

# ECE 320 - Homework #8

Boolean, DTL, &, TTL Logic. Due Monday, March 7th

## Boolean Logic

1) Design a circuit to implement Y using NAND gates

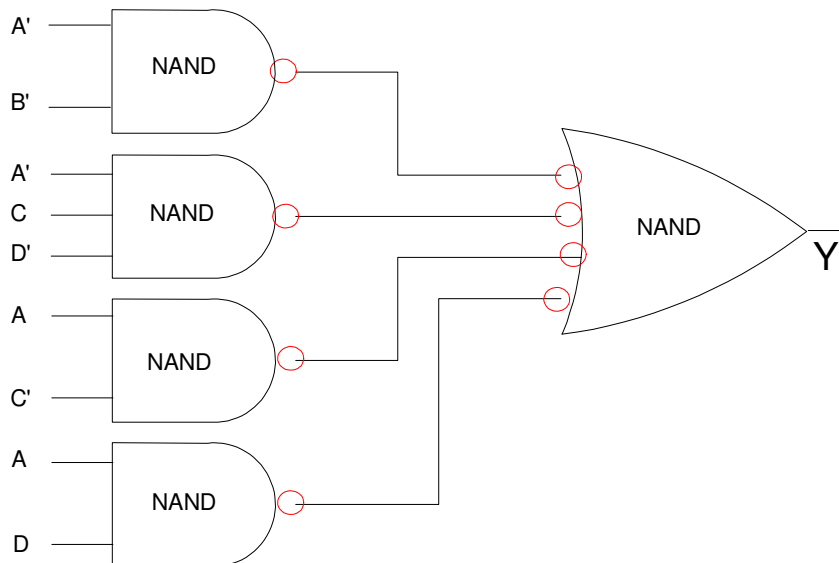
Y(A,B,C,D)		CD			
		00	01	11	10
AB	00	1	1	1	x
	01	0	0	0	1
	11	1	x	1	0
	10	x	1	x	0

Circle the ones

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

Implement with AND and OR gates

Add double negatives to turn these into NAND gates



2) Design a circuit to implement Y using NOR gates

Y(A,B,C,D)		CD			
		00	01	11	10
AB	00	1	1	1	x
	01	0	0	0	1
	11	1	x	1	0
	10	x	1	x	0

Circle the zeros

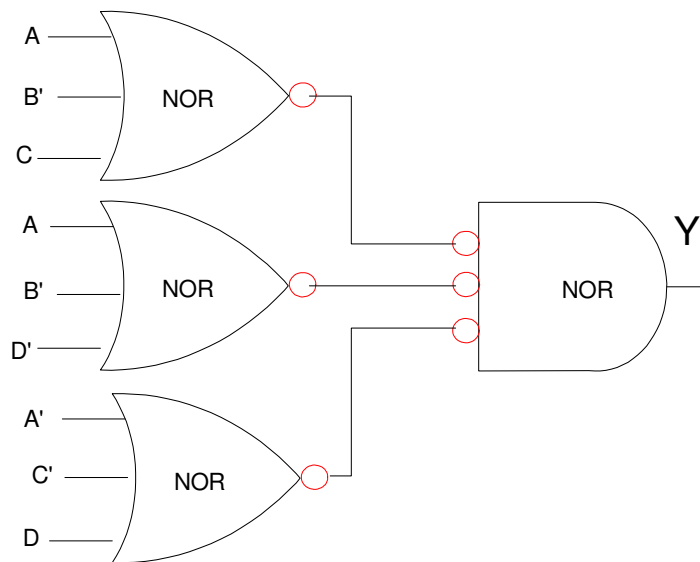
$$\bar{Y} = \bar{A}\bar{B}\bar{C} + \bar{A}BD + A\bar{C}\bar{D}$$

Use DeMorgan's Law

$$Y = (A + \bar{B} + C)(A + \bar{B} + \bar{D})(\bar{A} + \bar{C} + D)$$

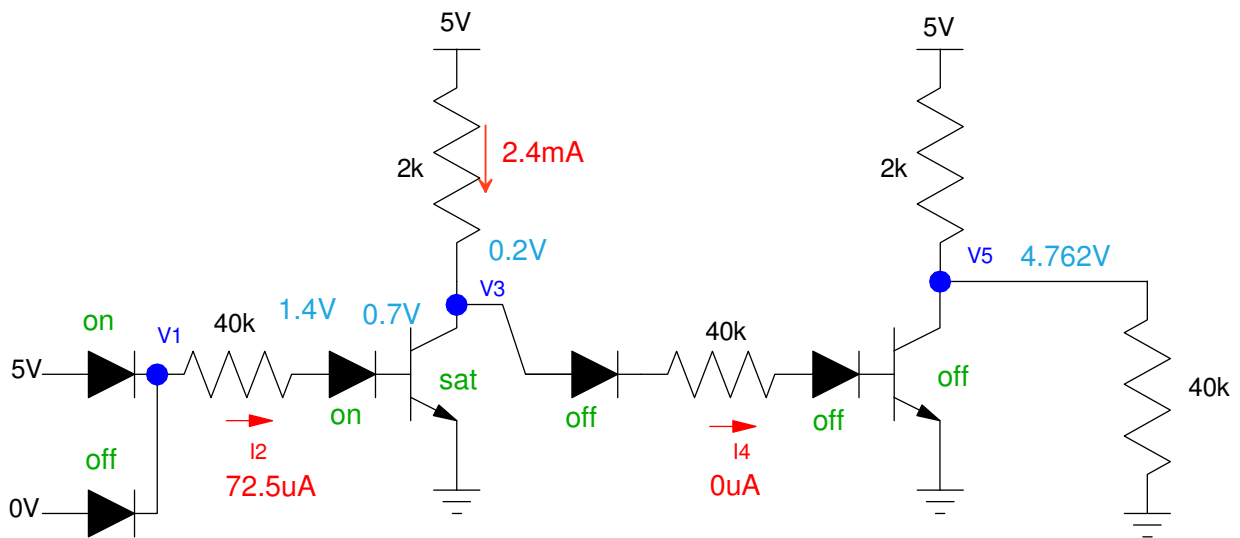
Implement using OR and AND gates

Add double negatives to make these NOR gates



## DTL Logic

2) Determine the voltages and currents for the following DTL OR gate. Assume 3904 NPN transistors



$$I_5 = \left( \frac{5V - 2.1V}{40k} \right) = 72.5\mu A$$

allows 7.25mA to flow

$$I_c = \left( \frac{5V - 0.2V}{2k} \right) = 2.4mA$$

$7.25mA > 2.4mA$ , meaning T1 is saturated

$$V_3 = 0.2V$$

$$I_4 = 0$$

0.2V isn't enough to turn on three diodes

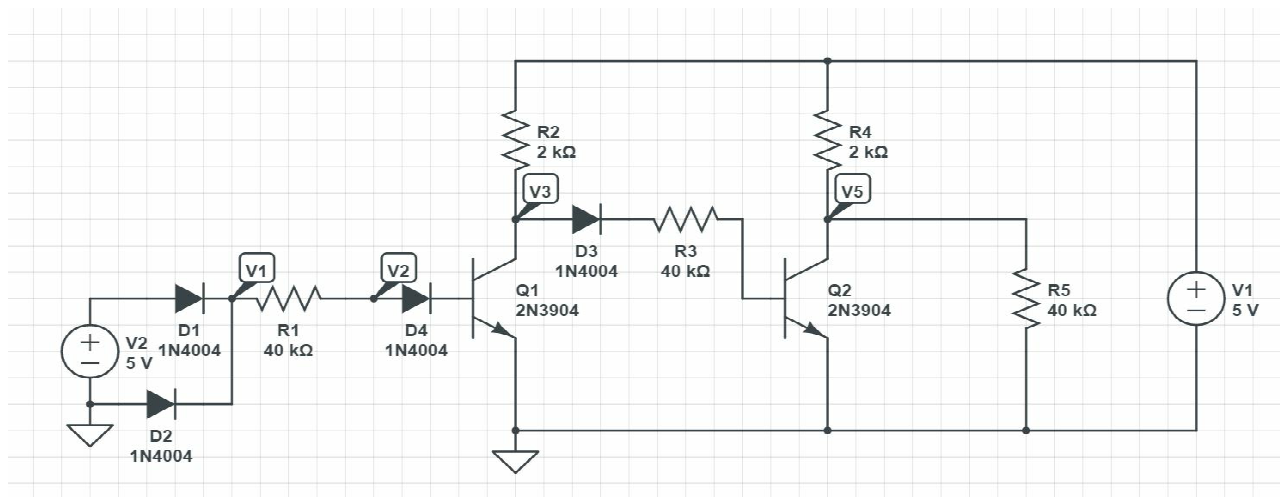
$$V_5 = \left( \frac{40k}{40k + 2k} \right) 5V = 4.762V$$

3) Simulate this circuit in CircuitLab to verify your answers

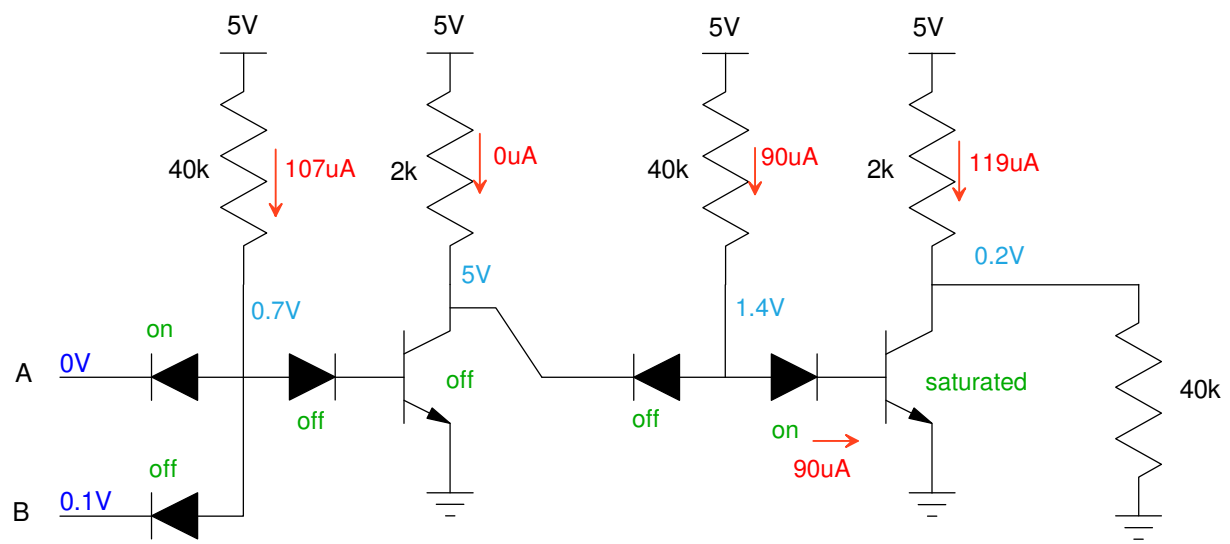
	V1	V2	V3	V5
Calculated problem 2	4.30 V	1.40 V	0.20 V	4.763 V
Simulated Problem 3	4.483 V	1.205 v	0.064 V	4.762 v

Answers are similar

- The voltage drop across a diode isn't exactly 0.7V
- The voltage drop across a saturated transistor isn't exactly 0.2V



4) Determine the voltages and currents for the following DTL AND gate. Assume 3904 NPN transistors

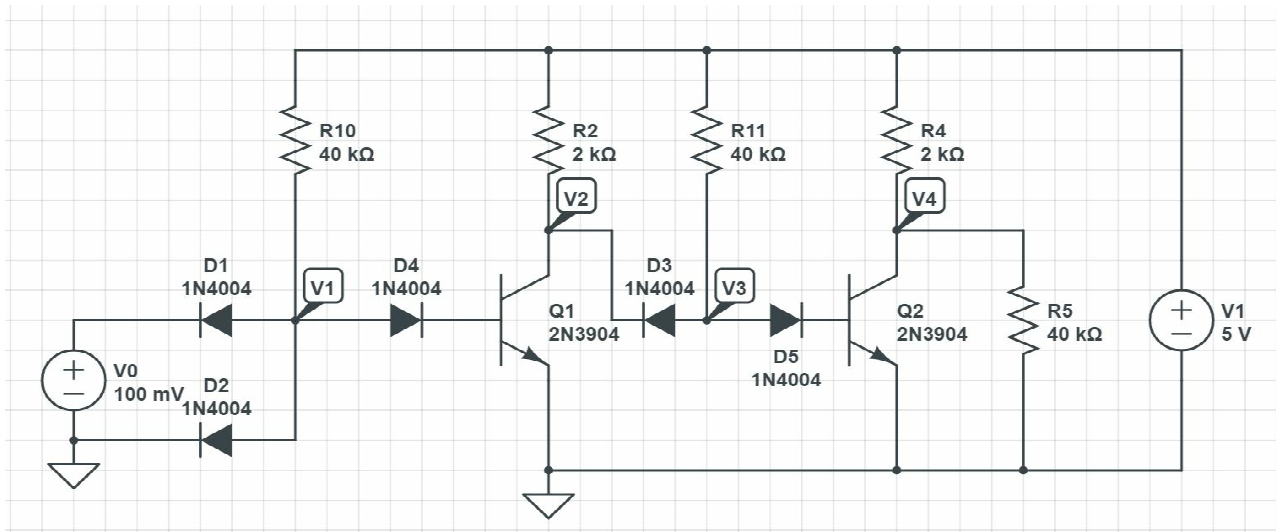


5) Simulate this circuit in CircuitLab to verify your answers

	V1	V2	V3	V4
calculated	0.700 V	5.000 V	1.400 V	0.200 V
simulted	0.526 V	5.000 V	1.211 V	0.060 V

Answers are close

- The voltage drop across a diode isn't exactly 0.7V
- The voltage drop across a saturated transistor isn't exactly 0.2V



▼ DC

V(V1)	526.2 mV		
V(V2)	5.000 V		
V(V3)	1.211 V		
V(V4)	60.39 mV		

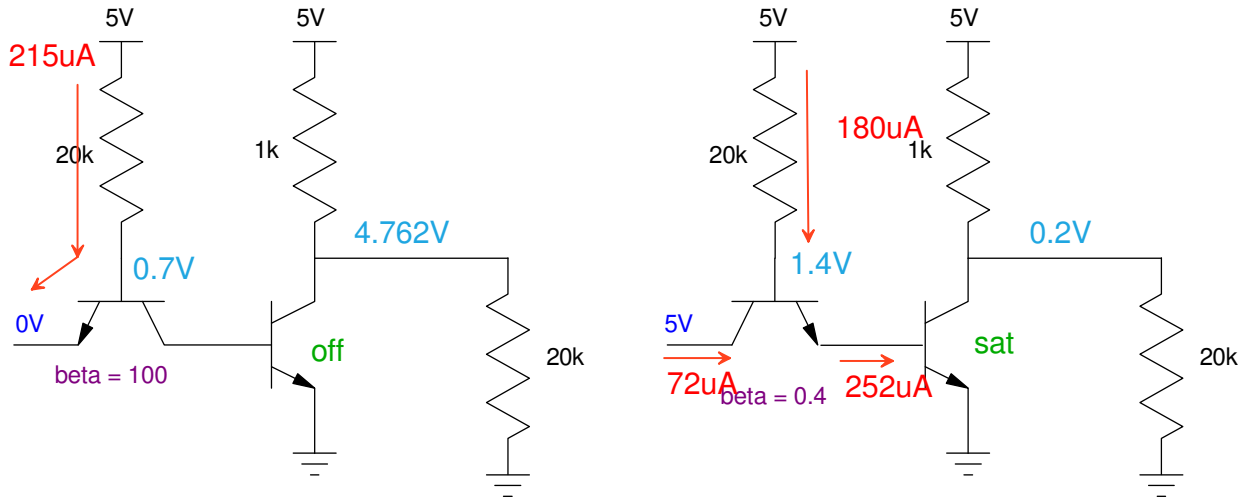
[+ Add Expression](#)

Export Results...

[Run DC Solver](#)

## TTL Logic

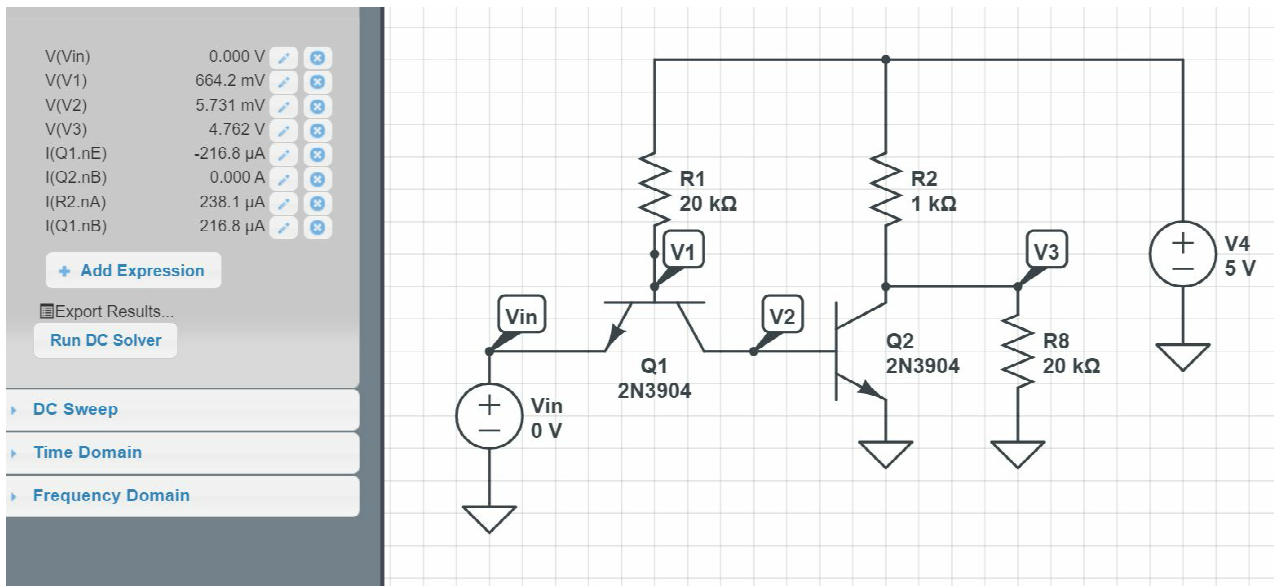
6) Determine the voltages for the following TTL inverter. Assume 3904 transistors.



7) Simulate these circuits in CircuitLab to verify your answers

$V_{in} = 0V$

	V1	V3	I(vin)	I(Q2.b)
Calculated	0.7000 V	4.762 V	-215 uA	0
Simulated	0.6642 V	4.762 V	-218.8 uA	0



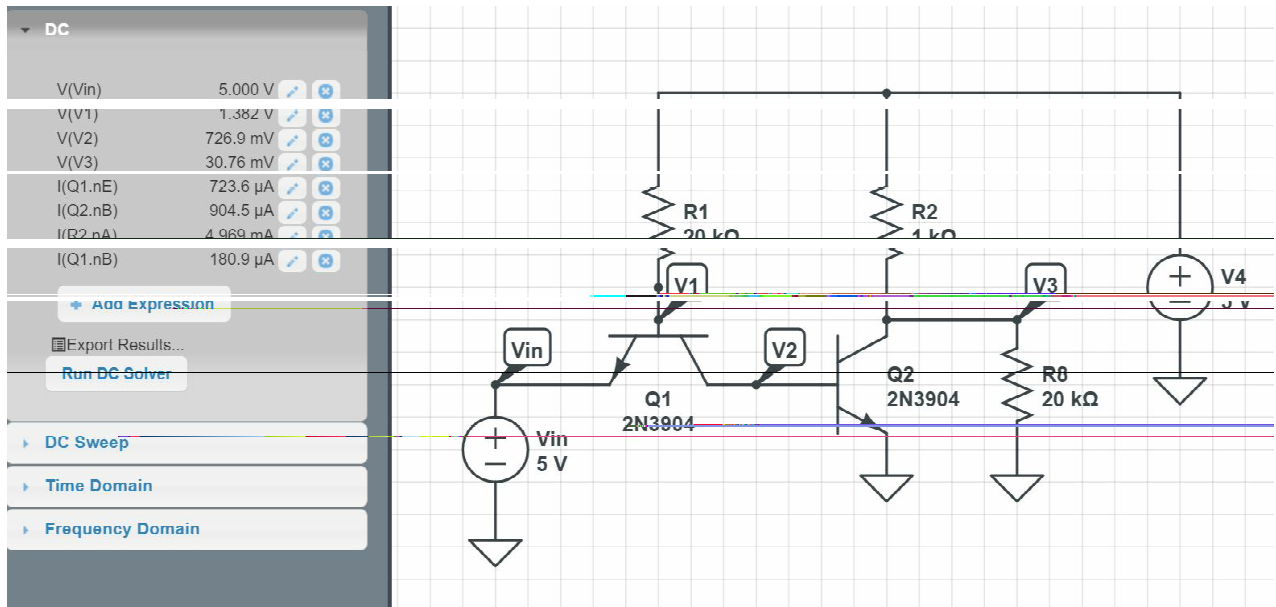
Vin = 5V

	V1	V3	I(vin)	I(Q2.b)
Calculated	1.400 V	0.2000 V	72uA	252uA
Simulated	1.382 V	0.0376 V	723.6uA	904.5uA

note: The current gain of Q1 when used backwards is actually

$$\beta = \left( \frac{I_c}{I_b} \right) = \left( \frac{723.6\mu A}{180.9\mu A} \right) = 4.00$$

while calculations assumed it to be 0.4





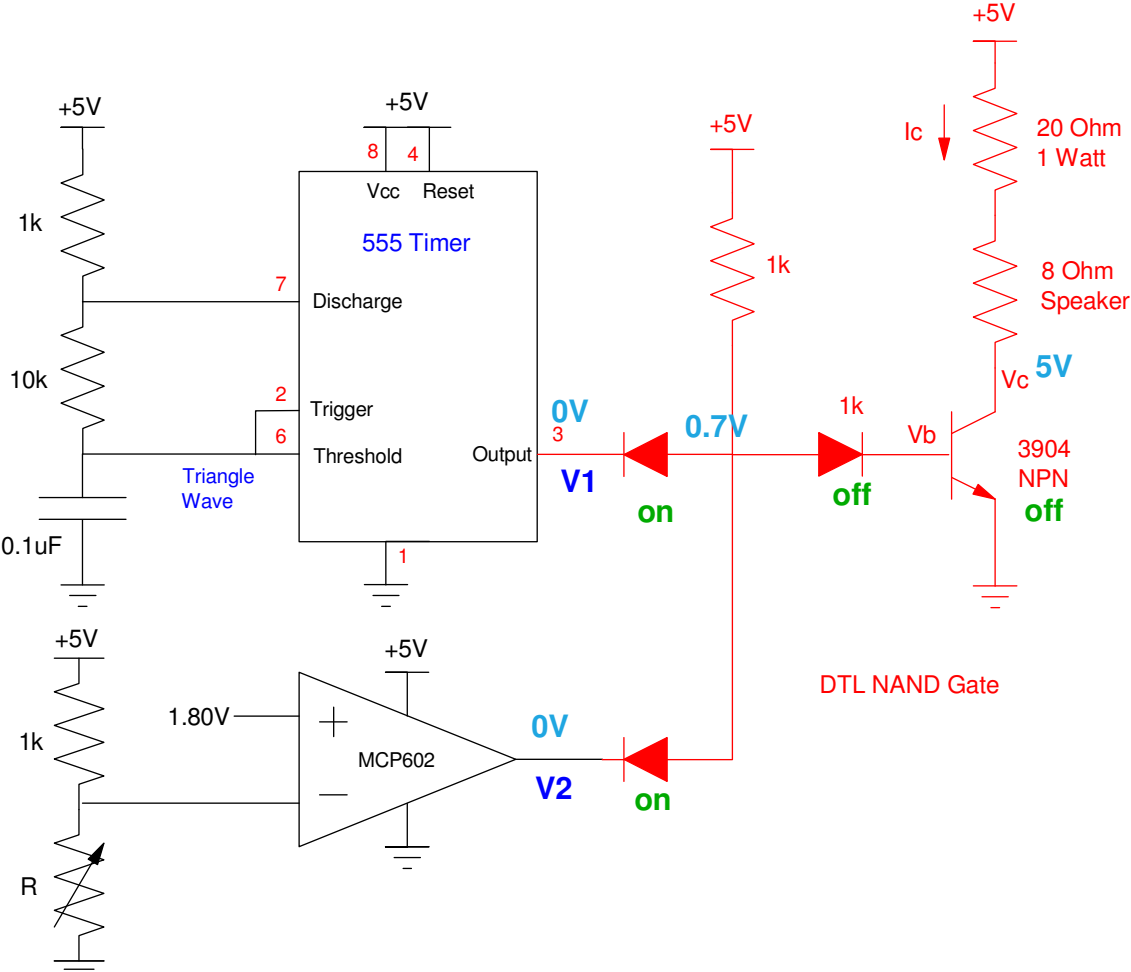
# Temperature Alarm using DTL Logic

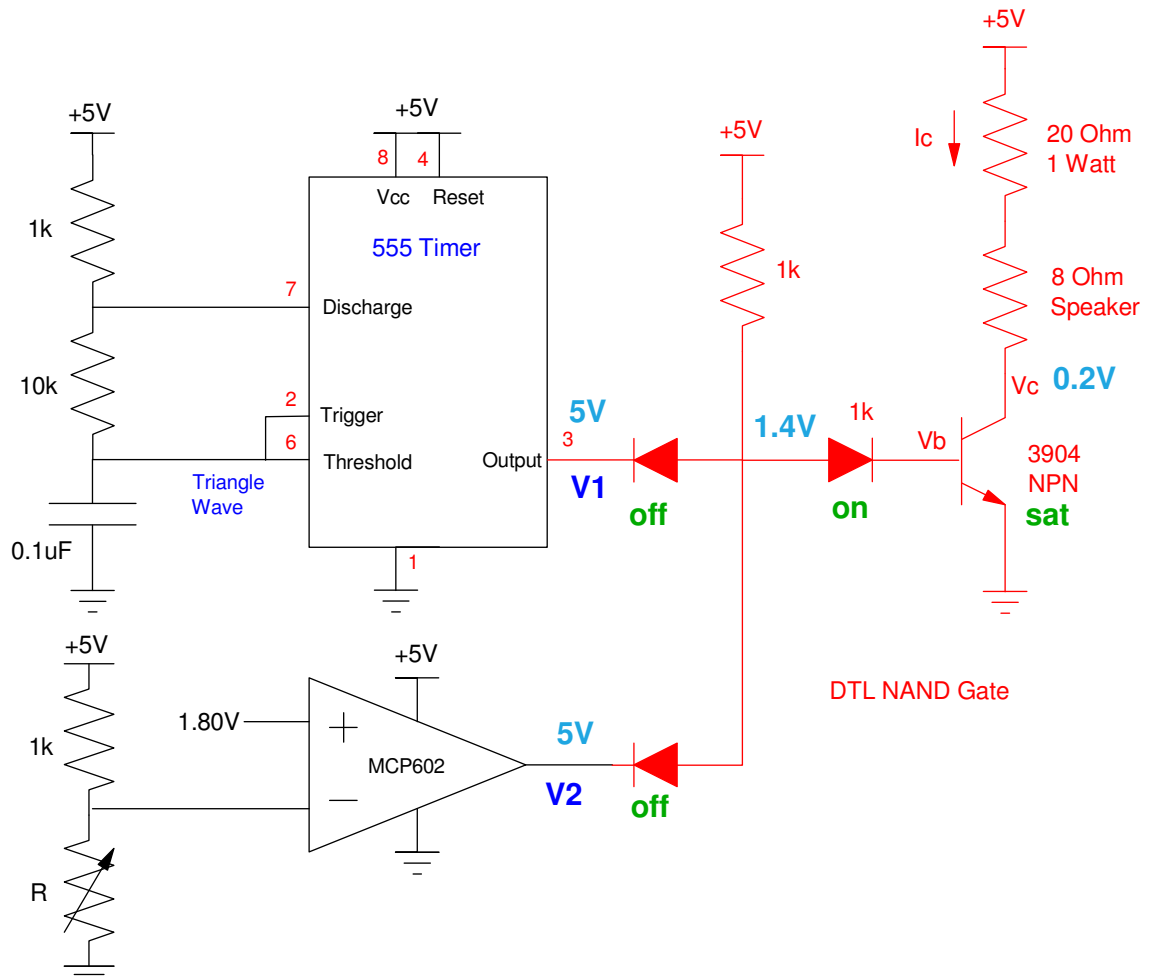
The circuit below uses a DTL NAND gate to drive the speaker when

- The 555 timer outputs 5V, and
- The comparitor outputs 5V,.

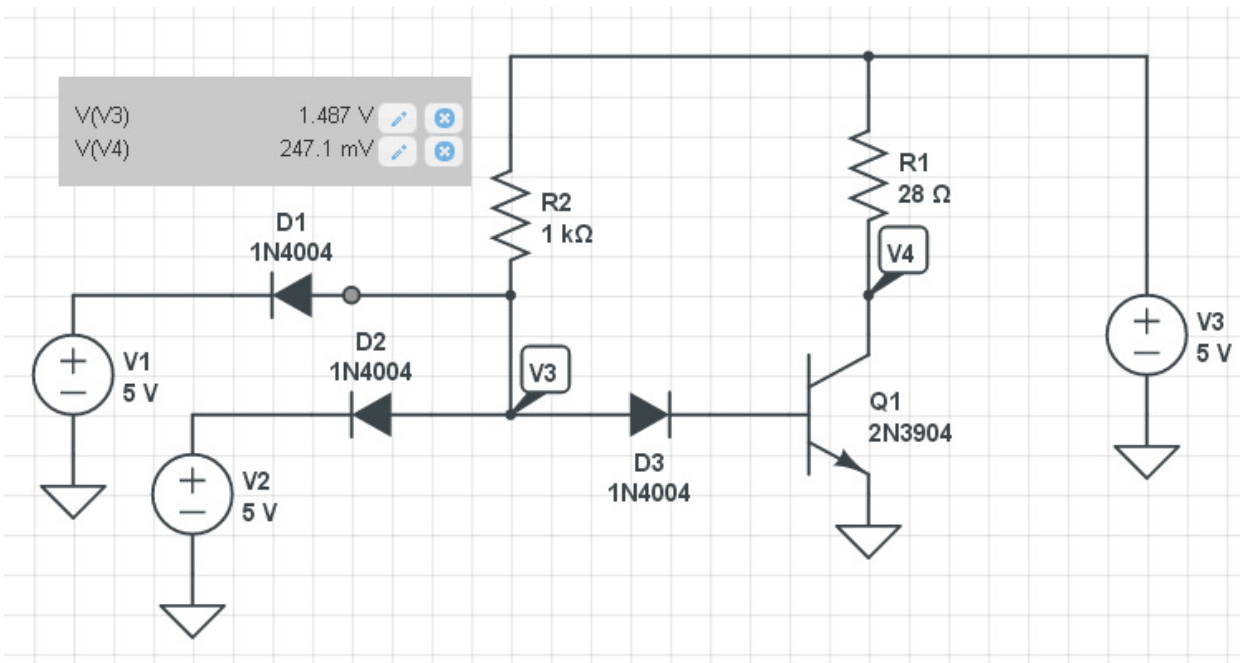
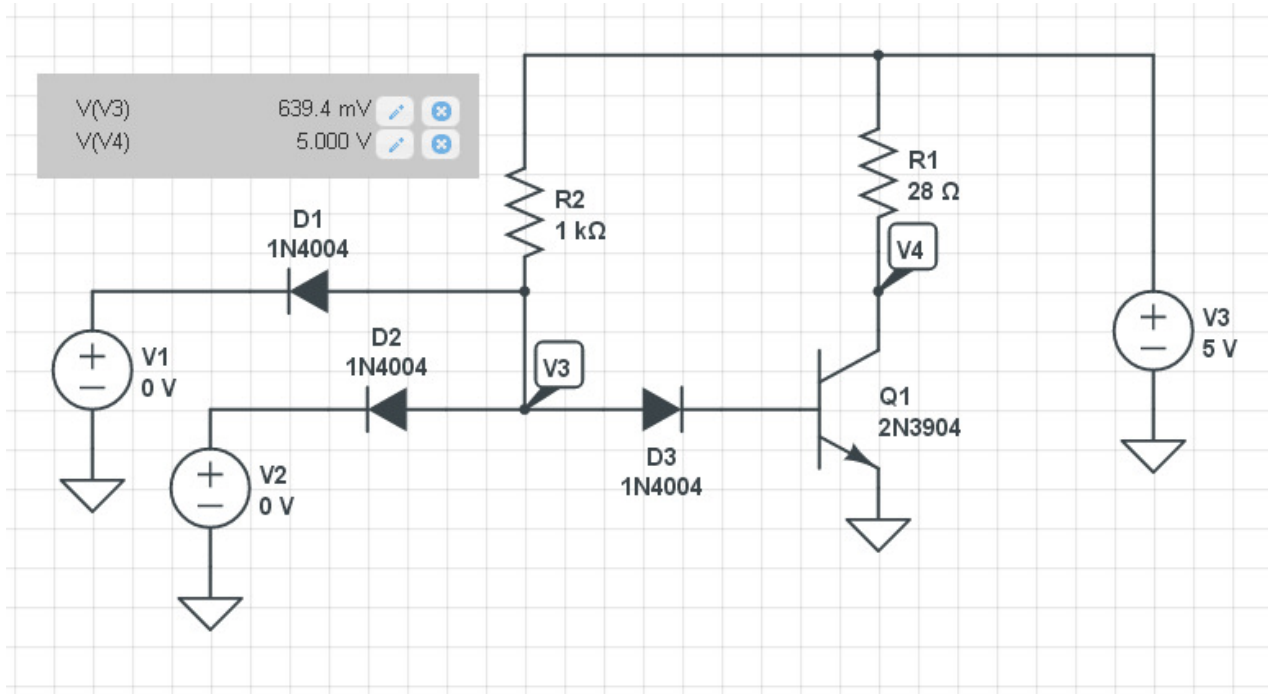
8) Determine the voltages when

- $V1 = V2 = 0V$
- $V1 = V2 = 5V$
- $V1 = 0V, V2 = 5V$



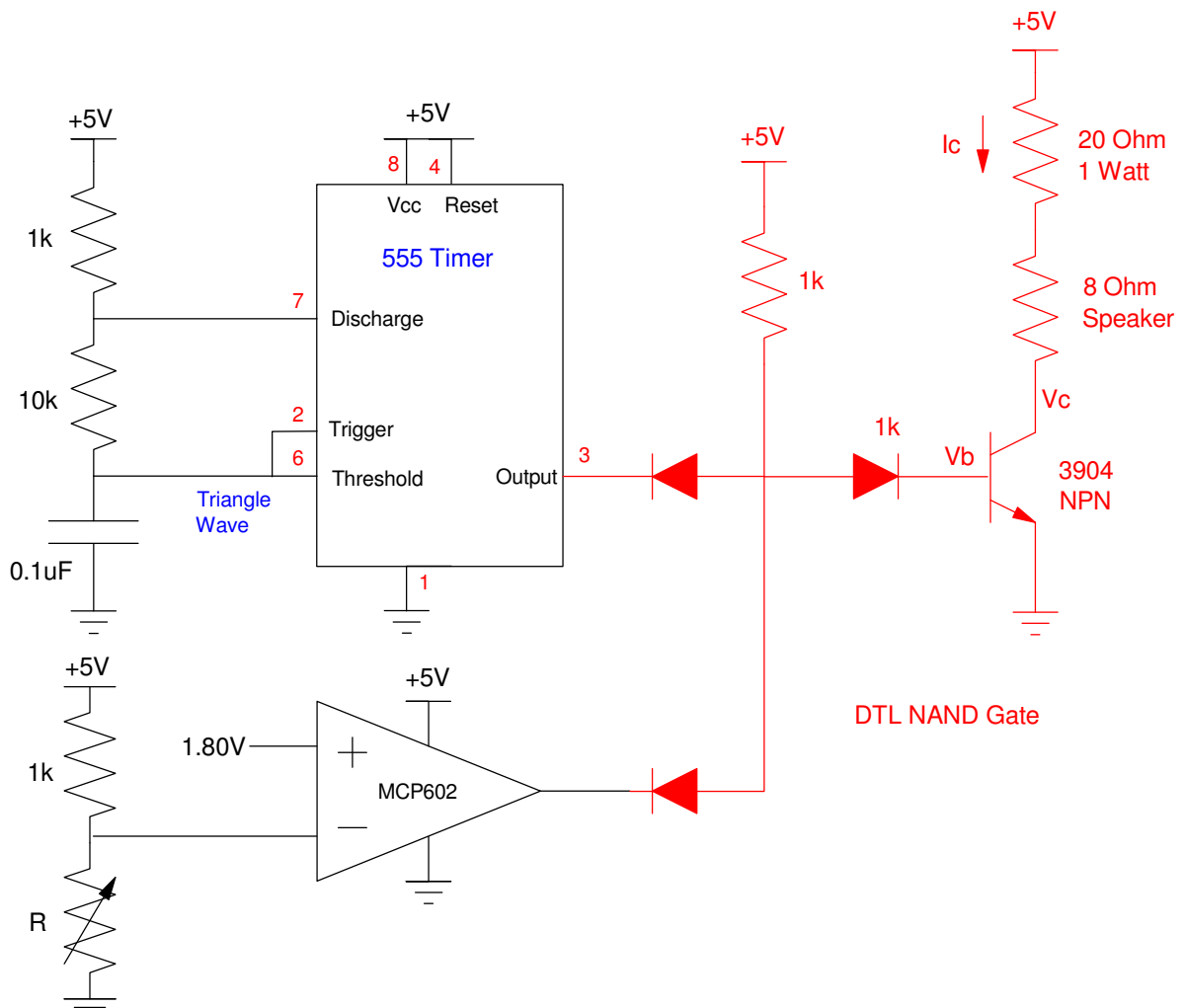
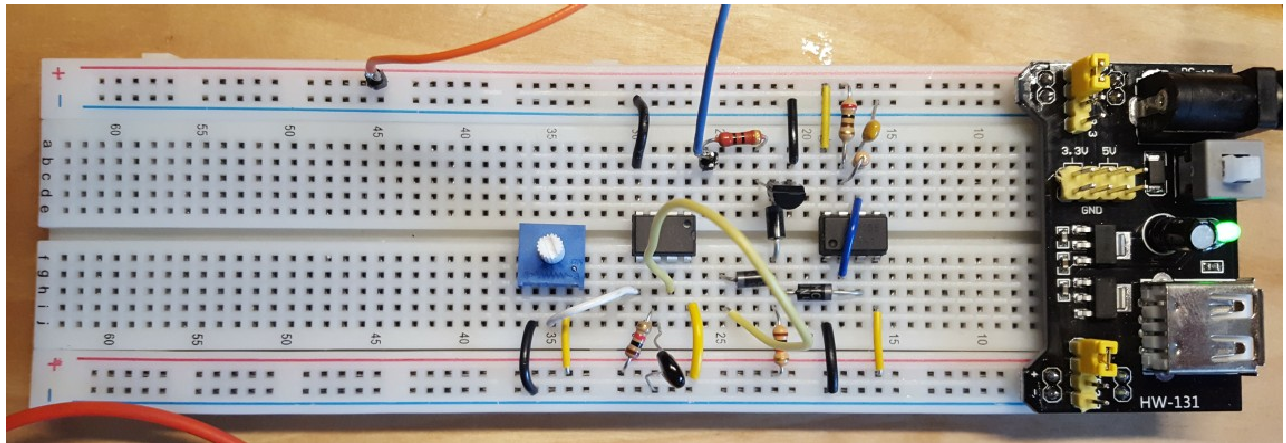


9) Verify your design using CircuitLab.



**Lab: 10) (20pt):** Verify your design in hardware (build and test the circuit with your lab kit).

- note: Use a potentiometer to simulate the temperature sensor.



- The 555 timer from homework set #5 for V1, and
- Connecting the comparator from homework set #5 for V2

Verify that

- The speaker turns on when  $T > T_{on}$  and
- The speaker turns off when  $T < T_{on}$

Setting the comparator to turn on at 1.80V

- Speaker turns on when  $V_r < 1.80V$
- Speaker turns off when  $V_r > 1.83V$

