ECE 320 - Homework #8

Comparitors, Schmitt Triggers, DTL Logic. Due Monday, October 16th, 2017

Assume a temperature sensor has the following lux / temperature relationship

$$R = 1000 \cdot \exp\left(\frac{3903}{T} - \frac{3903}{298}\right)\ \Omega$$

where T is the temperature in degrees C.

Comparitors

1) Design a circuit to turn on a heater if the temperature drops below 5C:

- Vo = 0V when T > 5C
- Vo = 10V when T < 5C

At 5C

- T = 278 Kelvin
- R = 3318 Ohms

Assume a voltage divider with a 3300 Ohm resistor

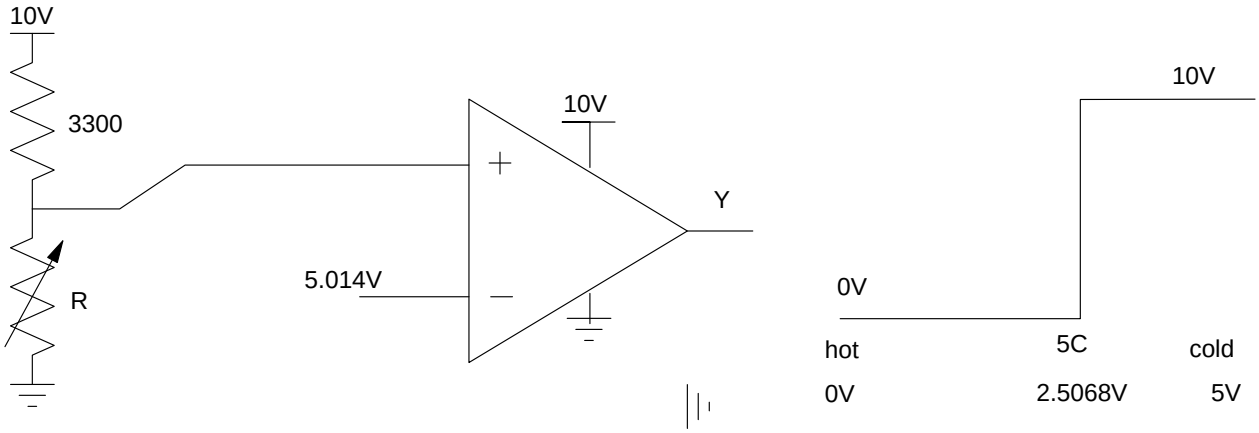
$$V = \left(\frac{3318}{3318+3300}\right)10V = 5.014V$$

Switch at 5.014V.

For the +/- input

- Vo = 10V
  - as T gets smaller
  - as R gets bigger
  - as Vin gets bigger

Connect to the + input: the output is large when the input is large

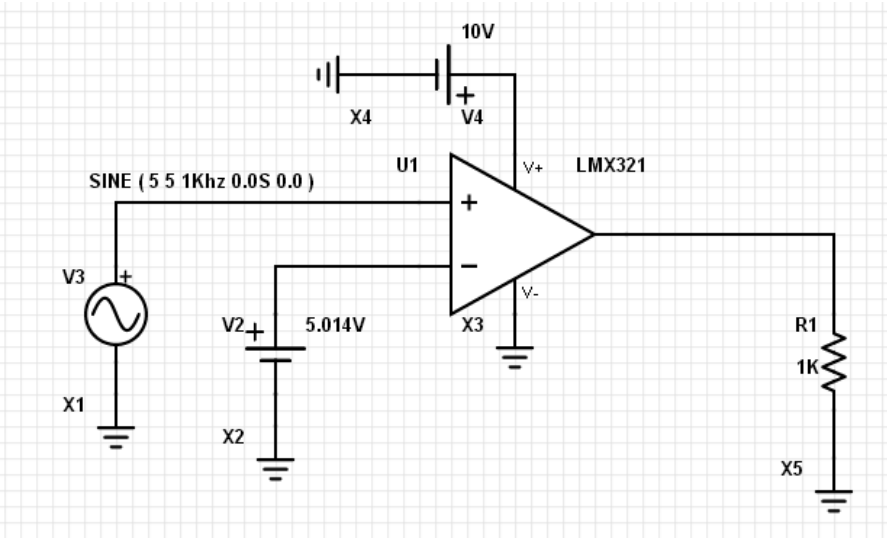


PartSim Smiulation (not required for homework - unless you do this for part of your term project)

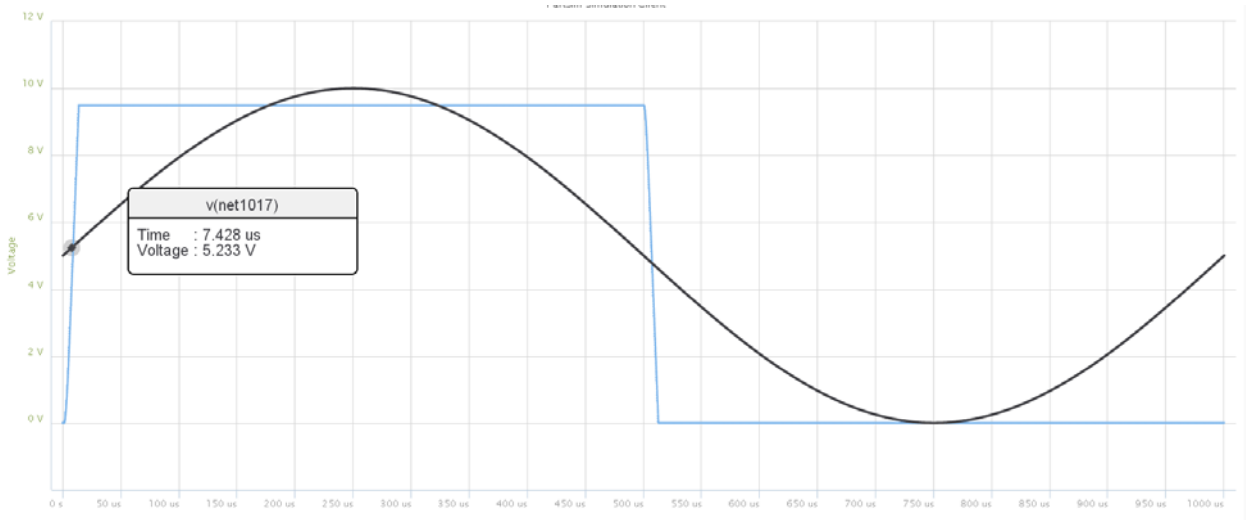
Goal: Verify that the output of the comparitor

- Turns on at 5.014V
- Turns off at 5.014V
- Logic 1 is 10V +/- 1V when under load (1k Ohm load of 10mA draw)

Circuit:



Transient Simulation (1ms since the input is 1kHz)



	Switch from Low to High		Switch from High to Low	
	Vin	Vout: "High"	Vin	Vout: "Low"
Expected (calc)	5.014V	10.0V	5.014V	0.0V
Simulated	5.233V	9.487V	4.899V	0.003V
Measured (lab)	-	-	-	-
Error	0.219V	0.513V	0.115V	0.003V

The voltages are off a little since the op-amp doesn't output 10.0V under load.

Schmitt Triggers

2) Design a circuit with hysteresis to turn on the heater:

- Vo = 10V when T < 5C
- Vo = 0V when T > 10C
- no change when 5C < T < 10C

Assume a 3300 Ohm resistor in a voltage divider again.

At 5C (Vo goes high)

- T = 278 Kelvin
- R = 3318 Ohms
- Vin = 5.014 Volts

At 10C (Vo goes low)

- T = 283 Kelvin
- R = 2002 Ohms
- Vin = 3.776 Volts

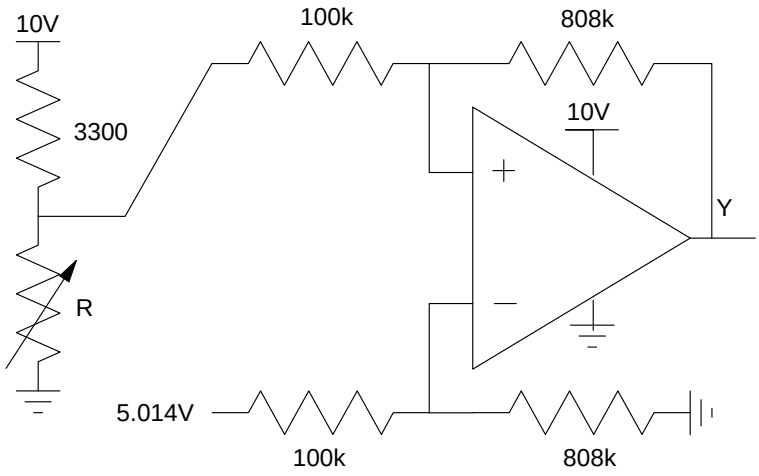
The output goes high when the input is large. Connect to the + input.

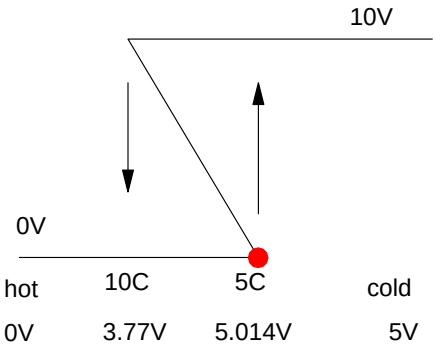
The gain needed is

$$gain = \left(\frac{\text{change in output}}{\text{change in inpu}}\right) = \left(\frac{10V–0V}{5.014V–3.776V}\right) = 8.08$$

Pick the resistors in an 8 : 1 ratio.

When the ouput is 0V, you switch at 5.014V. Make the offset 5.014V

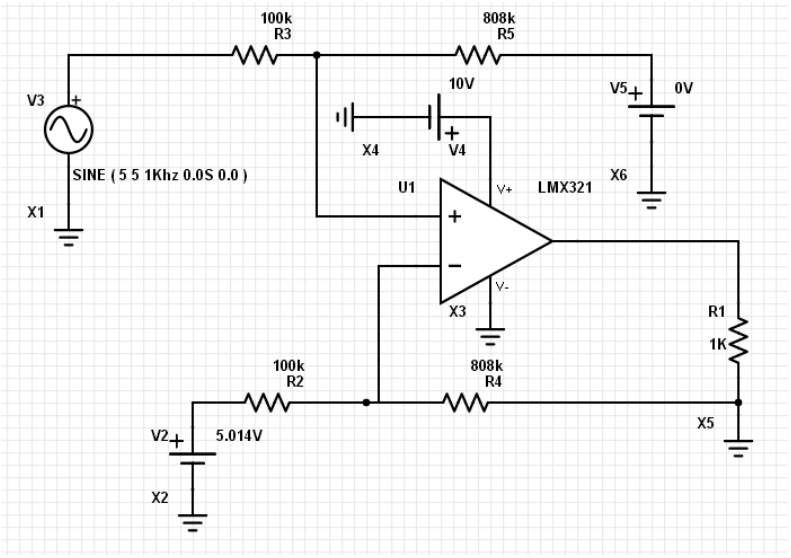




PartSim Simulation (again not necessary unless you're doing a Schmitt Trigger for your term project)

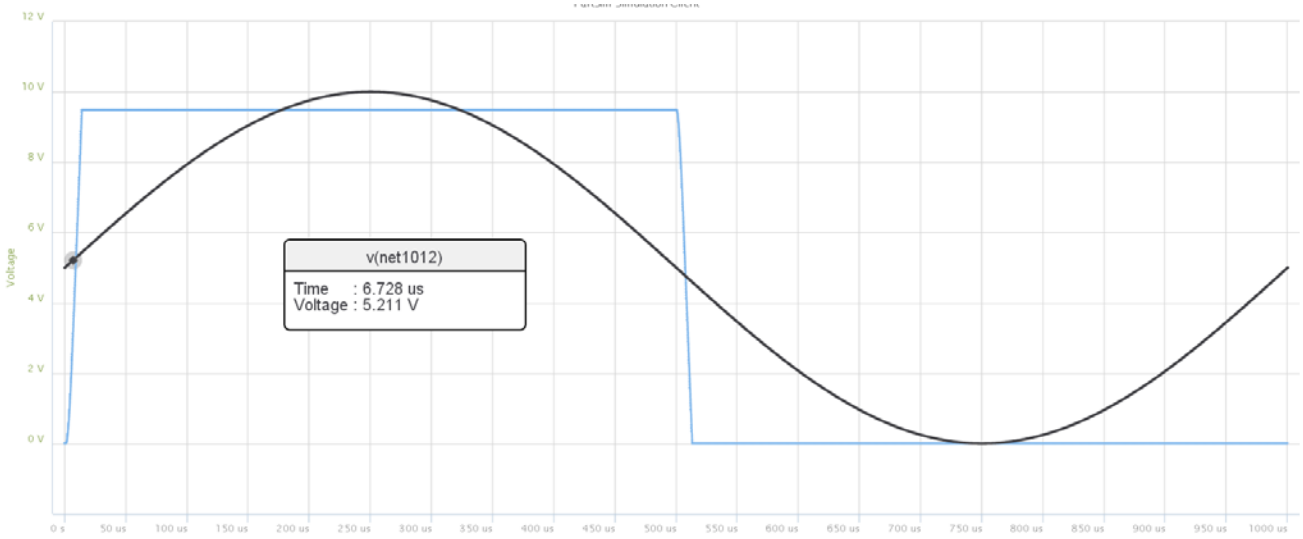
PartSim crashes for positive feedback. So, use the following instead.

When the output (V5) is 0V,

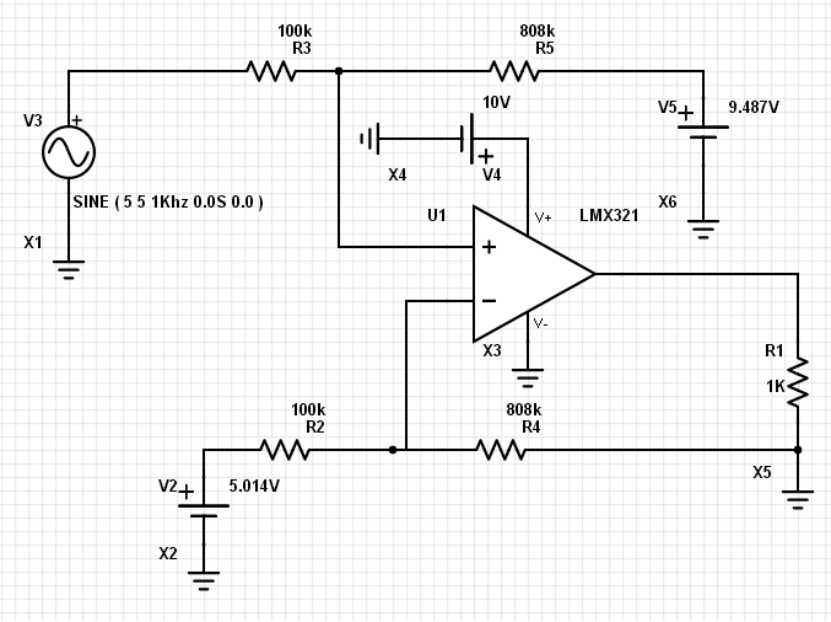


the output goes high

- At 5.211V (5.014V expected)
- 'High' is 9.487V (10V expected)

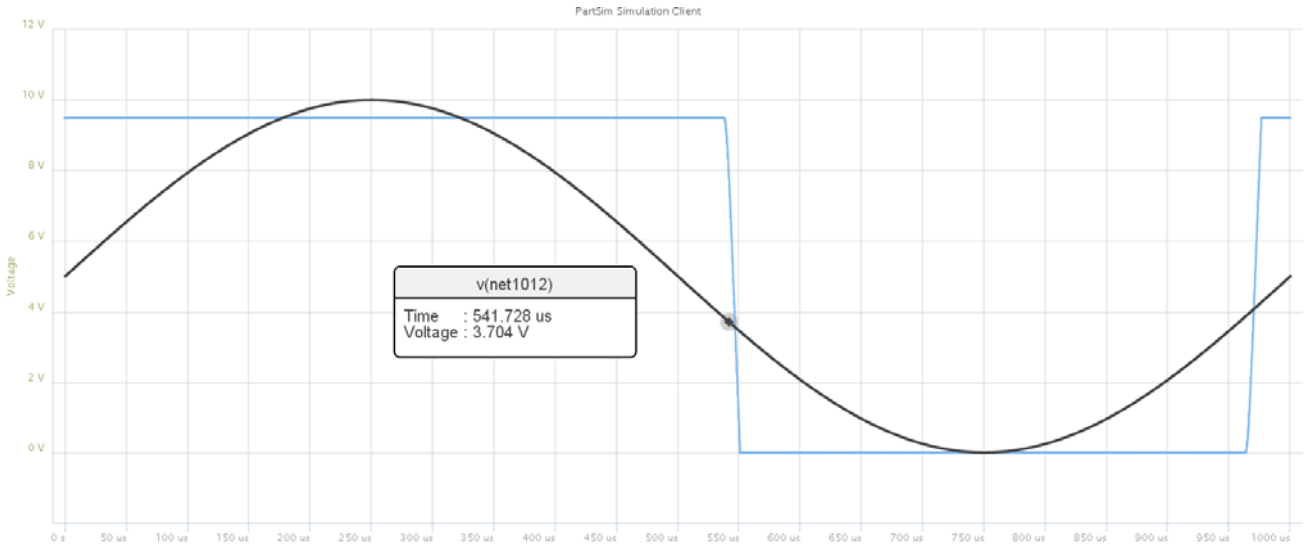


When the output is 9.487V (V5)



the output goes low

- At 3.704V (3.77V expected), and
- 'Low' is 3.8mV (0V expected)

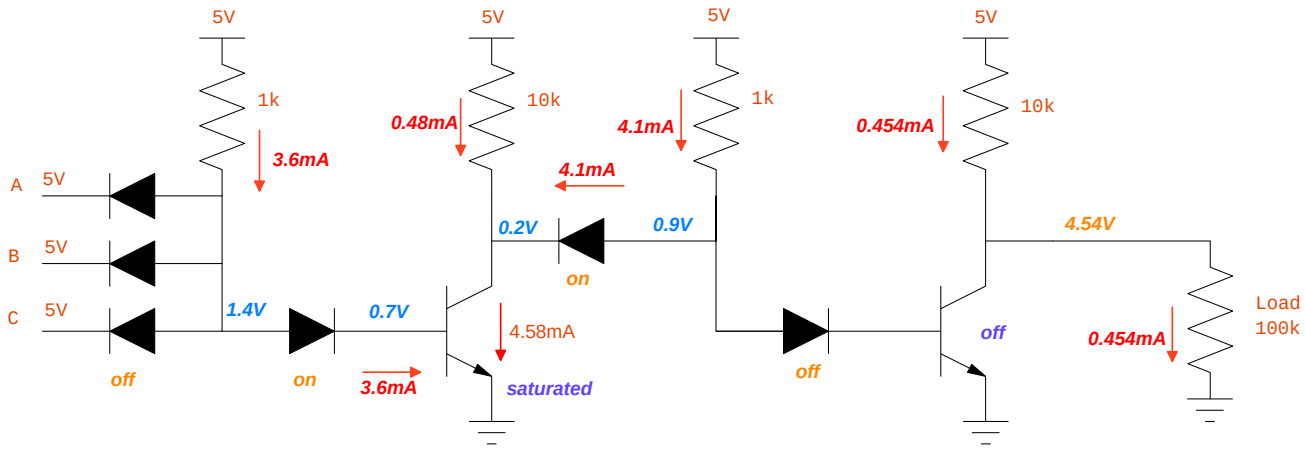


	Switch from Low to High		Switch from High to Low	
	Vin	Vout: "High"	Vin	Vout: "Low"
Expected (calc)	5.014V	10.0V	3.77V	0.0V
Simulated	5.211V	9.487V	3.704V	0.003V
Measured (Lab)	-	-	-	-
Error	0.219V	0.513V	0.115V	0.003V

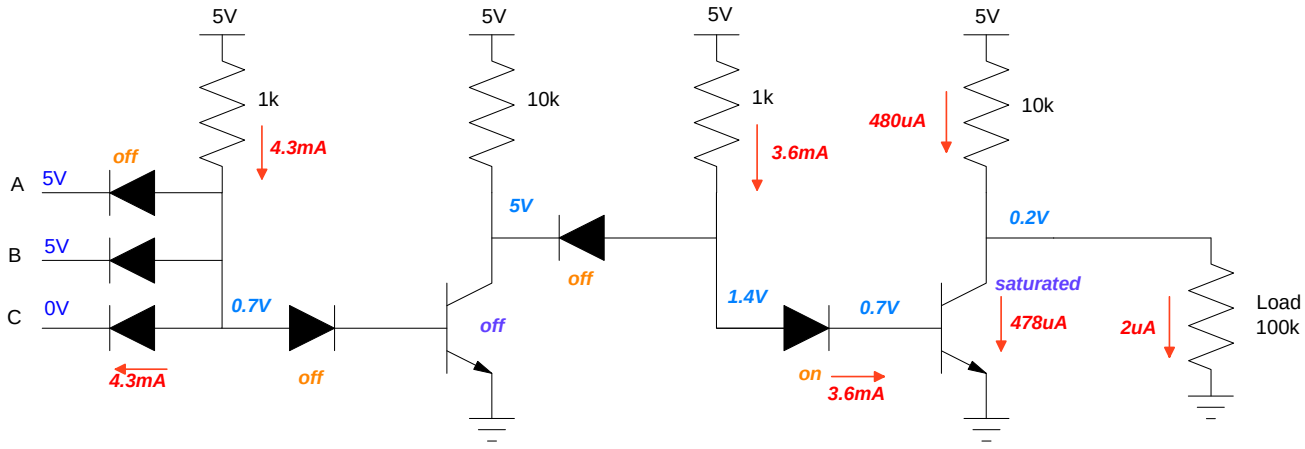
DTL Logic

3) Determine the voltages for the following DTL AND gate. Assume ideal diodes and transistors with

- Vbe -= 0.7V
- Vce(sat) = 0.2V
- β = 100



4) Determine the voltages for the following DRL AND gate



Lab: Term Project (part 1)

Design one part of your term project. Some suggestions are:

- Use a Schmitt Trigger (part 1) and an AC to DC converter (part 2) to drive a 12V DC motor when the temperature is below 5C.
- Use a DTL NAND gate (part 1) and an H-bridge (part 2) to drive a 10V DC motor forward when switch when $\overline{AB}$ is true, reverse when false
- Use an AC to DC converter (part 1) to convert 20Vp 60Hz AC to 20VDC, capable of 100mA (part 1), which then drives a DC to DC converter (part 2) which drives a DC motor from 0V to 20V.
- Other

5) Requirements: Specify the
   - Inputs
   - Outputs
   - How they relate

6) Analysis: Calculate the values of the components in your circuit to meet the requirements.

7) Simulation: Check your analysis using a circuit simulator, such as PartSim

8) Validation: Build your circuit and verify it meets the requirements