ELCT 201 – EE LABORATORY

RESISTIVE SENSORS

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21 SEPTEMBER 18, 2022

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ABSTRACT

For this lab, the function generator along with a DC power supply were utilized to deliver voltage to multiple circuits. The first two circuits were made up of a 10kΩ biasing resistor and either a photoconductor or a thermistor in series. The oscilloscope and digital multimeters were connected across the biasing resistor to measure the voltage's response to the sensing resistor. Voltage output measurements were made for both power supplies and for both types of sensing resistors. Later in the project, an operation amplifier, a potentiometer, and a light emitting diode in series with a 1kΩ resistor were added to the original circuit setup. This lab introduced new components such as biasing and sensing resistors, operational amplifiers, and potentiometers and how they can affect a circuit.

INTRODUCTION AND CIRCUIT SETUP

The first circuit used in this lab is shown in Figure 1:

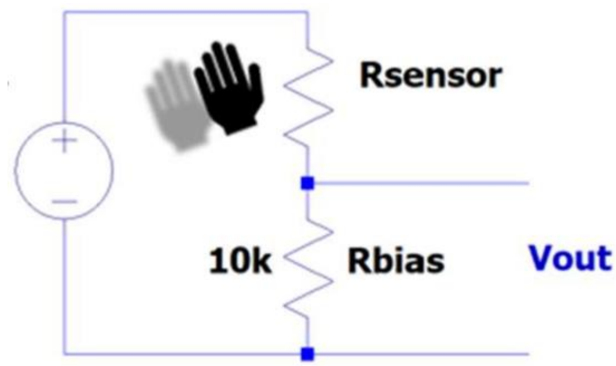

Figure 1: A photoconductor and a 10kΩ connected in series to a voltage source.

This circuit was first connected to a DC voltage source with 5V amplitude, and then connected to the waveform generator to deliver a 5 V_{rms} sine wave with a 10kHz frequency. Measurements of the voltage were taken when the photoconductor was covered and uncovered for both the DC and AC voltage sources. With the voltage generator still connected, measurements of the current flowing through the biasing resistor were also taken.

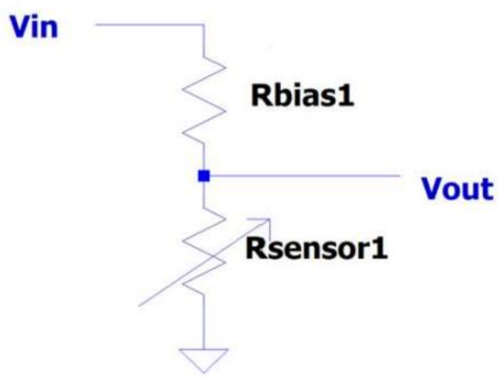

Figure 2: Reverse of Figure 1, with the photoconductor being placed after the biasing resistor.

The circuit was then changed to represent Figure 2, as the photoconductor and biasing resistor were switched. Voltage measurements for both 5V DC and a 5 V_{rms} AC voltage with a 10kHz frequency were taken.

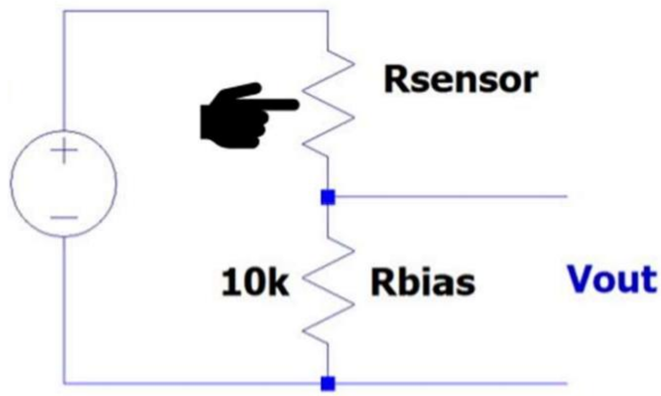

Figure 3: A thermistor and a 10kΩ connected in series to a DC voltage source.

The photoconductor used for Figure 1 and Figure 2 was then replaced with a thermistor and connected to a 5V DC voltage source. The thermistor was placed before the biasing resistor (similar to Figure 1) and measurements of the voltage at room temperature and body temperature were recorded.

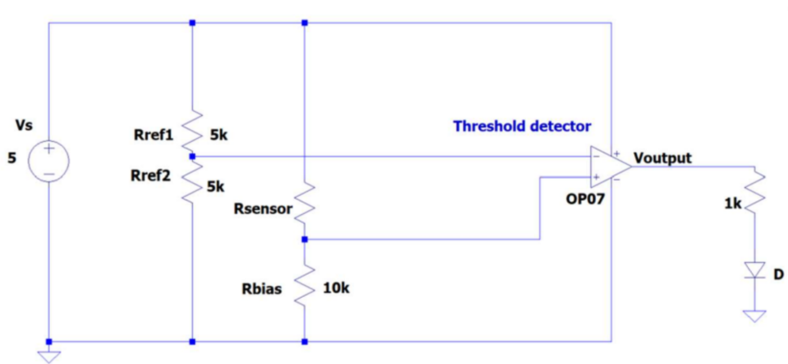

Figure 4: Simplest circuit (Figure 1 or Figure 3), with sensor and opamp both powered by single 5V source.

The final circuit utilized a potentiometer, and an operation amplifier with a 1kΩ resistor and LED connected to its output. Initially the photoconductor was connected as the sensing resistor, and if the photoconductor was covered it would increase the voltage sent to the op-amp, thus illuminating the LED. Lastly, the photoconductor was replaced by the thermistor. This caused the LED to illuminate if the temperature of the thermistor was increased.

DATA COLLECTED AND OSCILLISCOPE MEAUREMENTS

Sensor Status	Vout (V)
Covered	0.235
Uncovered	1.641

Table 1: Photoconductor voltage response to 5V DC in Figure 1 configuration

The data from Table 1 shows how the photoconductor can change the output voltage when connected to a 5V DC voltage source. When the sensor was covered the voltage decreased and when it was uncovered it increased.

Sensor Status	Vout (V)	Current (μA)
Covered	0.074	8.9
Uncovered	1.551	207.9

Table 2: Photoconductor voltage and current response to 5 V_{rms} *in Figure 1 configuration*

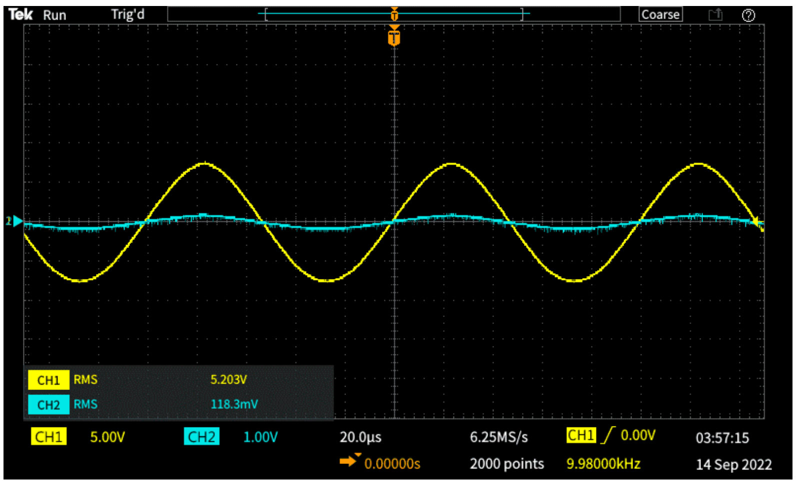

Figure 5: Oscilloscope screenshot of covered photoconductor in Figure 1 configuration

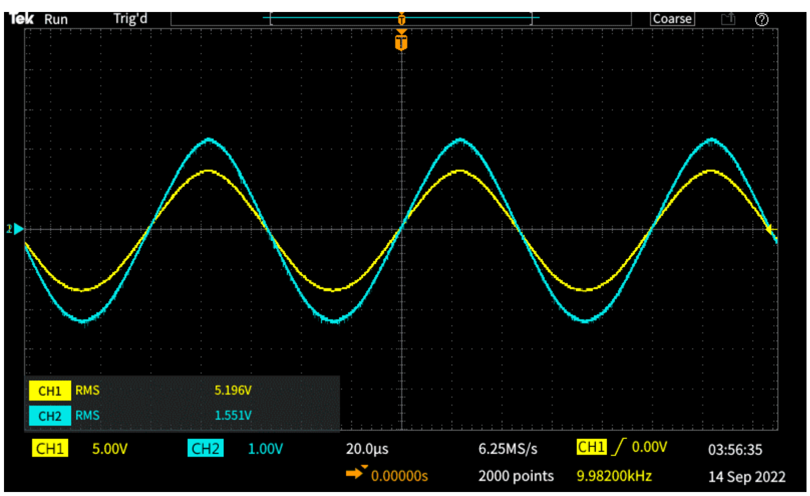

Figure 6: Oscilloscope screenshot of uncovered photoconductor in Figure 1 configuration

Table 2's data along with Figure 5 and Figure 6 indicate that the voltage and current both respond in the same manner to how much light is presented to the photoconductor. In fact, the voltage wave appears to be almost flat in Figure 5.

Sensor Status	Vout (V)
Covered	4.922
Uncovered	3.491

Table 3: Photoconductor voltage and current response to 5 V_{rms} *in Figure 2 configuration*

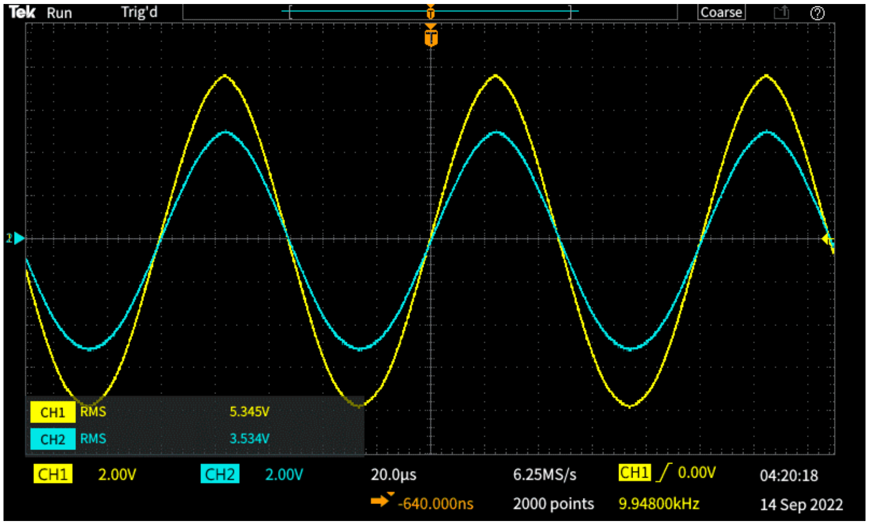

Figure 7: Oscilloscope screenshot of uncovered photoconductor in Figure 2 configuration

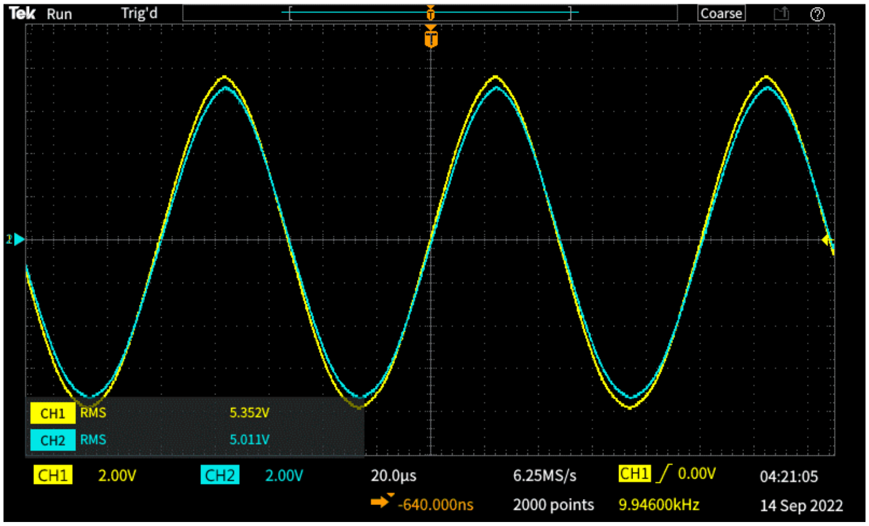

Figure 8: Oscilloscope screenshot of covered photoconductor in Figure 2 configuration

Table 3 expresses an inverse relationship of voltage and sensor status compared to Table 1 and Table 2. This is due to alternate placement of the biasing and sensing resistors (illustrated in Figure 2). The output voltages are generally larger than the output voltages in the previous configuration.

Sensor Status	Vout (V)
Room Temp.	2.376
Body Temp.	3.066

Table 4: Thermistor voltage response to 5V DC in Figure 3 configuration

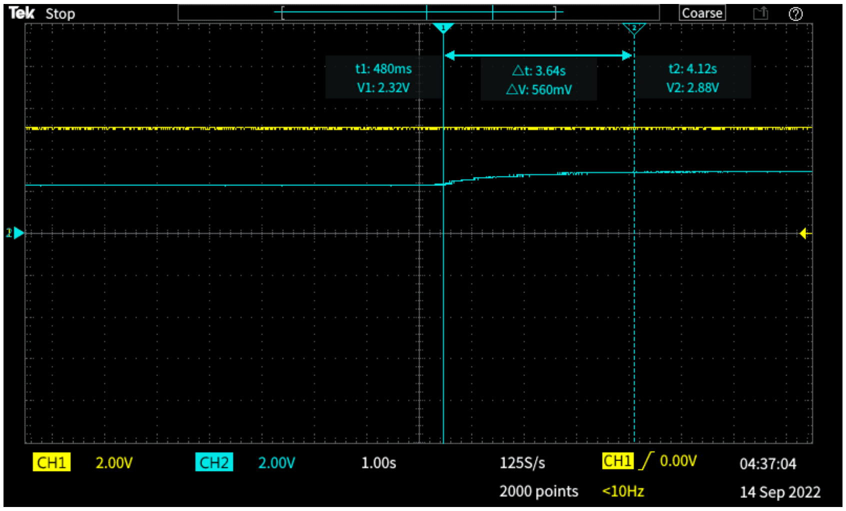

Figure 9: Oscilloscope screenshot of thermistor being raised to body temperature in Figure 3 configuration

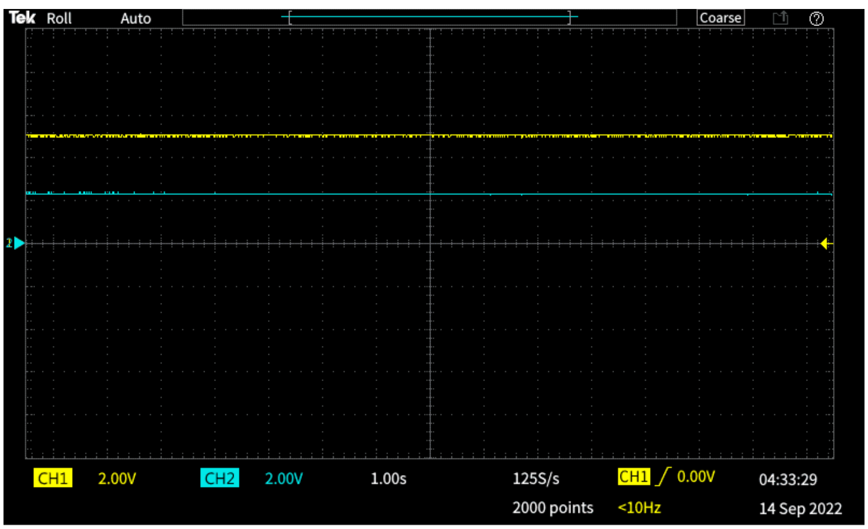

Figure 10: Oscilloscope screenshot of thermistor at room temperature in Figure 3 configuration

The thermistor increases the output voltage when the temperature is increased and decreases the output voltage when the temperature decreases. Figure 9 shows that the thermistor gradually increases the output voltage as it begins to heat up until it reaches the body temperature. Unlike the photoconductor, the change in output voltage takes much more time to change as the temperature cannot be changed instantly.

PRELAB MEASUREMENTS

The prelab instructions asked us to estimate the voltages output from the thermistor and the photoconductor. The datasheets for both components were estimated by the values presented upon their datasheets. Calculations were needed for both configurations of the circuit (Figure 1 and Figure 2) as the placement of the biasing resistor would affect the output voltage. The following equation was used to find the output voltage of the circuit:

$$V_{out} = V_{in} * \frac{R_2}{R_1+R_2} \qquad \text{Equation 1}$$

The following table shows the results from the prelab calculations:

Circuit	Temperature	Vin (V)	R1 (Ohm)	R2 (Ohm)	Vout (V)
Figure 1	Room Temp.	5	12488	10000	2.23
	Body Temp.	5	5330	10000	3.262
	Light	Vin (V)	R1 (Ohm)	R2 (Ohm)	Vout (V)
	10 lux	5	15000	10000	2
	500 lux	5	200	10000	4.902
	Temperature	Vin (V)	R1 (Ohm)	R2 (Ohm)	Vout (V)
Figure 2	Room Temp.	5	10000	12488	2.77
	Body Temp.	5	10000	5300	1.738
	Light	Vin (V)	R1 (Ohm)	R2 (Ohm)	Vout (V)
	10 lux	5	10000	15000	3
	500 lux	5	10000	200	0.098

Table 5: Prelab Output Voltage Calculations

In comparison, the results from Table 5 support my measurements from the lab. For example, the prelab output voltage calculations for the photoconductor behave in the same manner as the measured findings in Table 1 and Table 2.

CONCLUSIONS

This project was very helpful in introducing many new components such as sensors (the thermistor and photoconductor), operational amplifiers, and the potentiometer. Understanding how these components can affect a circuit will be very useful for future projects. Also, the relationship between the biasing resistor and the sensor was very influential in the magnitude of the output voltage. Generally, the output voltage was higher when in the Figure 1 configuration. Interestingly, the behavior of the sensor would change depending on the placement of the biasing and sensing resistors.