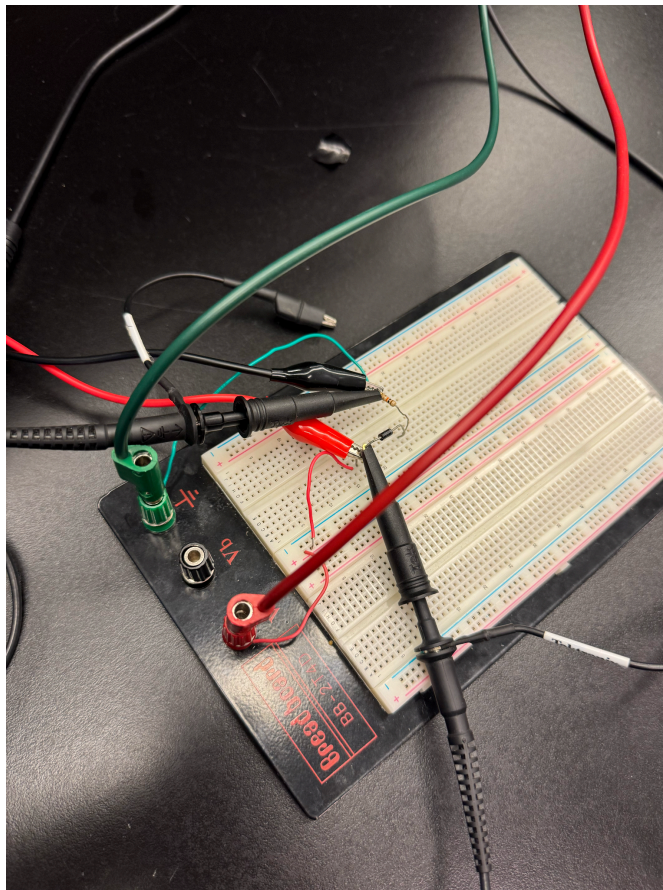


Laboratory 1
ENGG*3450 - Electronic Devices
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Cole Mayke - 1127413



Group 38: Monday Nov25th 3:30PM (Makeup Lab)

Experiment One

The primary objective of Experiment 1 is to characterize the current-voltage (I-V) behavior of both a 1N4004 semiconductor diode and a 1N4733 Zener diode. This experiment examines current response under both forward and reverse bias conditions, with particular focus on determining the cut-in voltage and minimum forward voltage for each diode. Additionally, I will investigate how these diodes approximate an open circuit under reverse bias and approach ideal conductor behavior under forward bias once exceeding the cut-in voltage threshold.

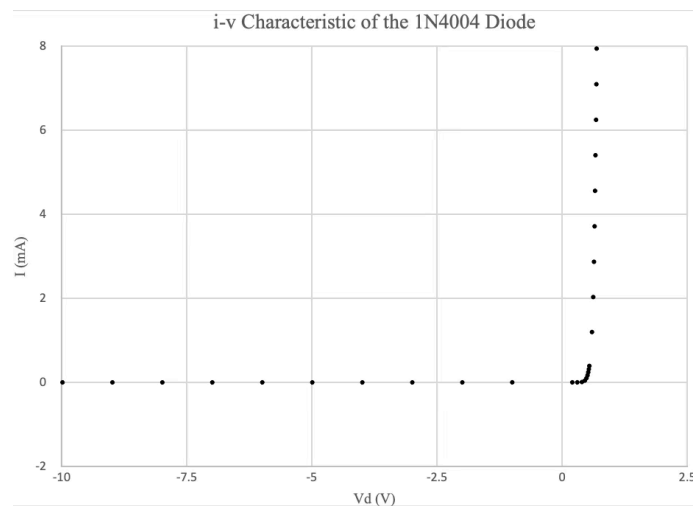


Figure 1: Plot of current against voltage for 1N4004 Diode.

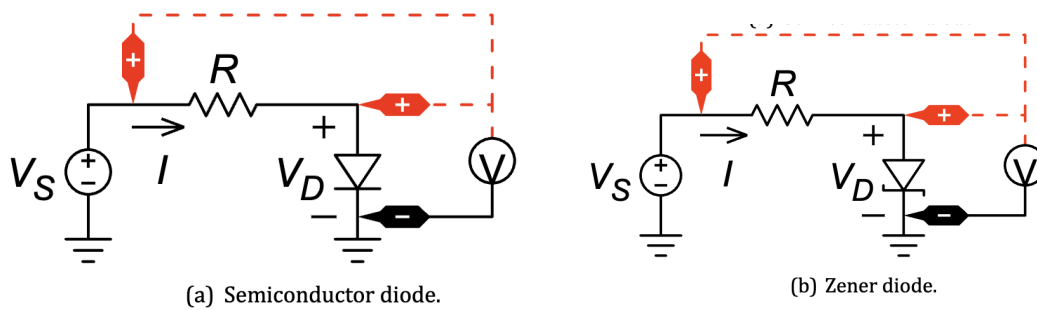


Figure 2: Circuit Schematic for Semiconductor (1N4004) and Zener (1N4733) Diode Characterization [1]

Analysis of the 1N4004 semiconductor diode data reveals negligible current flow under reverse bias conditions. The diode exhibits a distinct forward-bias cut-in voltage of approximately 0.6 V, beyond which the current demonstrates linear growth with increasing voltage. The I-V relationship near this activation threshold is detailed in Figure 2. The 1N4733 Zener diode demonstrates markedly different behavior. Under reverse bias, it conducts current when the voltage exceeds the Zener breakdown voltage of approximately -4 V, after which current increases linearly with more negative voltage. In forward bias, the diode begins conducting at roughly 0.7 V, followed by a steep linear increase in current with applied voltage. This bidirectional conduction behavior distinguishes it from the standard semiconductor diode.

Experiment Two

This experiment aims to characterize the operating characteristics of red and green Light Emitting Diodes (LEDs) by determining their forward voltage thresholds (V_D) required for light emission. The investigation includes measuring light intensity across a voltage sweep from -10V to +10V for both LED types. Additionally, the experiment explores the application of LEDs as polarity indicators by analyzing their emission intensity response to varying voltage conditions.

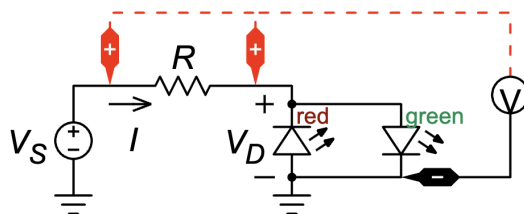


Figure 3: Wiring Diagram for Light-Emitting Diode Circuit [1].

The green LED demonstrated illumination within a voltage range of $V_D = [-1.83, -2.04]$ V, corresponding to a current range of $I = [-0.205, -8.118]$ mA. During green LED activation, the red LED remained non-conducting. The green LED's luminous intensity exhibited direct proportionality to current magnitude, with maximum brightness observed at peak current (-8.118 mA) and minimum brightness at threshold current (-0.205 mA). Conversely, the red LED activated within $V_D = [1.697, 3.49]$ V and $I = [0.316, 6.629]$ mA, while the green LED remained non-conducting. The red LED's luminous intensity similarly demonstrated direct proportionality to current magnitude across its operating range. Both LEDs remained non-conducting within the voltage range $V_D = [-0.705, 0.704]$ V, corresponding to $I = [0,0]$ mA. The mutual exclusivity of LED activation suggests circuit design constraints or potentially insufficient power supply capabilities. This behavior could be attributed to either intentional circuit design parameters or power supply limitations preventing simultaneous LED operation.

These observations must be considered within the context of measurement uncertainties, including component tolerances in the LEDs and resistors, as well as instrumental measurement errors. These factors may contribute to minor variations in the recorded values and should be considered when interpreting the results.

Experiment 3

This experiment examines a half-wave rectifier circuit that conducts only the positive half-cycle of an input signal. The circuit's behavior shows two main relationships:

1. With fixed capacitance: Increasing the input frequency raises both peak-to-peak and average output voltages. This occurs because the capacitor has less time to discharge between cycles.
2. With fixed frequency: Increasing the capacitance reduces both peak-to-peak and average output voltages, as larger capacitors discharge more slowly, smoothing out the ripple voltage.

The output voltage (V_o) produces a pulsating DC waveform from the input voltage (V_i), eliminating all negative components.

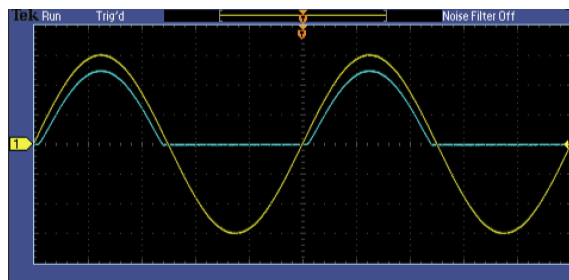


Figure 4: 600 Hz Oscilloscope Screenshot - Half wave rectifier

Looking at the waveform in Figure 4, the yellow line is the input sine wave, and the blue line shows the rectified output. When the yellow sine wave is higher than the blue line, the diode turns ON and conducts

current, which charges the capacitor. This happens at the peaks of the positive cycle. When the yellow wave drops below the blue line, the diode turns OFF. During this time, the capacitor gradually discharges - you can see this in the gentle downward slope of the blue line. During the negative part of the cycle (bottom half of yellow wave), the diode stays OFF and blocks all current, which is why the blue line flattens out here.

The voltage differential between V_i and V_o is fundamentally determined by the diode's forward voltage drop (cut-in voltage). This threshold voltage represents the point at which the semiconductor transitions from reverse bias to forward conduction, characterized by an abrupt increase in current flow. Below this threshold, the diode remains in reverse bias, maintaining the voltage differential below the cut-in voltage.

Based on Experiment 1's semiconductor diode measurements, the difference between peak input voltage (V_i) and peak output voltage (V_o) should be approximately 0.6-0.7V, which is the diode's cut-in voltage. This voltage difference occurs because the diode requires its cut-in voltage (forward voltage drop) before it starts conducting. So when the input voltage rises, the output voltage will always be about 0.6-0.7V less than the input due to this voltage drop across the diode. This matches what I learned about semiconductor diodes in Experiment 1, where I found the activation (cut-in) voltage was around 0.6V.

Conclusion

My experimental investigations of various diode types and the half-wave rectifier revealed distinct operational characteristics. The standard semiconductor diode demonstrated unidirectional conduction, blocking current flow under reverse bias conditions. In contrast, both the Zener diode and LEDs exhibited bidirectional behavior, permitting current flow under negative bias conditions, albeit with different voltage thresholds. This unidirectional conduction property of the semiconductor diode was further demonstrated in the half-wave rectifier circuit, where the negative portions of the input signal were effectively blocked, resulting in a zero-voltage output during negative half-cycles.

References

[1] M. A. E. Nasr., and S. Gregori *ENGG*3450 Electronic Devices – Laboratory Manual 1*. (Fall 2024). University Of Guelph [Accessed: 29-Nov-2024]