Lab 12 – Notes

Spring 2024

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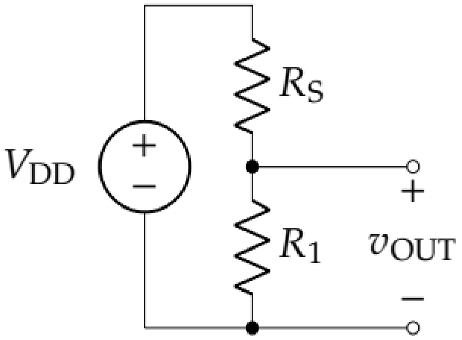
Task 1

Task 12.4.1: Temperature Sensor Characterization

1. *Construct* the circuit in figure 12.1 using the NTC as R_S, a 15 kΩ resistor as R_1, and a V_{DD} of 5 V.
2. *Measure* the output voltage of the sensor.
3. *Configure* the data logger in Waveforms to convert the measured voltage to temperature in Celsius or Fahrenheit. If using Scopy, configure the datalogger to record the voltage to a CSV in 0.1s increments then use Excel to calculate the temperature in Fahrenheit and Celsius.
4. *Measure* the ambient temperature. Compare the temperature sensor provided by your GTA. *Capture* a screenshot of the data logger graph in waveforms or generate a plot of temperature vs. time in Excel.
5. *Chill* the thermistor and measure the new output voltage and temperature.
6. *Pinch* the thermistor and measure the temperature of your fingers.



$$T = \frac{1}{\frac{1}{298} + \frac{1}{4050}\ln\left[\frac{15}{47}\left(\frac{5-v_{OUT}}{v_{OUT}}\right)\right]}$$

* You will need the Data Logger tool for this task.

** You will find the thermistor with the extra components that were given to you at the beginning of the semester.

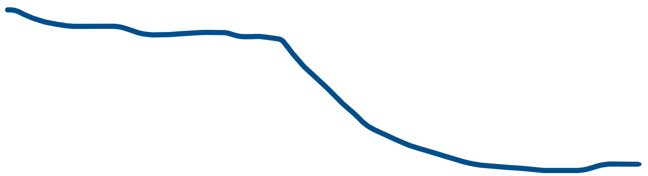
2. Measure the output DC voltage.

3. Use the data logger tool (you don't need to use the excel). Type the temperature relations to calculate the temp in Kelvin, Celsius, and Fahrenheit.

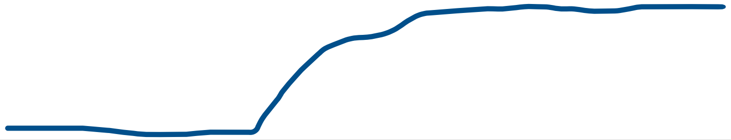
4. Assume the reference temp is the room temp (25 degree Celsius).

5/6. You need to show a screenshot for the variation of temp vs time starting from the room temperature till the temperature saturates

5. Chilling by touching ice:



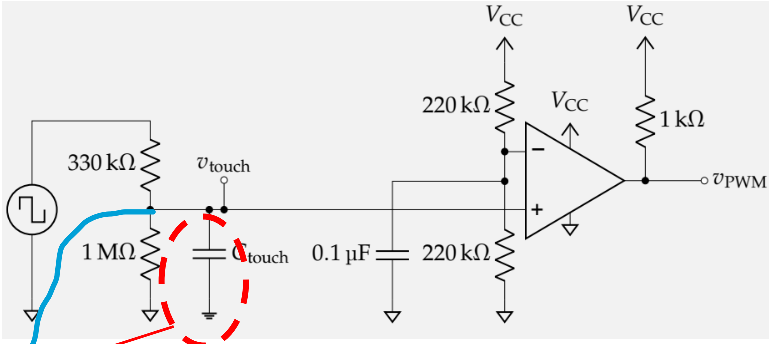
6. Pinching with your finger:



Task 2

Task 12.4.2: Capacitance Sensor Characterization

1. Build a capacitive touch sensor on your breadboard by placing 5 medium length wires in parallel with each other. All of the wires should be electrically connected.
2. *Build* the circuit in figure 12.6 using the LM339 or LM393 comparator and $V_{CC} = 5\,\text{V}$. Note that the oscilloscope probe will act as the $1\,\text{M}\Omega$ resistor! Don't connect the capacitor yet.
3. *Apply* a 20 kHz 0 V to 5 V signal as the input.
4. *Capture* a screenshot showing v_{PWM} and v_{touch} when the sensor is not yet attached.
5. *Connect* the sensor to the circuit and *record* the duty cycle of the output.
6. *Touch* the insulation of the touch sensor wires without touching any of the exposed metal. *Record* the new duty cycle.
7. *Comment* on the relationship between the duty cycle and the amount of pressure you use when pushing the wires.



1. Place the wires to be connecting between two horizontal lines of the breadboard to form C_{touch}. Please note that C_{touch} is NOT connected to gnd, it should be kept floating (this is a virtual gnd).

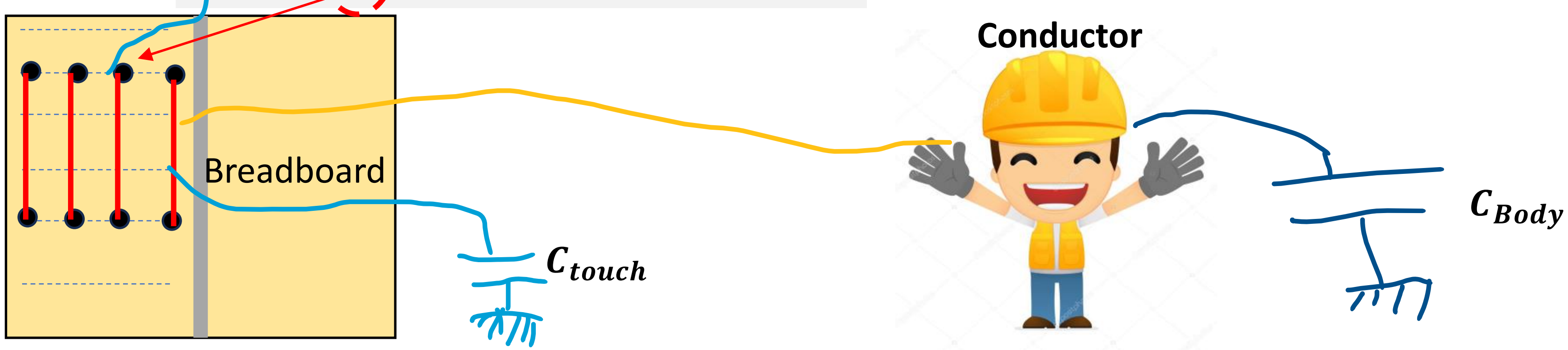
2. Do NOT add the 1 MΩ resistor, it's already the input impedance of the oscilloscope.

4. Take a screenshot + measure Duty cycle when C_{touch} (the wires) is not connected.

5. Repeat when C_{touch} (the wires) is connected.

6. Repeat after touching C_{touch} (touch the plastic of the wire not the metal).

7. Comment.



Task 3

Task 12.4.3: Capacitive touch board soldering

1. *Solder* the components to the provided capacitive touch board.
   a) First, solder all of the surface mount components on the bottom.
   b) Next, solder the through hole resistor and diode.
   c) Third, solder all of the LEDs.
   d) Fourth, solder the SIP resistor.
   e) Last, solder the headers.
2. *Verify* that everything is soldered correctly with your instructor.
3. *Set* a 150 mA current limit on the power supply.
4. *Apply* 3.3 V to the power supply input on the board.
5. *Verify* that the capacitive touch sensor works.
6. In your report, describe the process used to solder the board. Make sure to include all safety considerations for soldering including a discussion of the chemical safety of the solder and flux used. Your discussion should include potential concerns for the technician while soldering and the end user while using the product.

Watch the Demo video

In the report, all what you need to do is step 6.

Enjoy ☺

Task 4

Task 12.4.4: Extra Credit: Infrared Object Detector

This entire task is extra credit.

A phototransistor is a device that changes the current flowing through it based on the amount of light that it measures. Phototransistors can be fabricated to only respond to certain wavelengths of light. For example, the infrared phototransistor (PT204-6B) [4] measures infrared light at a wavelength of 940 nm.
We will build a system that detects an object by measuring reflected infrared light and outputs a binary signal that indicates if an object is too close.

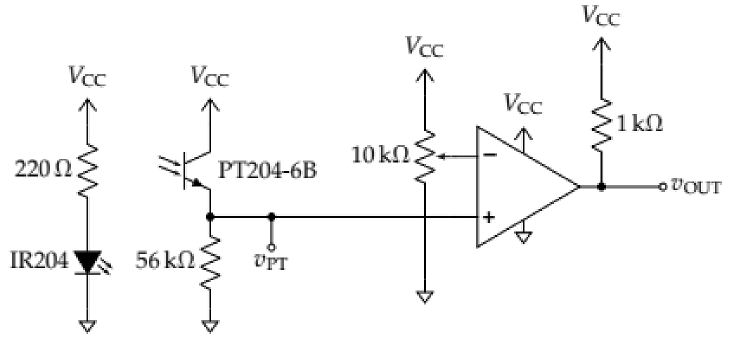
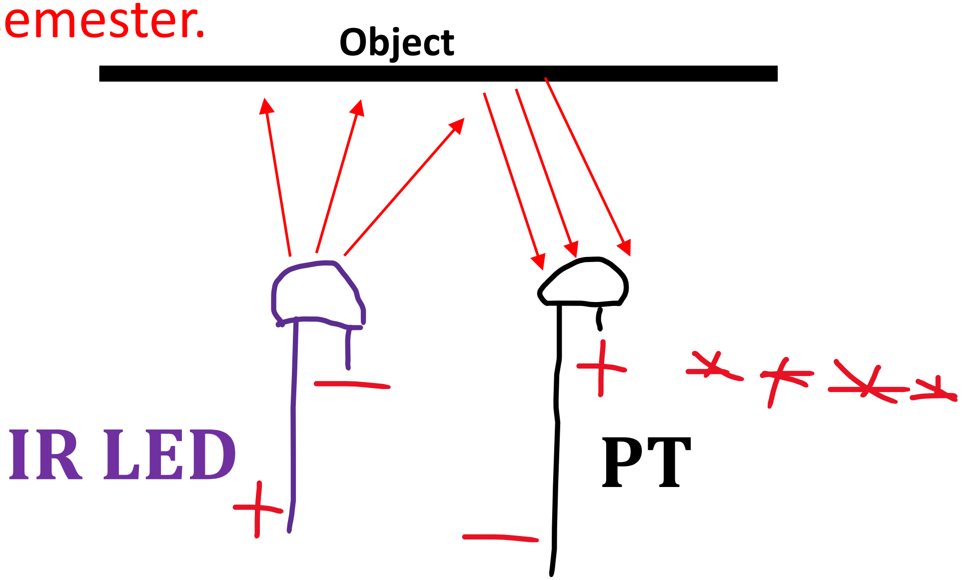


Figure 12.7: Active infrared proximity sensor

1. *Build* the circuit in figure 12.7 using the LM339 or LM393 comparator. Install the phototransistor and infrared LED next to each other on the breadboard and have them point in the same direction.
2. *Set* V_{CC} = 5 V and measure v_{PT}.
3. Hold your hand or a sheet of paper over the infrared LED and phototransistor. *Describe* the relationship between v_{PT} and the proximity of the object to the sensor.
4. *Record* the voltage of v_{PT} when your object is about 5 cm away.
5. *Adjust* the potentiometer to output this voltage to the negative comparator input.
6. *Record* the value of v_{OUT} when the object is farther than 5 cm and when the object is closer than 5 cm.
7. *Capture* an oscilloscope screenshot or data logger window showing both v_{PT} and v_{OUT} as an object crosses the object detection threshold.

* The entire task is extra credit.

** You will find the IR LED and the PT with the extra components that were given to you at the beginning of the semester.



1. The LED and PT should be close to each other, and both should be pointing upwards.

4. Place a sheet of paper above the sensor and measure the DC voltage at v_{PT} (x volts).

5. Adjust the potentiometer till you measure x volts at V-.

6/7. Measure and show screenshot for both v_{PT} and v_{OUT} showing when you cross the detection threshold many times. You can either use the data logger or the oscilloscope (use shift mode).