ECE 376 - Homework #3

Binary Inputs, Binary Outputs, and Timing. Due Monday, January 30th

Please make the subject "ECE 376 HW#3" if submitting homework electronically to Jacob_Glower@yahoo.com (or on blackboard)

Binary Inputs (hardware)

Assume a thermistor has a resistance-temperature relationship of

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

1) Design a circuit which outputs

- 0V when T < -15C
- 5V when T > -15C

At =15C, the resistance is 7627 Ohms.

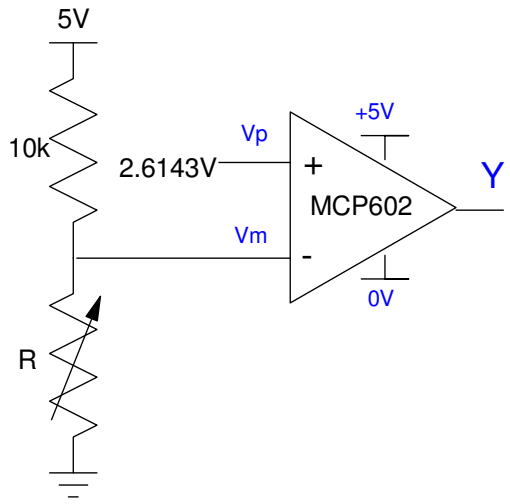
Assume a voltage divider with a 10k resistor

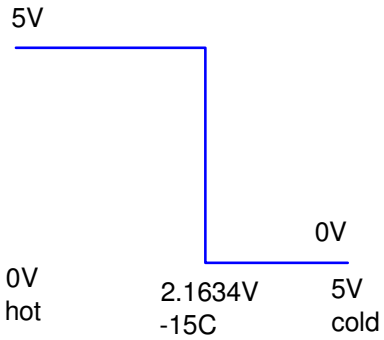
$$V = \left(\frac{7627\Omega}{7627\Omega+10k\Omega}\right)5V = 2.1634V$$

For the +/- inputs, as temperature goes up

- R goes down
- V goes down
- Output goes up

Connect to the minus input to get this inverse correlation





2) Design a circuit which outputs

- 0V when T < -20C
- 5V when T > -15C

This would be a Schmitt trigger. Assume a voltage divider with a 10k resistor

-20C (off)

- R = 10,285 Ohms
- Vm = 2.5352V
- Y = 0V

-15C (on)

- R = 7626 Ohms
- Vm = 2.1634V
- Y = +5V

As the input goes down, the output goes up

connect to the minus input

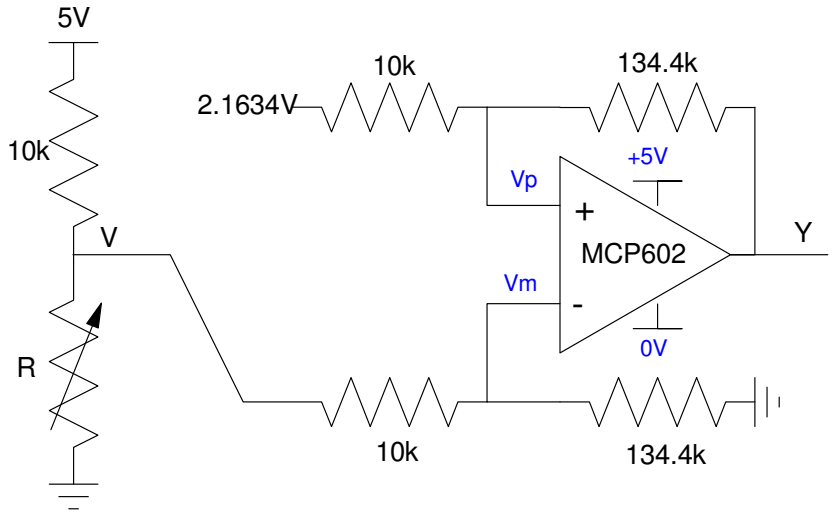
The output is set when Vm = 2.1634V.

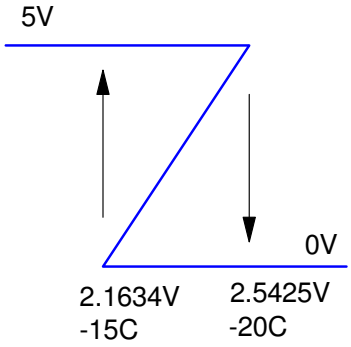
Make the offset 2.1634V

The gain needed is

$$gain = \left(\frac{\text{change in output}}{\text{change in inpu}}\right) = \left(\frac{5V-0V}{2.5352V-2.1634V}\right) = 13.4465$$

Make the resistor ration 13.44 : 1





3) Design a circuit which outputs

- 5V when -20C < T < -15C
- 0V otherwise

Use two comparitors to output

A = (T > -20C)

B = (T < -15C)

Y = 0V if either A or B is 0V

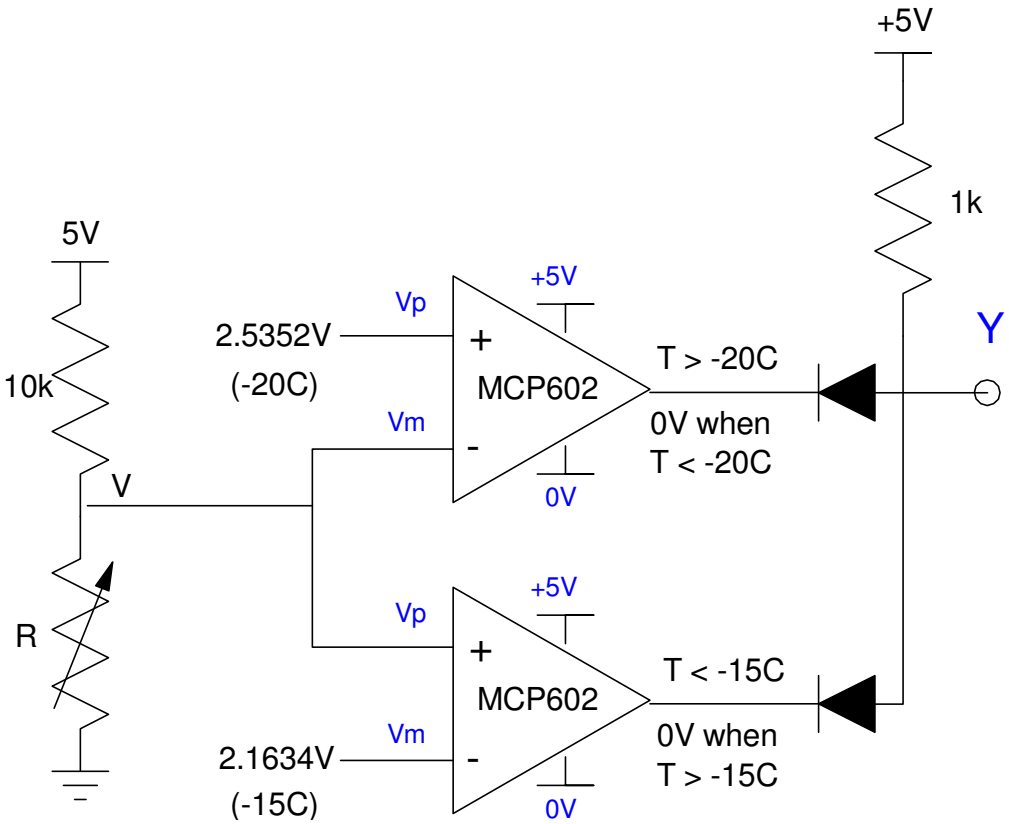
use diodes - if either signal is 0V, Y = 0V (actually 0.7V)

A: Comparitor for T > -20C

- offset voltage = 2.5352V
- connect to the minus input for T > -20C

B: Comparitor for T < -15C

- offset voltage = 2.1634V
- connect to the plus input for T > -15C



Binary Outputs

4) Design a circuit which allows your PIC board to turn on and off an RGB Piranah LED at 0mA (off) and 20mA (on). Assume the specifications for the LEDs are:

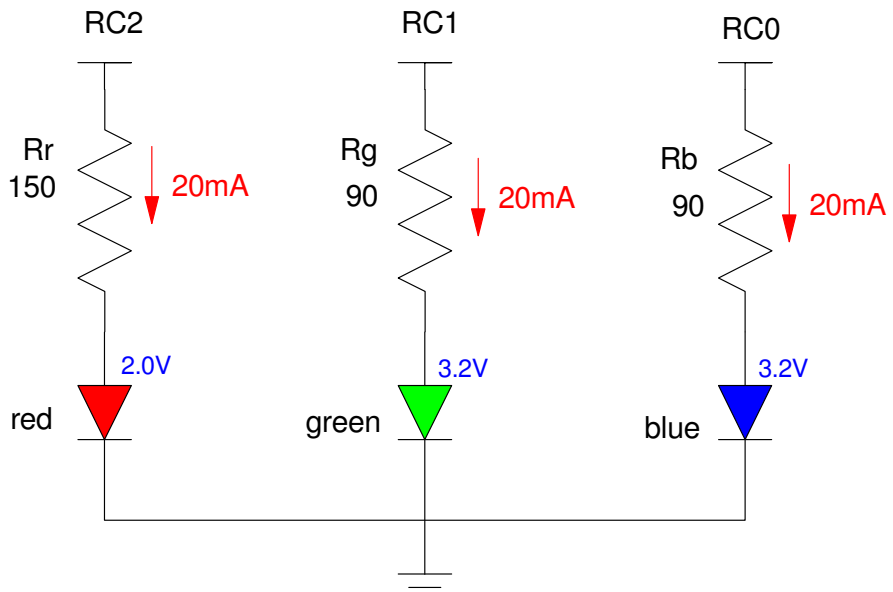
Color	Vf @ 20mA	mcd @ 20mA
red	2.0V	10,000
green	3.2V	10,000
blue	3.2V	10,000

The output is less than 5V and less than 25mA. This means you can drive the outputs directly using just a resistor.

$$R_r = \left(\frac{5V-2.0V}{20mA}\right) = 150\Omega$$

$$R_g = \left(\frac{5V-3.2V}{20mA}\right) = 90\Omega$$

$$R_b = \left(\frac{5V-3.2V}{20mA}\right) = 90\Omega$$



Note: To vary the brightness, you could

- Vary the resistors (hardware solution used in ECE 320)
- Vary the duty cycle (software solution used in ECE 376)

To vary the duty cycle, you turn the pins on and off

- RC2 = on for 10% of the time makes it look like Ir = 2.0mA (on average)

Anything you can do in hardware, you can do in software (and visa versa)

5) Design a circuit which allows your PIC board to turn on and off a 5W LED. The specs for the LED are:

- Vf = 6.0-7.0V
- Current = 700mA
- 500-600 Lumens (equivalent to a 60W light bulb).

https://www.ebay.com/itm/1W-3W-5W-10W-50W-100W-High-power-SMD-Chip-LED-COB-White-Blue-Red-Light-Beads/124011607823

Assume you have a 6144 NPN transistor:

- max continuous current = 3A
- current gain = 300
- Vbe = 0.7V, Vce(sat) = 0.2V

In this case,

- The voltage is more than 5V, meaning you need to use a transistor.
- The current is more than 25mA, meaning you need to use a transistor

Step 1: Find Rc

Assume a 12V power supply.

$$R_c = \left(\frac{12V - 6.0V - 0.2V}{700mA}\right) = 8.28\Omega$$

Step 2: Find Rb

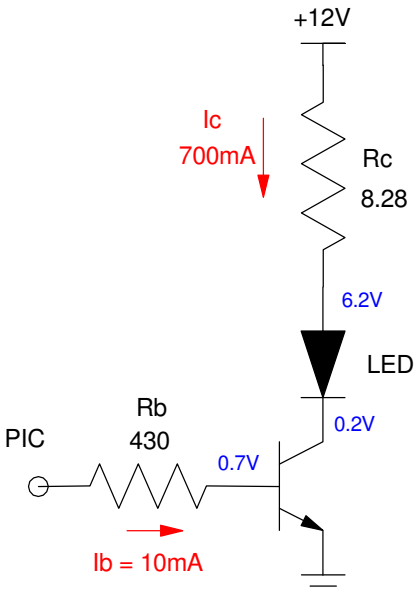
The base current has to be at least 2.33mA

$$\beta I_b > I_c = 700mA$$

$$I_b > \left(\frac{700mA}{\beta}\right) = 2.333mA$$

The base current has to be less than 25mA (all the PIC can output). Let Ib = 10mA

$$R_b = \left(\frac{5V - 0.7V}{10mA}\right) = 430\Omega$$



Timing:

6) Write a program which outputs the music note D3 (146.83 Hz)

- Verify the frequency of the square wave you generate
- (Pano Tuner app on you cell phone works well for this)

Step 1: Calculate the number of clocks per toggle

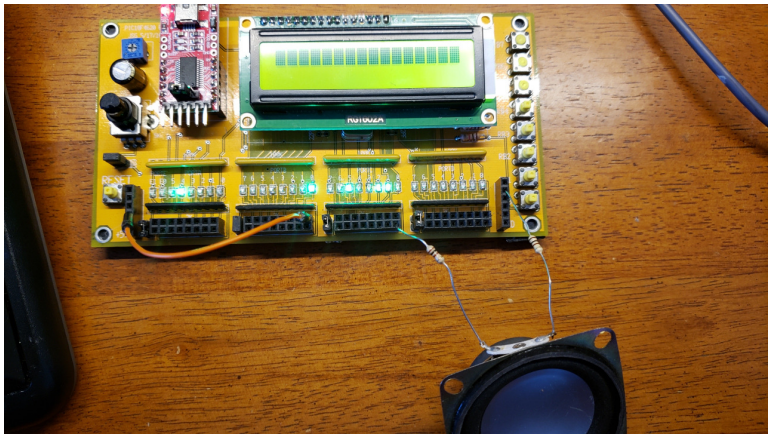
$$N = \left(\frac{10{,}000{,}000}{2 \cdot Hz}\right) = 34{,}052.98$$

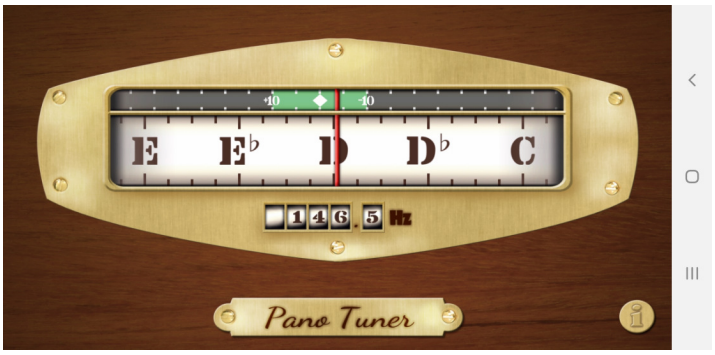
N = 10AB + 5A + 4

A = 14, B = 243 results in N = 34,094 (0.12% too high)

Come up with a wait routine that burns 24,053 clocks (or close)

```
; Variables
CNT0 EQU 1
CNT1 EQU 2

; Program
   org 0x800
   call Init
Loop:
   incf  PORTC,F
   call Wait
   goto Loop

; --- Subroutines ---

Init:
   clrf TRISA
   clrf TRISB
   clrf TRISC
   clrf TRISD
   clrf TRISE
   movlw 0x0F
   movwf ADCON1 ;everyone is binary
   return

; Wait 34,053 clocks  (actual wait = 15,164)
Wait:
   movlw 14         ; A
   movwf CNT1
W1:
      movlw 243     ; B
      movwf CNT0
W0:
         nop        ; 10 clocks
         nop
         nop
         nop
         nop
         nop
         nop
         decfsz CNT0, F
         goto W0
      decfsz CNT1, F
      goto W1
   return
```





Lab: LED Flashlight

7) Give the flow chart for a program to turn your PIC board into an LED flashlight:

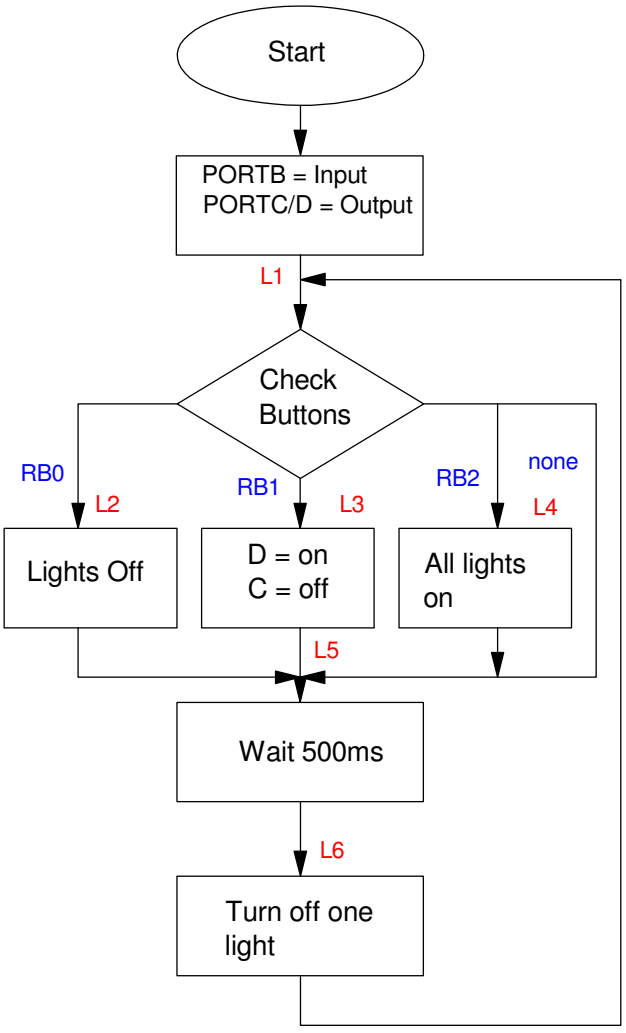
- PORTB = input
- PORTC & D are output (the LED's)
- RB0: All lights turn off (PORTC = PORTD = 0);
- RB1: Half of the lights are on (PORTC = 0, PORTD = 255)
- RB2: All lights are on (PORTC = PORTD = 255)

To save energy, one LED turns off every 500ms.

Once all LEDs are off, they remain off until RB1 or RB2 are pressed.

8) Write the corresponding assembler code

```
    org 0x800

    movlw 0xFF
    movwf TRISB
    clrf  TRISC
    clrf  TRISD
    movlw 0x0F
    movwf ADCON1
L1:
    btfsc PORTB,0
    goto  L2
    btfsc PORTB,1
    goto  L3
    btfsc PORTB,2
    goto  L4
    goto  L5
L2:
    clrf  PORTC
    clrf  PORTD
    goto  L5
L3:
    clrf  PORTC
    movlw 0xFF
    movwf PORTD
    goto  L5
L4:
    movlw 0xFF
    movwf PORTC
    movwf PORTD
L5:
    call  Wait
L6:
    bcf   STATUS,C
    rrcf  PORTC,F
    rrcf  PORTD,F
    goto  L1
```



9) Test your code.

- Compile and program your PIC board
- Verify each button's operation

RB0 turns off the LEDs (check)

RB1 turns on PORTD, turns off PORTC (check)

RB2 turns on PORTC and PORTD (check)

When the lights are on, they turn off , one LED every 500ms (check)

10) (20 points) Demonstration

- In-person of with a video