ECE 65 – Components and Circuits Lab

Lab 3 Report – Circuit Simulations

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Abstract

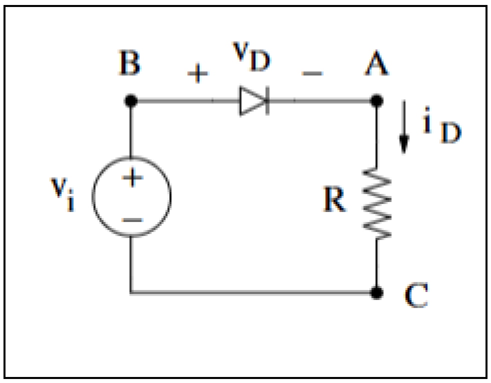
The purpose of this lab was to explore the functionality of diodes and their relationship with current and voltage. We conducted various experiments to analyze diode behavior in different circuit configurations. The first experiment involved a simple circuit consisting of an input voltage source and a diode. We then extended this experiment by incorporating an op-amp to investigate the diode's influence on circuit performance. In the second experiment, we utilized a Zener diode and implemented a circuit with a 10kΩ potentiometer. We recorded the output voltage as we varied the resistor value to observe the voltage regulation properties of the Zener diode. The results of these experiments aligned with our expectations, reinforcing our understanding of diode behavior and their integration into circuits.

Lab Exercise:

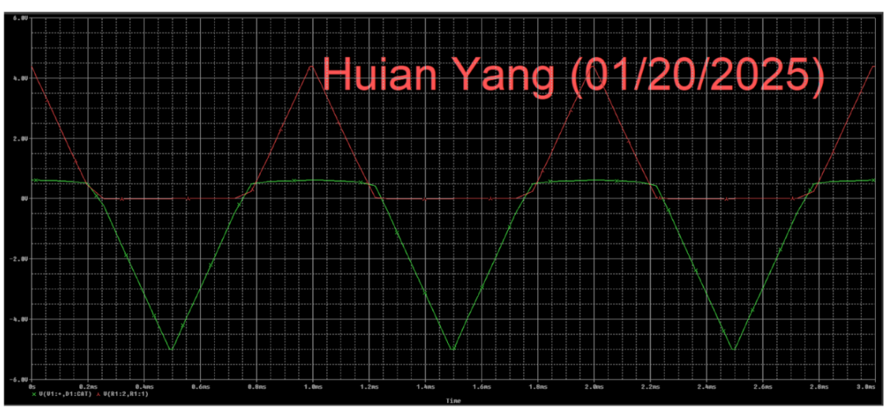
Experiment 1

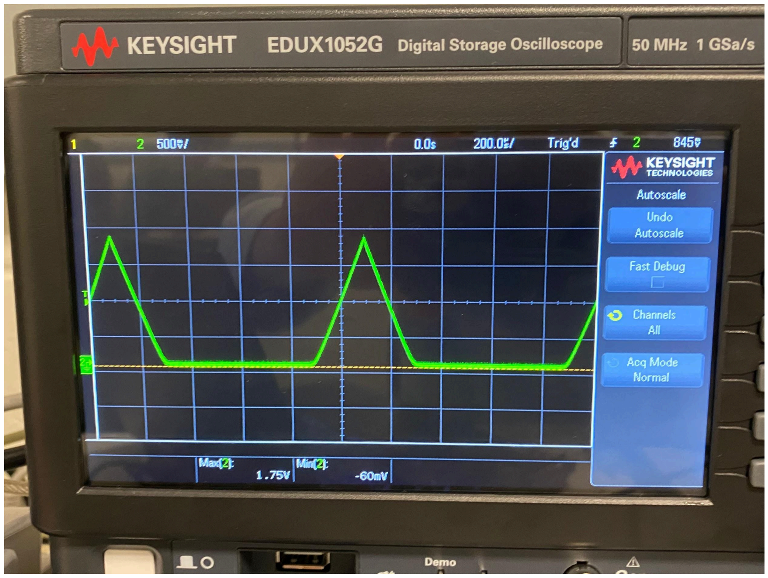
It turns out that the circuit of Fig 1 will not work in the lab, and we need a more complicated circuit.

To understand the reason, build the circuit of Fig. 1. Vi is supplied by the function generator and is a 1-kHz triangular wave with a peak to peak value of 10 V and a DC offset of zero (similar to simulation). The scope should be in its default mode of showing channel traces as functions of time.



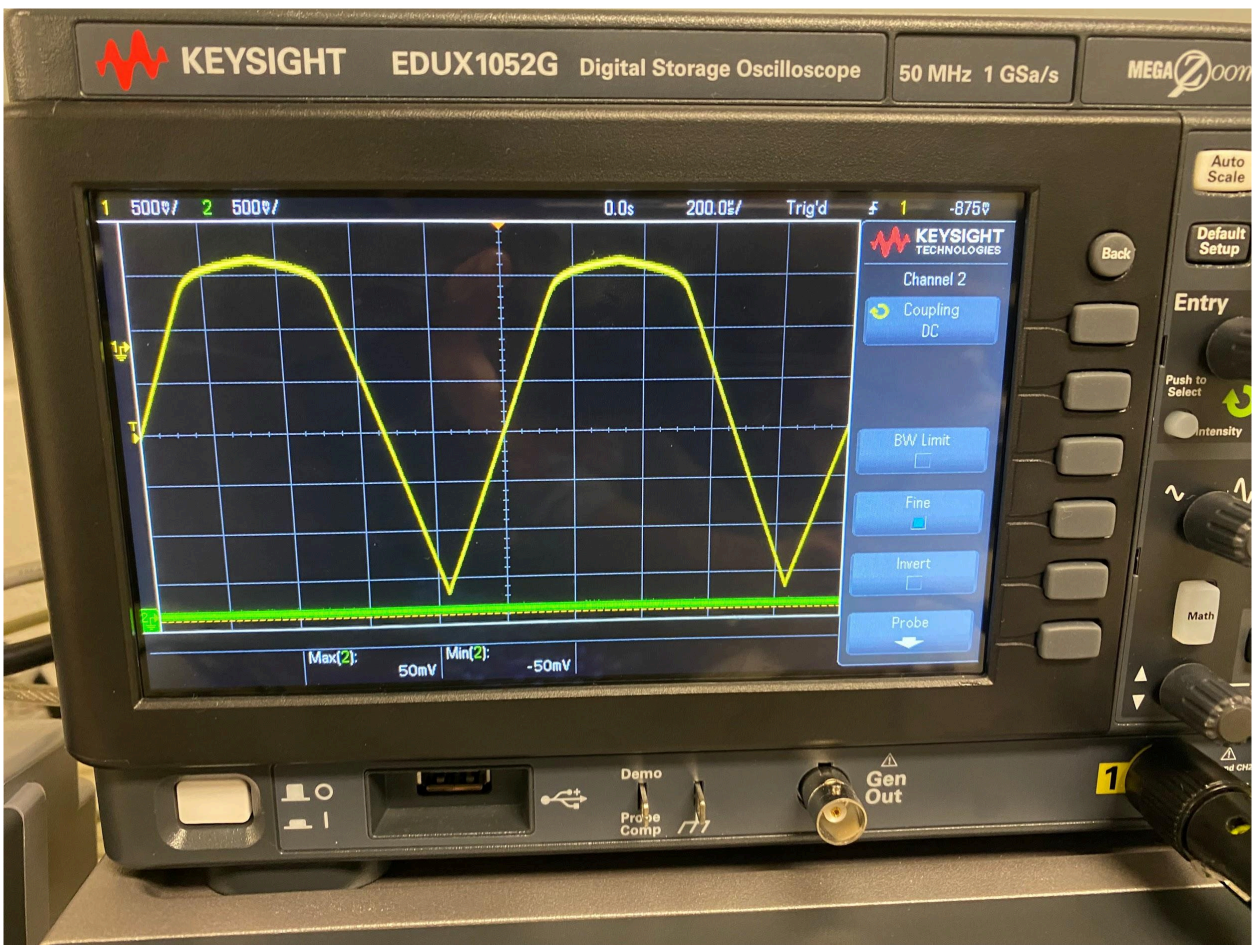
1. Use scope probe for channel 2 to view vR (i.e., attach the scope ground to point C and the probe to point A). Compare with your simulation.

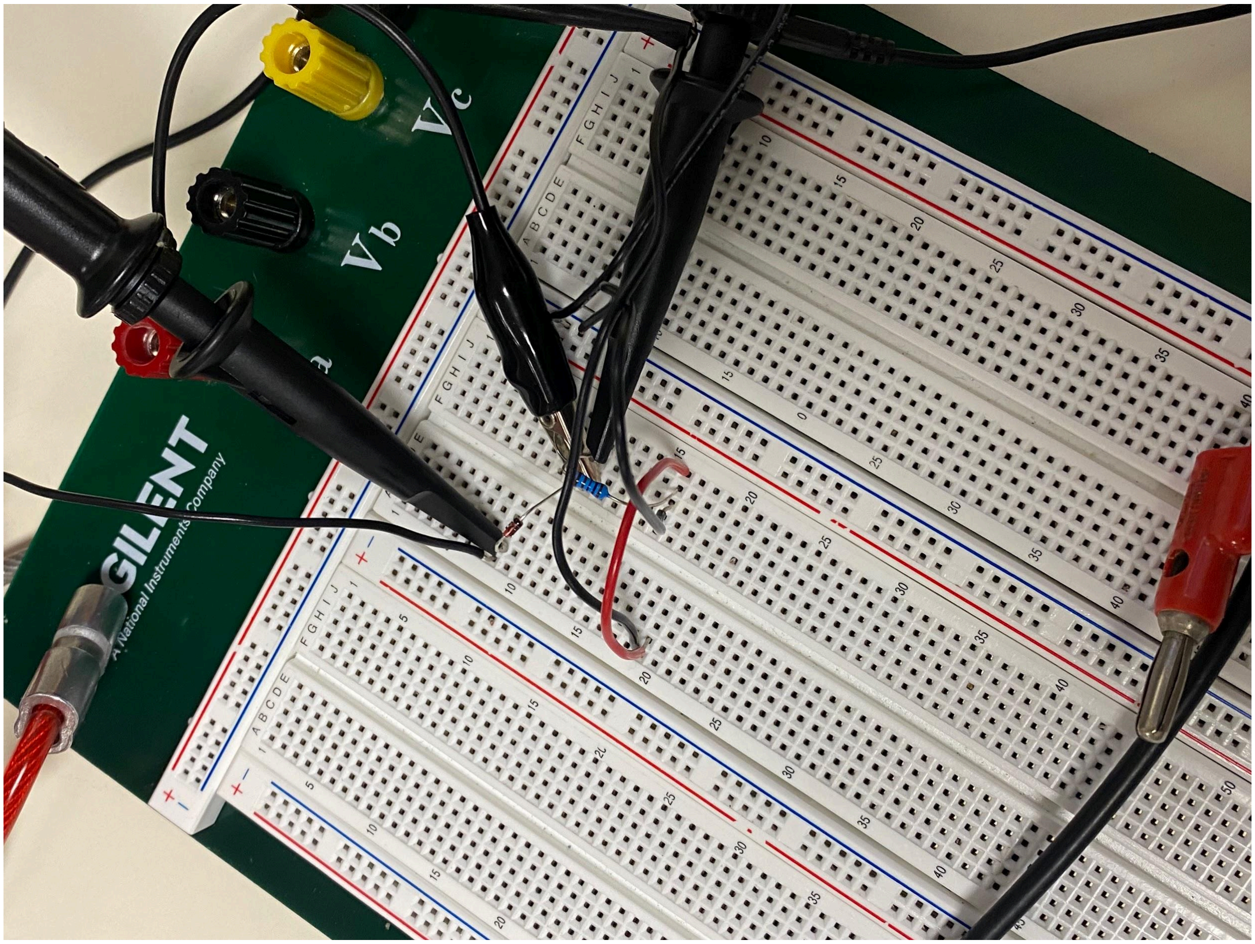




In real-life, vi shows as we expected from the simulation, however vD amounts to 0V.

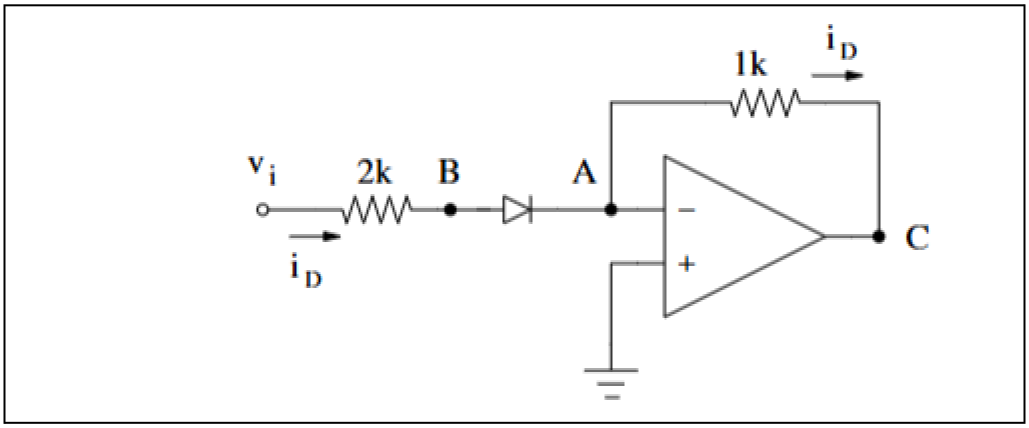
<u>2. Try to simultaneously read vD on channel 1 of the scope. What happens to the channel 2 trace? Explain why this setup does not work while the circuit simulator gives the correct answer.</u>

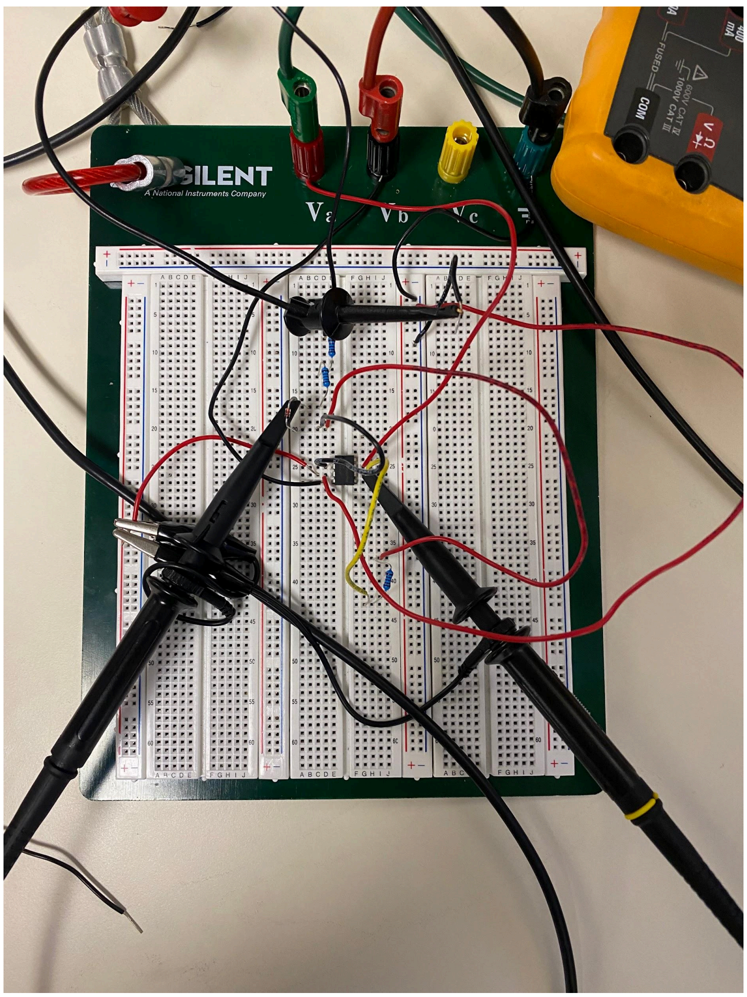


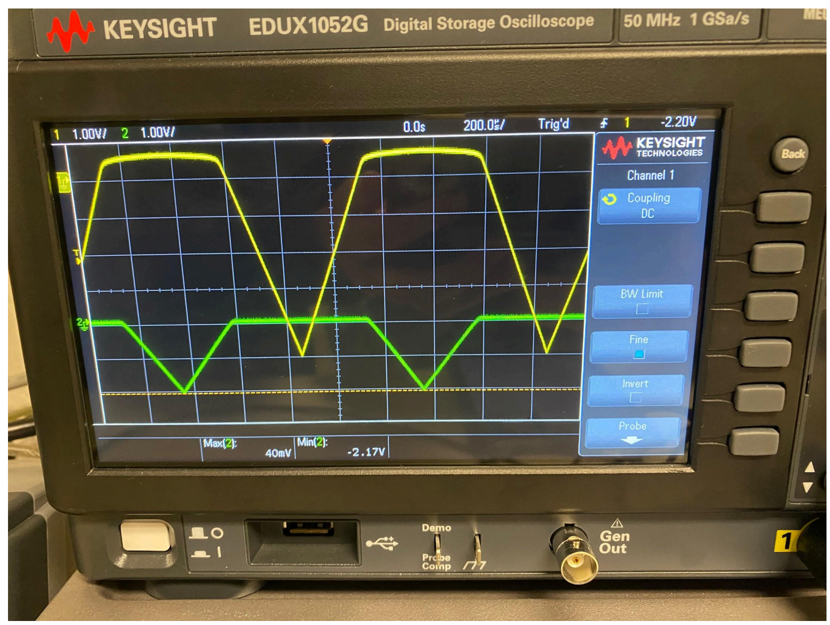


- It does not work because the resistor gets shorted as there is a ground in both sides (between point A and C) rendering Vr = 0

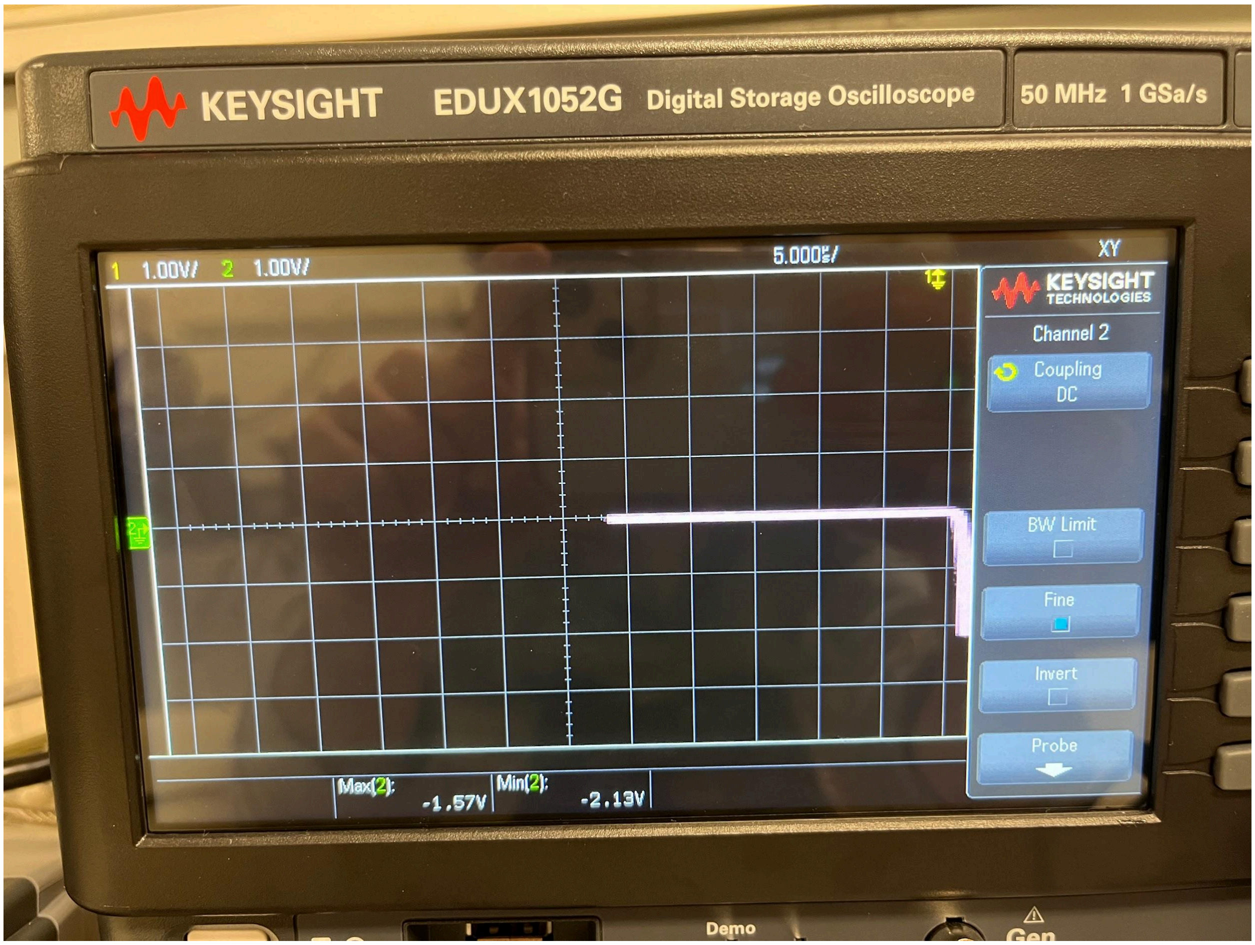
3. Build the below circuit with a 741 Op-amp chip







4. Using the same function generator setting, set the scope to show (x vs y). Set both channels to 1 V/division. The scope should show one point. Move the point such that it is at the lowest, right-most voltage division marks on the scope. Slowly increase the amplitude of the input. The scope shows the i − v characteristics of the diode. Increase the amplitude of the input wave until the diode iv curves "fills" the scope display. Print out the scope output and mark and label the axes.



To accomplish this step, we had to adjust some of the settings on the Digital Storage Oscilloscope using the Push Fine settings and the cursors. We continued adjusting these settings until the amplitude of the input reached the side of the display.

5. What is the function of the 2k resistor?

The 2k resistor serves as a current-limiting resistor for the diode. This makes sure that there is not an excessive amount of current that goes through the diode.

Experimental Procedures and Results

Experiment 2

Assemble the circuit. Start with the potentiometer set at maximum resistance (i.e., about 10 kΩ). Measure the load current and the load voltage. Then, vary the potentiometer resistance and measure the load voltage for a range of load currents. Plot vo, versus io. Compare with your circuit analysis and simulation and explain the results (especially the observed slight drop in vo when io is increased).

```
current = [0.564, 0.682, 0.781, 0.806, 0.986, 1.065, 2.639, 4.1, 8.2]
voltage = [5.412, 5.398, 5.384, 5.376, 5.351, 5.315, 5.075, 3.564, 0.011]
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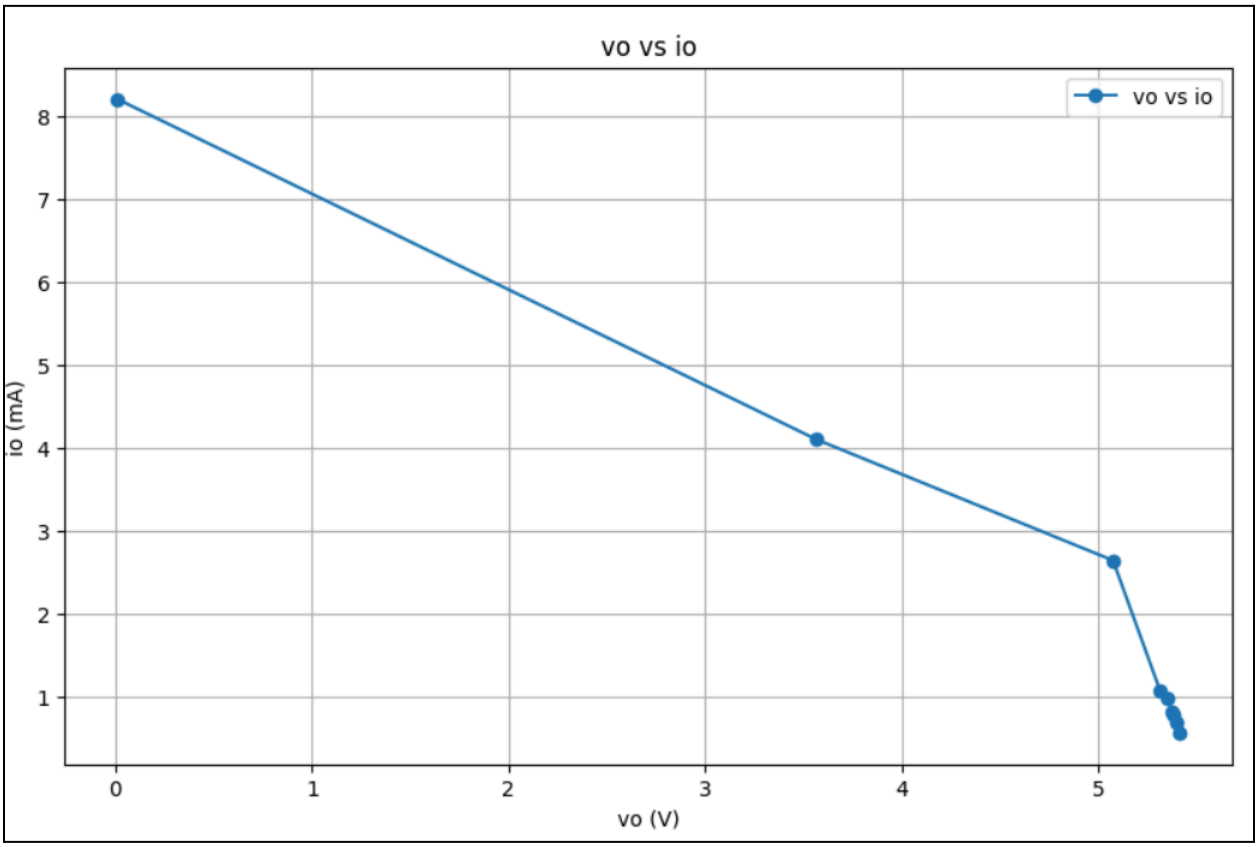
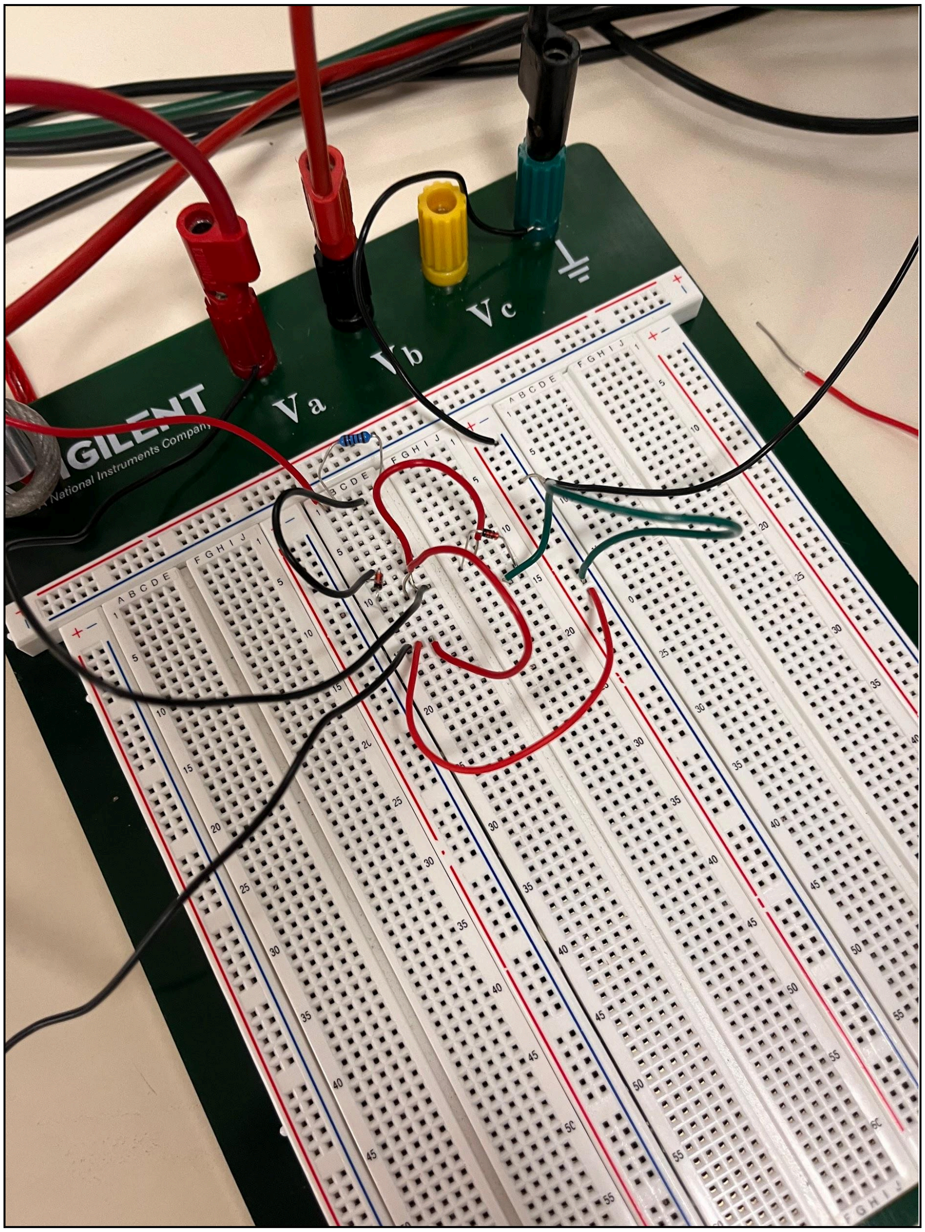


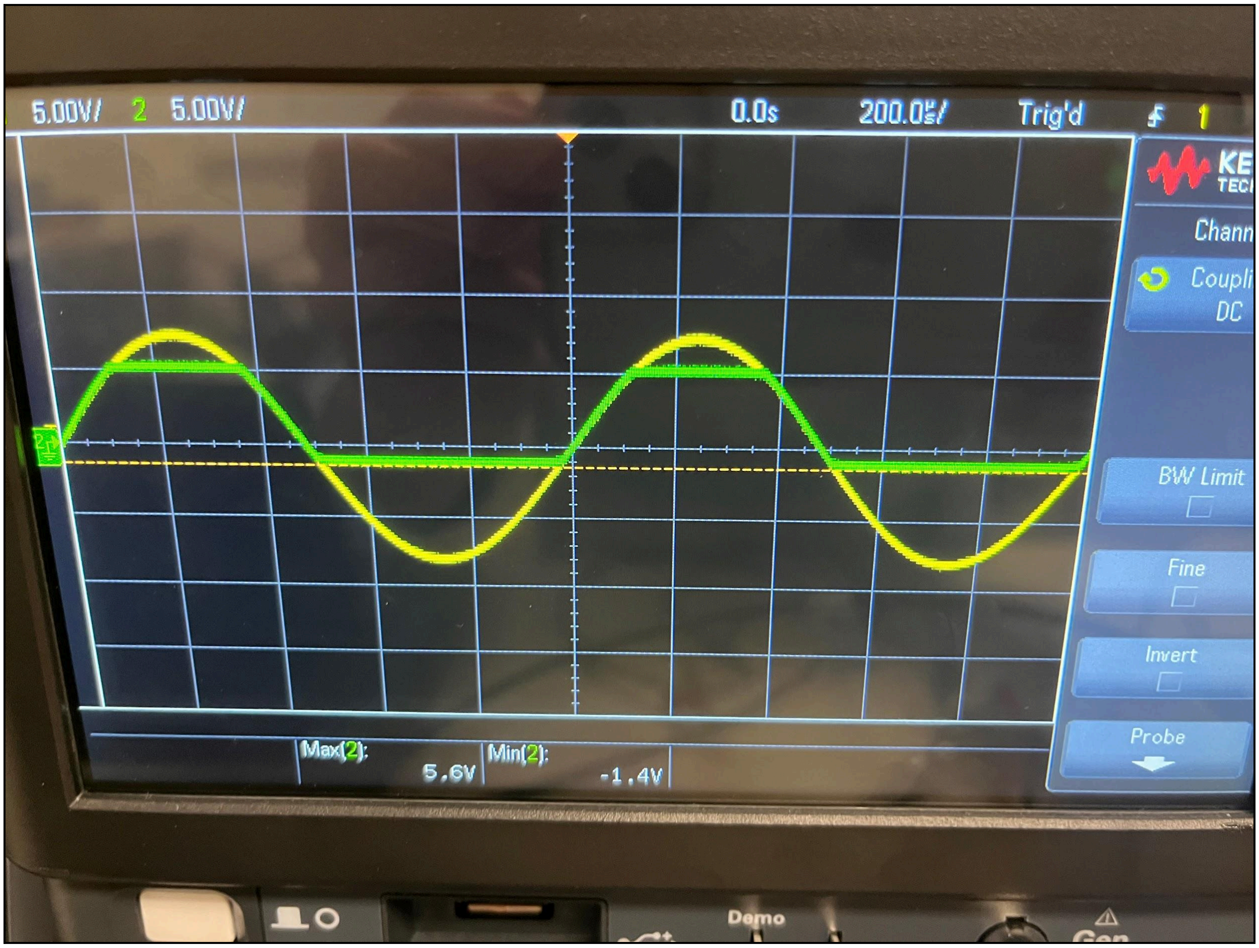
The value of the load current and the load voltage are 0.564mA, and 5.412V. When the potentiometer decreases, io increases while vo decreases, and vice versa (when potentiometer increases, io decreases and vo increases). This makes a lot of sense because based on Ohm's law, when resistance decreases, vo will increase and the io will decrease.

Experiment 3: Clipper Circuit

Lab Exercise: 1. Assemble the circuit that you have designed. Take a picture of the setup and include it in your report.



<u>2. Apply a sinusoidal wave with a frequency of 1 kHz, an amplitude of 8 V, and a DC offset of zero to the circuit. Adjust the oscilloscope settings to display vi and vo properly. Take a picture of the oscilloscope display and include it in your report.</u>



<u>3. Increase the DC offset of the input. What do you see? Does it follow your simulation results? Explain.</u>

When we increased the DC offset of the input, we observed that the waveform shifted upward, effectively increasing the amplitude of the signal. This behavior aligns with our simulation results. The increase in DC offset adds a constant voltage to the input signal, causing the entire waveform to move higher along the voltage axis. Since the offset directly impacts the input, the observed "larger curves" are a result of this shift rather than a change in the waveform shape itself.

4. Set the DC offset to +2V. Adjust the oscilloscope settings to display vi and vo properly. Take a picture of the oscilloscope display and include it in your report. Explain the results.

This aligns with the claims we made in question 3—when the DC offset increases positively, the input shifts upward. The same applies to the output, as it is directly dependent on the input.

Conclusion

In this lab, we analyzed the functionality of general purpose diodes (1N4148), the conditions of voltage and current in a circuit with zener diodes, and the behavior of clipper circuits with a DC offset within three different experiments.

In the first experiment, we examined the relationship between voltage and current in a circuit with a diode. We first simulated a circuit with a resistor and a diode that would not function in real-life due to the shorting of the resistor, resulting in vD having a voltage of 0V. After this discovery, we then recreated a circuit similar to the first one, but with the addition of an op-amp powered by ±15V to properly observe the *iv (current and voltage)* characteristics of the diode. This alteration to the circuit reflected our findings for the *iv* behavior of the diode from prelab, with the addition of an increase in the diode voltage due to the op-amp.

In the second experiment, we assembled a circuit with a zener diode (which was replaced with a DC source as we assumed the zener diode to be in the zener region) and observed how voltage and current output changed based on the value of the potentiometer resistance. We noticed that as we decreased the potentiometer resistance from its max value (10kΩ), io increased and vo decreased and vice versa when the potentiometer resistance is increased to its max value. This finding coincides with our expectations based on Ohm's law.

In the final experiment, we designed a clipper circuit and recorded vi and vo, and observed how an increase in DC offset of the input voltage affects the output voltage. With 0 DC offset of the clipper circuit, the vo clips at 5.7V and -0.7V. With a DC offset of 2V, we noticed that the input voltage and output voltage waveforms were vertically shifted upwards.