ECE 320 - Homework #8

Schmitt Triggers, Boolean Logic, DTL Logic. Due Monday, March 5th, 2018

Assume

- MCP602 op-amps which operate at 0V / 5V and are capable of driving up to 30mA.
- 3904 NPN transistors which are capable of driving up to 200mA and have a current gain of 100.
- A temperature sensor has the relationship

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

  where T is the temperature in degrees Kelvin (0 Celsius = 273 Kelvin).
- A DC motor which draws 200mA at 10V.

1) Design a comparitor circuit which outputs

- 0V when when the temperature is below 30C
- 5V when the temperature is above 30C

At 30C (303K)

R = 805 Ohms

Use a voltage divider with a 1k resistor. This results in the voltage being

$$V_a = \left(\frac{R}{R+1000}\right) \cdot 5V$$

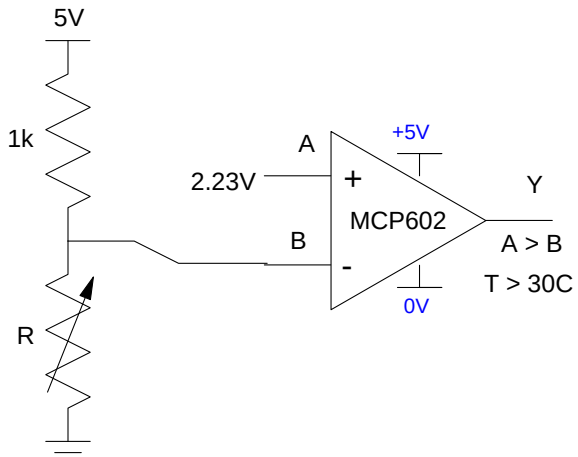
$$V_a = 2.23V$$

Build a comparitor which switches at 2.23V (30C).

When the temperature gets really high (100C)

- R goes to zero
- Va goes to zero
- Vo goes to 5V

Connect to the - input.



2) Modify this circui tso that it can drive a DC motor which draws 200mA at 10V when turned on.

Add a transistor to act as a switch. Use a 3904 NPN transistor

$$I_c = 200mA$$

To saturate the transistor:

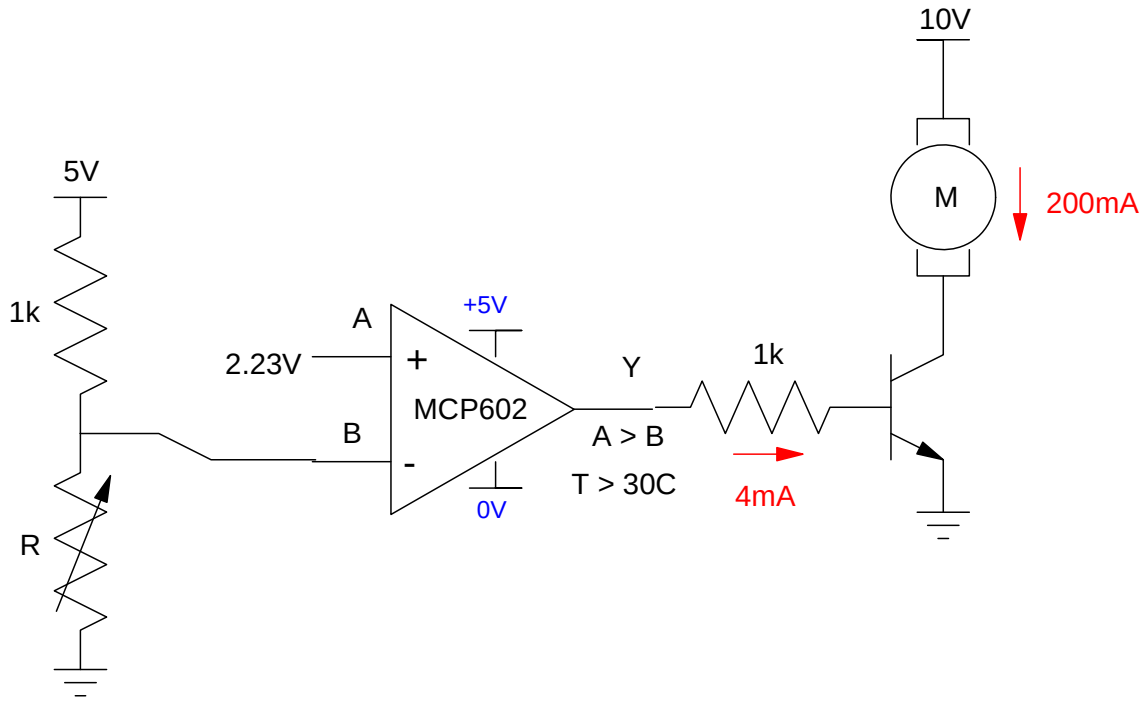
$$\beta I_b > I_c$$

$$I_b > 2mA \qquad \text{(beta = 100 for a 3904)}$$

Let

$$I_b = 4mA$$

$$R_b = \left(\frac{5V - 0.7V}{4mA}\right) = 1075\Omega$$



3) Build this circuit in lab and verify your design. (note: use a decade resistor in place of the temperature sensor when verifying what temperature / resistance the motor turns on).

4) Design a Schmitt Trigger which outputs

- 0V when the temperature drops below 30C,
- 5V when the temperature goes above 35C, and
- No change for 30C < T < 35C

Assume a 1k resistor for a voltage divider (same as problem #1)

At 30C

R = 805 Ohms

Va = 2.23V

At 35C

R = 653 Ohms

Va = 1.9761 V

The gain you need is

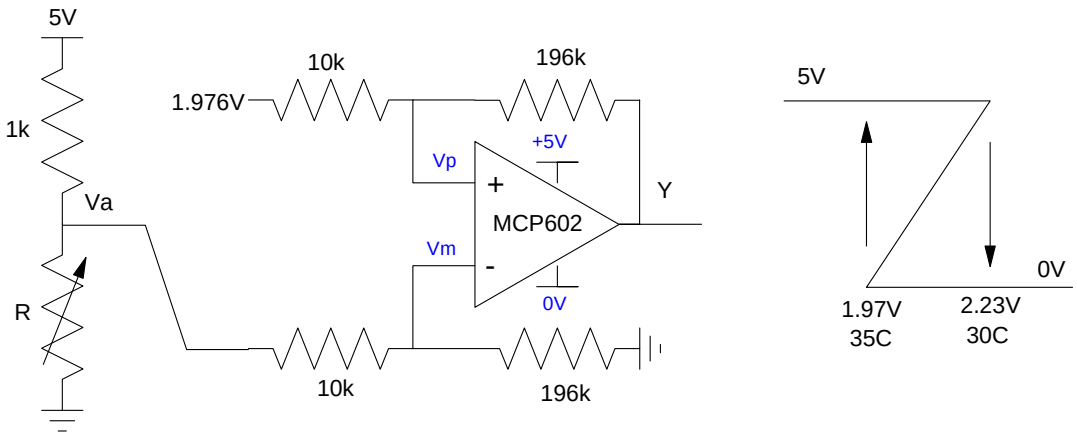
$$gain = \left(\frac{5V-0V}{2.23V-1.97V}\right) = 19.63$$

When temperature goes up

- R goes to zero
- Va goes to zero
- Vo goes to 5V

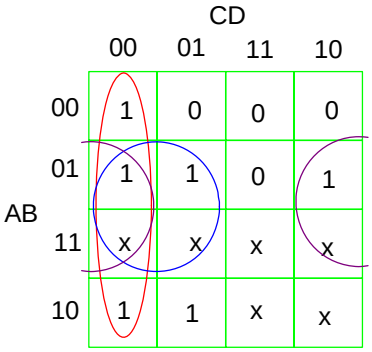
Connect to the - input

When the ouput is 0V, you switch at 35C (1.97V). Connect the - input to 1.97V

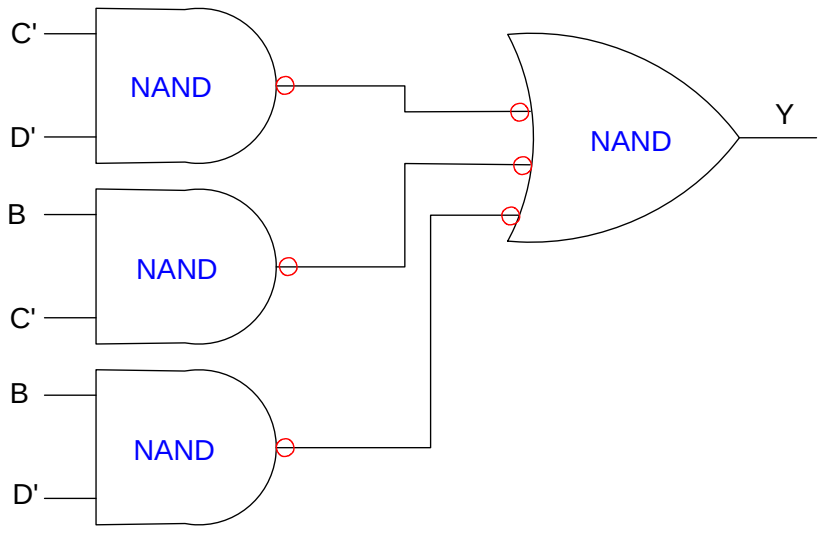


Boolean Logic

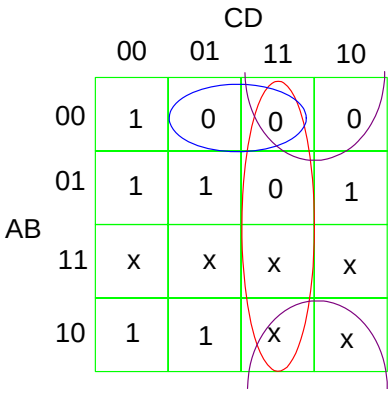
5) Design a circuit using NAND gates (circle the ones) to implement the following logic:



$$Y = \overline{C}\overline{D} + B\overline{C} + B\overline{D}$$



6) Design a circuit using NOR gates (circle the zeros) to implement the following logic:

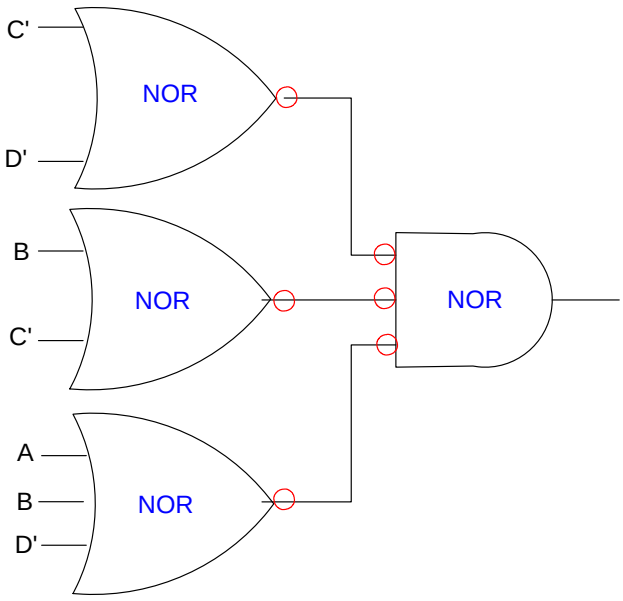


$$\overline{Y} = CD + \overline{B}C + \overline{A}\overline{B}D$$

Using DeMorgan's theorem

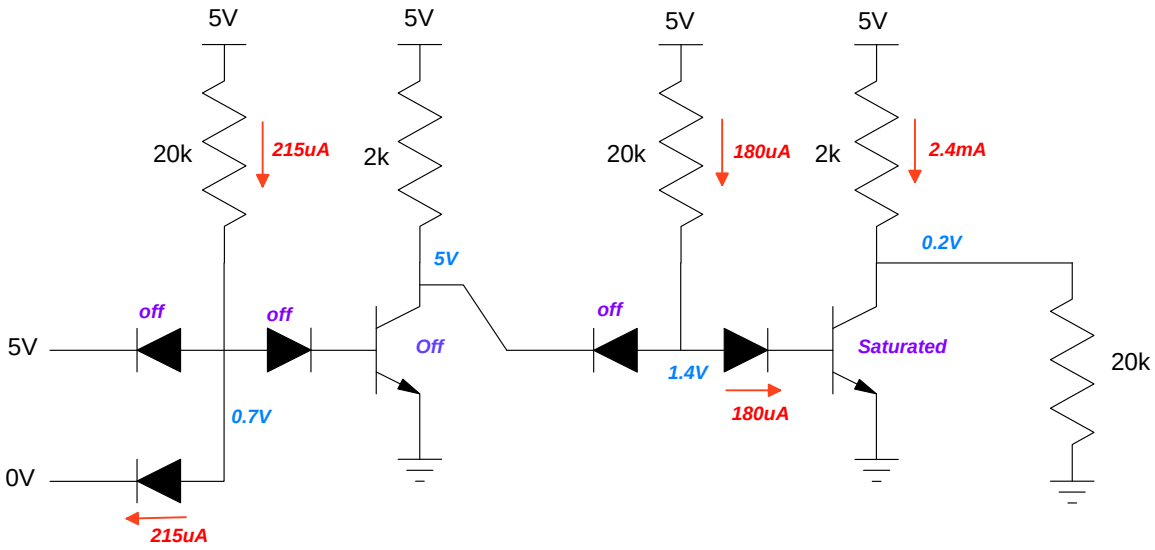
$$Y = \overline{CD + \overline{B}C + \overline{A}\overline{B}D}$$

$$Y = \left(\overline{C} + \overline{D}\right)\left(B + \overline{C}\right)\left(A + B + \overline{D}\right)$$



DTL Logic

7) Determine the voltages for the following DTL AND gate



8) Determine the voltages for the following DTL AND gate