ECE 376 - Homework #1

PIC Background
Due Wednesday, January 22nd

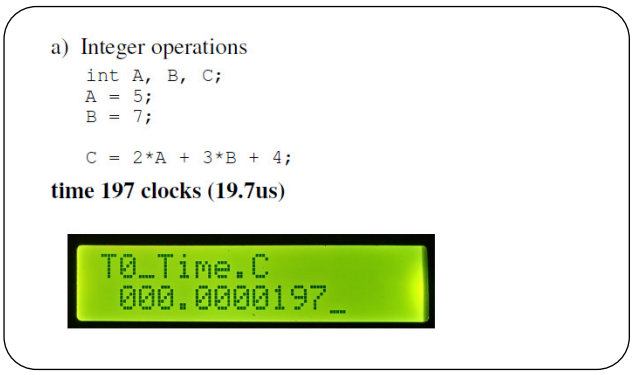
Problem	Answer
1) How many clocks does it take to do an integer operation in C? • Check Homework #9 solutions for Spring 2024	**197 clocks**
2) A PIC's output is limited to 25mA. Assuming V2 is 5V, what is the smallest resistance youcan connect to the output? (how small can R3 be?)	**200 Ohms**
A PIC 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 = 2.2k Ohms nominally? • How much does R2 have to change from 2.2k Ohms for V1 to change by 4.88mV?	**8.606 Ohms**
4) Assume R2 is a thermistor. • What temperature is it if R2 = 2.2k Ohms? • How much does the temperature have to change for V1 to change by 4.88mV?	**8.0872C** **0.079C**
A PIC can measure time to 100ns. To give an idea of how small this is....	
5) The fastest X-man is Quicksilver - able to run 175mph. How far can Quicksilver run in 100ns?	**7.823um**
6) Assume for the 555 timer • R1 = 2.2k, R2 = 2.2k, C = 0.22uF • What frequency does the 555 timer output on pin #3?	**993.59Hz**
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?	**0.0987Hz**
8) With this circuit, you can build an Ohm-meter (replace R2 with the resistance to be measured.) Assume R2 = 2.2k 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?	**0.32788 Ohms**
9) Replace R2 with a thermistor at a temperature where R2 is 2.2k 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?	**0.00292C**

1) How many clocks does it take to do an integer operation in C?

- Check Homework #9 solutions for Spring 2024

ans: 197 clocks

Note: If you need help doing a homework assignment, a good place to go is Bison Academy. Homework problems are changed every semester. However, previous homework solutions can give you a good idea on where to start.



from homework #9, Spring 2024

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

$$V = IR$$

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

Note: This means

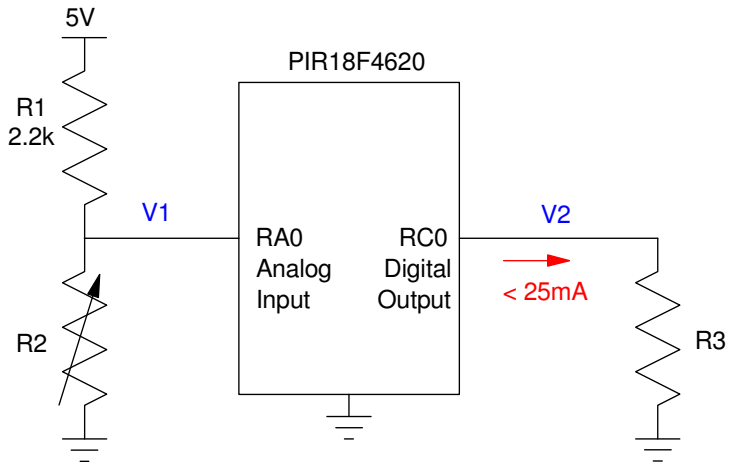
- A PIC can drive a 200+ Ohm load
- A PIC cannot drive an 8-Ohm speaker directly.

If you want to drive a speaker, you need to add a resistor to limit the current or some electronics as a buffer. (more on this later)

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 = 2.2k Ohms nominally?

How much does R2 have to change from 2.2k Ohms for V1 to change by 4.88mV?



At nominal resistance (R2 = 2.2k)

$$V_1 = \left(\frac{R_2}{R_2+R_1}\right)5V = 2.5000V$$

Adding 4..88mV (the smallest change in voltage a PIC's A/D can detect)

$$V_1 = 2.50488V$$

Recalculating R2

$$2.50488V = \left(\frac{R_2}{R_2+2.2k}\right)5V$$

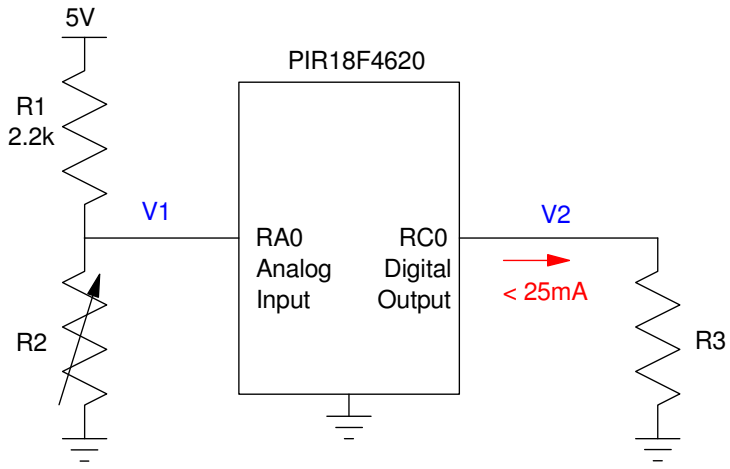
$$R_2 = \left(\frac{2.50488V}{5-2.50488V}\right)2.2k$$

$$R_2 = 2208.606\Omega$$

for a change of 8.606 Ohms

With this circuit, the smallest change in resistance a PIC can detect is 8.606 Ohms

4) Assume R2 is a thermistor.



What temperature is it if R2 = 2.2k Ohms?

$$R_2 = 2.2k\Omega = 1000 \cdot \exp\left(\frac{3905}{T+273} - \frac{3905}{298}\right)\Omega$$

Solving for T

$$T = 8.0872C$$

How much does the temperature have to change for V1 to change by 4.88mV?

Recalculate when R2 = 2208.606 Ohms

$$R_2 = 2208.606\Omega = 1000 \cdot \exp\left(\frac{3905}{T+273} - \frac{3905}{298}\right)\Omega$$

$$T = 8.0083C$$

The change in temperature is the smallest change in T you can detect

$$\delta T = 0.0790C$$

With this circuit, the smallest change in tempeature you can detect is 0.079C

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

5) The fastest X-man is Quicksilver - able to run 175mph. How far can Quicksilver run in 100ns?

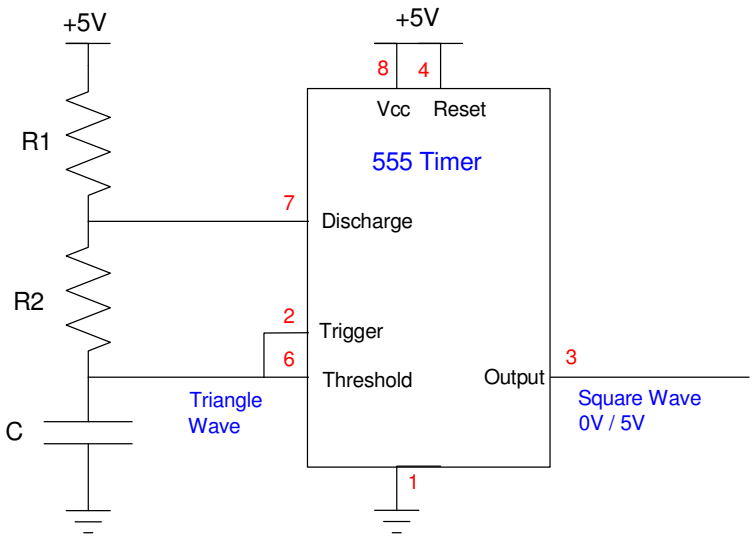
Convert to metric

$$\left(175\frac{miles}{hour}\right)\left(\frac{1609.3m}{mile}\right)\left(\frac{1hr}{3600s}\right) = 78.2299\frac{m}{s}$$

$$d = (78.2299\frac{m}{s})(100ns) = 7.823\mu m$$

Quicksilver moves 7.823 microns in one clock (less than the thickness of a human hair)

6) Assume for the 555 timer



R1 = 2.2k, R2 = 2.2k, C = 0.22uF

What frequency does the 555 timer output on pin #3?

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

$$T = 1.0064ms$$

$$f = \frac{1}{T} = 993.5916Hz$$

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

Increase T by 100ns

$$T_7 = 1.0065ms$$

$$f_7 = \frac{1}{T_7} = 993.4929Hz$$

$$\delta f = 0.0987Hz$$

The smallest change in frequency a PIC can detect is 0.0987Hz

8) With this circuit, you can build an Ohm-meter (replace R2 with the resistance to be measured.) Assume R2 = 2.2k Ohms (nominally). How much does R2 have to change for the period to change by 100ns?

The nominal period when R2 = 2200 Ohms is

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

$$T = 1.00645ms$$

Increase the period by 100ns

$$T = 1.00655ms$$

Recalculate R2

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

$$T = 1.00655ms = (2200\Omega + 2R_2) \cdot 0.22\mu F \cdot \ln(2)$$

$$R_2 = 2200.32788\Omega$$

With this circuit, you can measure resistance to 0.32788 Ohms

9) Replace R2 with a thermistor at a temperature where R2 is 2.2k Ohms nominally. How much does the temperature have to change for the period to increase by 100ns?

When R2 = 2200 Ohms

$$R_2 = 2200.00\Omega = 1000 \cdot \exp\left(\frac{3905}{T+273} - \frac{3905}{298}\right)\Omega$$

$$T = 8.0872C$$

When R2 = 2200.32788 Ohms

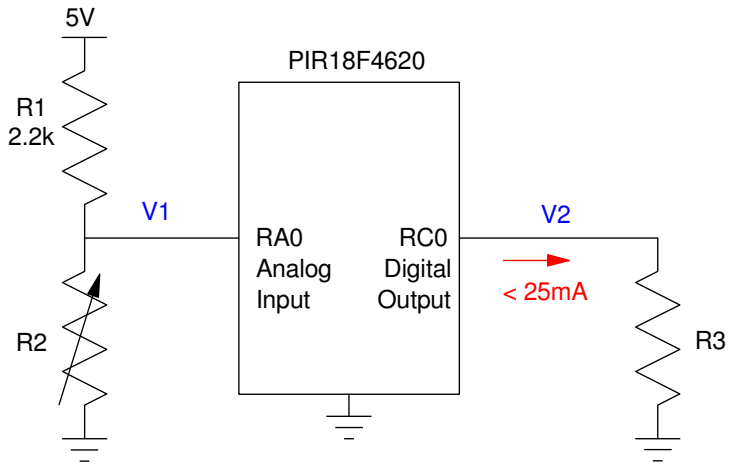
$$R_2 = 2200.32788\Omega = 1000 \cdot \exp\left(\frac{3905}{T+273} - \frac{3905}{298}\right)\Omega$$

$$T = 8.08422C$$

for a difference of

$$\delta T = 0.0029C$$

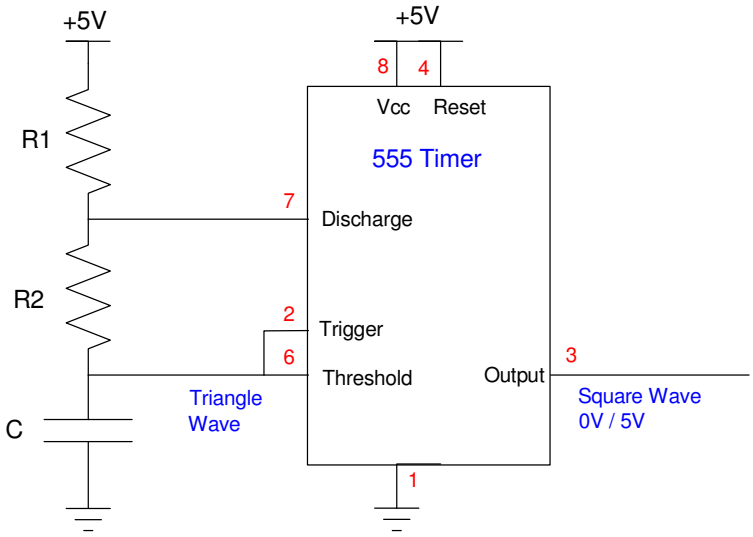
With this circuit, you can measure temperature to 0.0029C



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