ECE 376 - Homework #1

PIC Background. Due Monday, August 28th
Please submit as a hard copy, submit on BlackBoard, or email

Problem	Answer
1) How many clocks does it take to write the LCD display? • Check Homework #9 solutions for Spring 2023	**6.2543ms**
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 = 3300 Ohms nominally? • How much does R2 have to change from 3300 Ohms for V1 to change by 4.88mV?	**18.12 Ohms**
4) Assume R2 is a thermistor. • What temperature is it if R2 = 3300 Ohms? • How much does the temperature have to change for V1 to change by 4.88mV?	**T = 0.1161C** **dT = 0.0115C**
A PIC can measure time to 100ns. To give an idea of how small this is....	
5) A peregrine falcon is the fastest animal in the world, able to reach 320 km/h. How far can a peregrine falcon fly in 100ns?	**8.889um**
6) Assume for the 555 timer • R1 = 1k, R2 = 3300, C = 0.1uF • What frequency does the 555 timer output on pin #3?	**1898.2829Hz**
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?	**0.3602Hz**
8) With this circuit, you can build an Ohm-meter (replace R2 with the resistance to be measured.) Assume R2 = 3300 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?	**0.7213 Ohms**
9) Replace R2 with a thermistor which reads 3300 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?	**0.004174 C**

3) What is the smallest change in R2 a PIC can measure if R2 = 3300 Ohms nominally?

- How much does R2 have to change from 3300 Ohms for V1 to change by 4.88mV?

The voltage at V1 is

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

$$V_1 = \left(\frac{3300}{3300+1000}\right)5V = 3.837209V$$

If V1 increases by 4.88mV, then

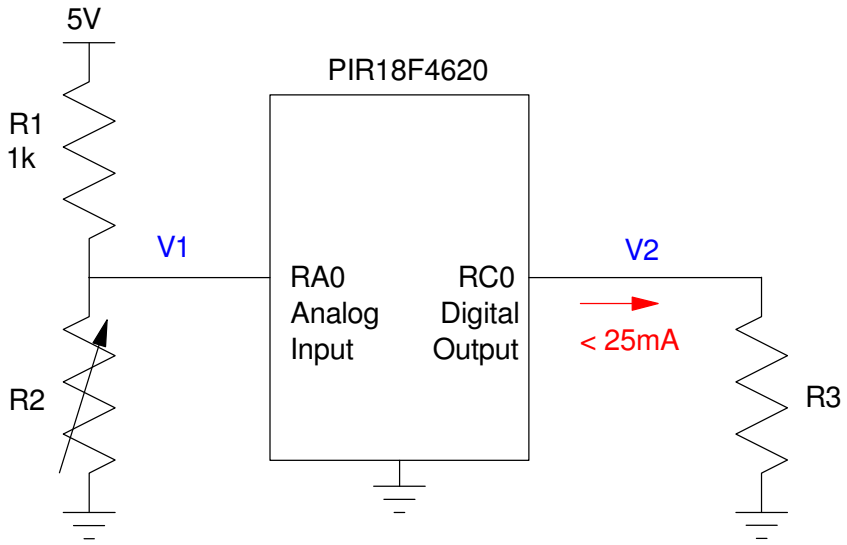
$$V_1 + 4.88mV = 3.842089$$

Solving backwards for R2

$$R_2 = \left(\frac{V_1}{5-V_1}\right)R_1 = 3318.122296\Omega$$

meaning...

- R2 has to change by 18.122296 Ohms for V1 to change by 4.88mV
- The PIC can read R2 with a resolution of 18.12 Ohms



4) Assume R2 is a thermistor.

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

What temperature is it if R2 = 3300 Ohms?

Solving for T

$$3300\Omega = 1000 \cdot \exp\left(\frac{3905}{T+273} - \frac{3905}{298}\right)\Omega$$

backwards,

T = 0.116089 C

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

(R2 = 3318.12296 Ohms from problem #3)

Solve for T

$$3318.12296\Omega = 1000 \cdot \exp\left(\frac{3905}{T+273} - \frac{3905}{298}\right)\Omega$$

T = 0.011517C

The difference is 0.104572C, meaning...

- Temperature has to change by 0.104C for a PIC to detect the change
- The resolution is 0.104C

5) A peregrine falcon is the fastest animal in the world, able to reach 320 km/h. How far can a peregrine falcon fly in 100ns?

$$320\left(\frac{km}{hr}\right)\left(\frac{1000m}{1km}\right)\left(\frac{1hr}{3600s}\right) = 88.889\frac{m}{s}$$

$$(88.889\frac{m}{s})(100ns) = 8.889\mu m$$

A peregrine falcon flies 8.889 microns in 100ns.

6) Assume for the 555 timer

- R1 = 1k, R2 = 3300, C = 0.1uF

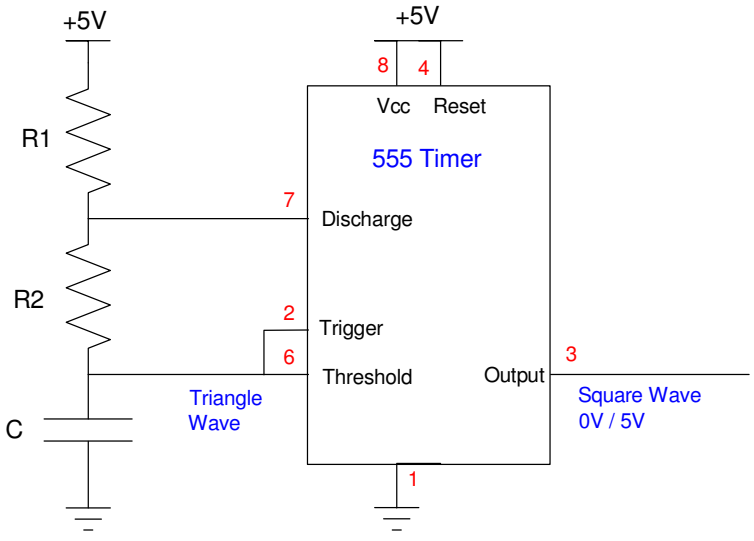
What frequency does the 555 timer output on pin #3?

The period is

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

T = 526.8us

f = 1/T = 1898.2829Hz



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

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?

If the period is 100ns longer

$$T = 5.26892\mu s$$

$$f = \frac{1}{T} = 1897.922669Hz$$

The difference is

$$\delta f = 0.3602Hz$$

A change of frequency of 0.3602Hz results in the period becoming 100ns longer

A PIC can detect a change of frequency of 0.3602Hz

8) With this circuit, you can build an Ohm-meter (replace R2 with the resistance to be measured.) Assume R2 = 3300 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 with R1=1000, R2=3300, C=0.1uF is

T = 5.26792us

If the period is 100ns longer

T = 5.26892us

Solving for R2 (keeping R1 = 1000, C = 0.1uF)

R2 = 3300.7213 Ohm

Meaning

- R2 has to change by 0.7213 Ohms for the PIC to detect the change
- The PIC has a resolution of 0.7213 Ohms

9) Replace R2 with a thermistor which reads 3300 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?

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

If R2 = 3300 Ohms

T = 0.116 089 183 C

If R2 = 3300.7213 Ohms

T = 0.111 914 591 C

The difference is the resolution

dT = 0.004 174 C

A PIC can detect a change of temperature of 0.004174 C