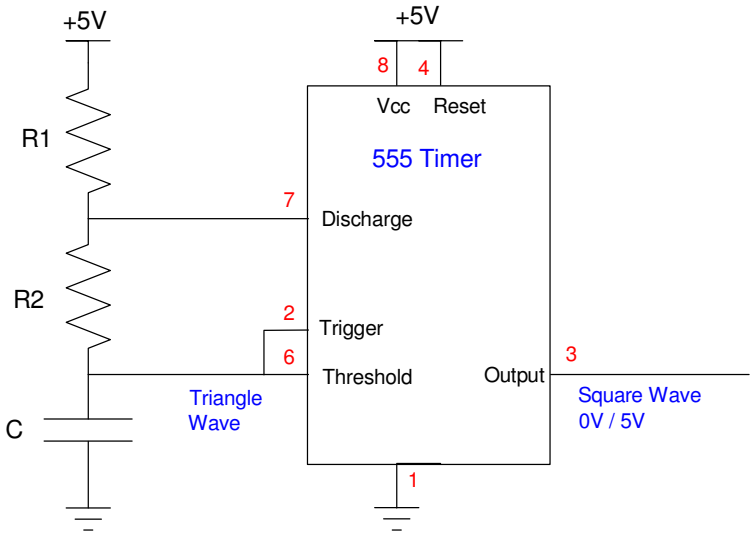
With this 555 timer circuit, you can detect a change of 0.0166 C



Problem #1 to #3

If R2 is a thermistor, assume

$$R_2 = 1000 \cdot \exp\left(\frac{3905}{T+273} - \frac{3905}{298}\right)\Omega$$



Astable 555 Timer: Problems 5-8

The square wave at the Output has a period of $T = (R_1 + 2R_2) \cdot C \cdot \ln(2)$ seconds