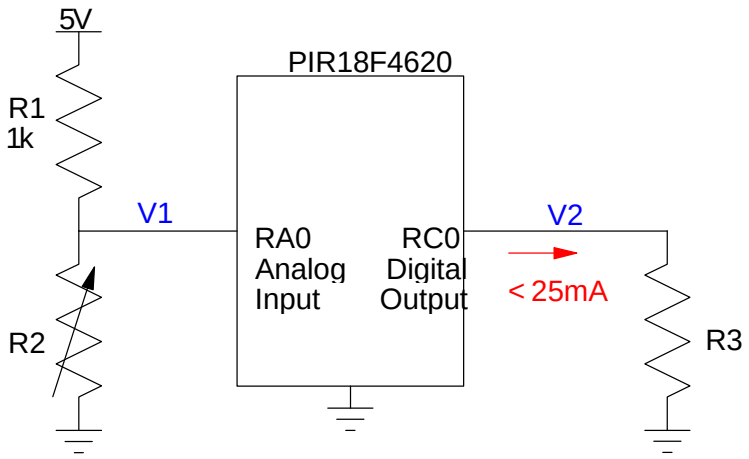
ECE 376 - Homework #1

PIC Background. Due Wednesday, January 18th

Please submit in class or online as a Word /pdf file submitted via BlackBoard or email with header ECE 376 HW1

Problem	Answer
1) 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?) $$R = \frac{5}{25 \cdot 10^{-3}} = 200\ \Omega$$	$R3 = 200\ \Omega$
A PIC can measure voltage to 4.88mV. To give an idea of how small this is....	
2) What is the smallest change in R2 a PIC can measure if R2 = 800 Ohms nominally? • How much does R2 have to change from 800 Ohms for V1 to change by 4.88mV? $$V_1 = \frac{R_2}{R_2 + R_1} \cdot V_{IN} = \frac{800}{800 + 1000} \cdot 5 = \frac{20}{9} V \simeq 2.22\ V$$ $$V_1 = \frac{20}{9} + 4.88 \cdot 10^{-3} = 2.2271\ V$$ $$R_2 = \frac{2.2271}{5 - 2.2271} \cdot 1000 = 803.1678\ \Omega$$ The smallest change in resistance a PIC can see is $R = 803.1678 - 800 = 3.1678\ \Omega$	$R = 3.1678\ \Omega$
3) Assume R2 is a thermistor. • What temperature is it if R2 = 800 Ohms? $$R_2 = 1000 \cdot \exp\left(\frac{3905}{T + 273} - \frac{3905}{298}\right)\Omega$$ $$R_2 = 800\ \Omega \rightarrow \ T = 30.1624\ °C$$ • How much does the temperature have to change for V1 to change by 4.88mV? $$R_2 = 803.1678\ \Omega \rightarrow \ T = 30.0695\ °C$$ The smallest change in temperature a PIC can detect is $T = 0.0929\ °C$	$T = 0.0929\ °C$
A PIC can measure time to 100ns. To give an idea of how small this is....	
4) The fastest hockey puck shot was 110.3 mph (46.98 m/s) by Denis Kulyash in 2011. If the puck travels 89 feet to the net (shot from mid-line), • How long does it take to travel to the net? $$d = v \cdot t$$ $$27.1272 = 46.98 \cdot t$$ $$t = 0.5774201788\ s$$ • How much faster would the puck have to travel for it to take 100ns less to travel this distance? $$t = 0.5774202788\ s$$ $$v = \frac{27.1272}{0.5774202788} = 46.97999186 \frac{m}{s}$$	$t = 0.5774201788\ s$ $\Delta v = 0.00000813618 \frac{m}{s}$

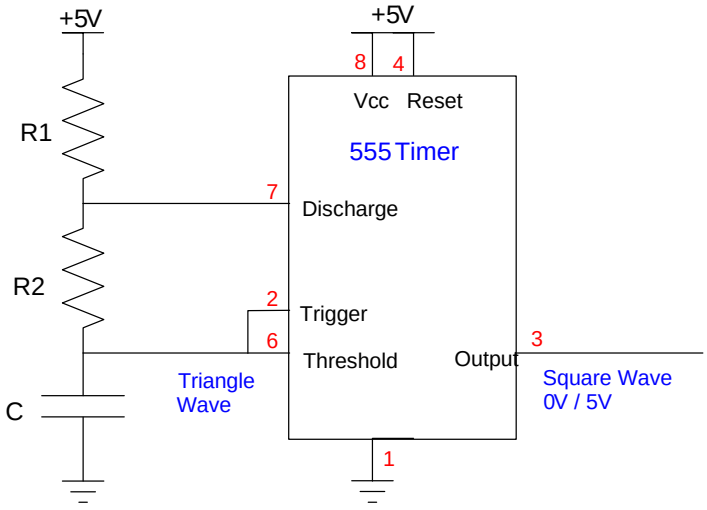
5) The world record for a 500m speed skate is 38.9 seconds (Hasse Borjes in 1970). How far behind would you have to be (in meters) if you cross the finish line 100ns behind Hasse Borjes? $d = \frac{500}{38.9} \cdot 100 \cdot 10^{-9} = 0.00000128534\ m$ $d = 1.28534\ \mu m$	$d = 1.28534\ \mu m$
6) Assume for the 555 timer • R1 = 1k, R2 = 800, C = 0.22uF • What frequency does the 555 timer output on pin #3? $T = (R_1 + 2R_2) \cdot C \cdot \ln(2)$ $T = (1k + 2 \cdot 800) \cdot 0.22\mu \cdot \ln(2) = 0.39648\ ms$ $f = \frac{1}{T} = 2522.19\ Hz$	$f = 2522.19\ Hz$
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? $T = 0.39648ms + 100ns = 0.39658\ ms$ $f = \frac{1}{T} = 2521.56\ Hz$ $\delta f = 0.63\ Hz$	$\delta f = 0.63\ Hz$
8) With this circuit, you can build an Ohm-meter (replace R2 with the resistance to be measured.) Assume R2 = 800 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? $T = 0.39658\ ms = (1k + 2 \cdot R_2) \cdot 0.22\mu \cdot \ln(2)$ $R_2 = 800.3273\ \Omega$ A PIC can detect a change in resistance of $R = 0.3273\ \Omega$	$R = 0.3273\ \Omega$
9) Replace R2 with a thermistor. How much does the temperature have to change for the period to increase by 100ns? • i.e. what is the resolution in degrees C? $R_2 = 1000 \cdot \exp\left(\frac{3905}{T + 273} - \frac{3905}{298}\right)\Omega$ $R_2 = 800\ \Omega \rightarrow\ T = 30.1624\ °C$ $R_2 = 800.3273\ \Omega \rightarrow\ T = 30.1528\ °$ The smallest change in temperature a PIC can detect is $T = 0.0096\ °C$	$T = 0.0096\ °C$



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