**Lab 3: Understanding Diodes**

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**Bench** 19

**Electronics** 1 Lab

**EECE.3110 P 1 804A**

**Date submitte**d 02/28/2022

**Due date** 03/27 /2022

1. **SUMMARY**

N**/A**

1. **EQUIPMENT**

|  |  |  |
| --- | --- | --- |
| **Equipment Type** | **Details** | |
| * Oscilloscope | *Make:* | InfiniiVision |
| *Model:* | DSO-X2004A |
| *Serial Number:* | MY52161432 |
| * Digital Multimeter | *Make:* | Keithley |
| *Model:* | 2110 5½ |
| *Serial Number:* | 8004026 |
| * DC Power Supply | *Make:* | GWInstek |
| *Model:* | GPD-3303D |
| *Serial Number:* | EM840514 |
| * Function Generator | *Make:* | Tektronix |
| *Model:* | AFG1022 |
| *Serial Number:* | AFG102217331728 |
| * Analog Discovery | *Make:* | Digilent |
| *Model:* | Analog Discovery 2 |
| *Serial Number:* | 210231B0DF82 |
| * Breadboard * Bench “Shoebox” with connector cables, adapters, clips etc. | N/A | |

**Table 1. Equipment**

**Table 2. Components**

|  |  |  |
| --- | --- | --- |
| **Component Type** | **Quantity** | **Details** |
| Resistor | 1 | 1k Ω |
| Resistor | 1 | 330 Ω |
| Resistor | 1 | 470 Ω |
| Resistor | 1 | 1M Ω |
| Diode | 1 | 1N914 |
| Diode | 1 | 1N3064 |
| Diode | 1 | 5v Zener, 1N4733A or equivalent |
| LED | 1 | red |
| LED | 1 | green |
| PowerBrick | 1 | 12v |

1. **INTRODUCTION**

N/A

1. **CIRCUIT DESCRIPTION**

Diagram, schematic

Description automatically generated

Figure 1 describes the bread board configuration when testing diode biases with a LED. In step 1 of the process the LED is inserted in reverse polarity and will not turn on. Then, it is properly inserted and lights.

Diagram, schematic

Description automatically generated

Figure 2 is the schematic used to construct a clipping/clamping circuit. It is called this because when a sinusoidal signal is inputted, if the voltage is higher than the diode forward voltage (typically 0.7v for silicon diodes) the output is shorted. Thus, the signal is clipped, or the output is clamped.

A picture containing text, clock, gauge

Description automatically generated

Diagram

Description automatically generatedFigure 3 is the circuit configuration when testing a diode in reverse bias. This set up clips the input signal when the negative voltage is high enough to turn on the diode so, the bottom half of the output wave clips around 0.7v.

Figure 4a is the circuit configuration used while testing how a diode interacts with a transformer.

**A screenshot of a computer

Description automatically generated with medium confidence**

Figure 4b is an alternative to figure 4a. This is used if one chooses to use the Analog Discovery in place of a transformer.

**Chart, line chart

Description automatically generatedFigure 5a. Forward Biased V-I Characteristic Curves**

Visual representation of the current and voltage across forward biased diode in figure 2.

**Figure 5b. Reverse Biased V-I Characteristic Curve**

**Chart, line chart

Description automatically generated**

Visual representation of current versus voltage across the reverse biased diode in figure 3.

**Figure 6. Semi-Logarithmic Plot of Forward Biased V-I Characteristic Curve**

**Chart, line chart

Description automatically generated**

Logarithmic representation of figure 5a.

**Graphical user interface, chart

Description automatically generatedFigure 7. Signal Diode**

Output of the half-wave rectifier in figure 4b with the 1N914 signal diode in forward bias. Channel one is the voltage drop across the diode, channel two shows the voltage across the resistor and M1 is the current across the diode.

**A screenshot of a computer

Description automatically generated with medium confidenceFigure 8. Output of figure 4b with Red LED**

Channel one is the voltage across the LED, channel 2 is the voltage across the resistor, and M1 is the current across the LED.

**Graphical user interface

Description automatically generatedFigure 9. Output of figure 4b with Green LED**

Channel one is the voltage across the LED, channel 2 is the voltage across the resistor, and M1 is the current across the LED.

**Graphical user interface, chart

Description automatically generatedFigure 10. Output of figure 4b with Zener Diode**

Channel one is the voltage across the Zener diode, channel 2 is the voltage across the resistor, and M1 is the current across the Zener diode.

**Chart

Description automatically generatedFigure 11. Design Challenge, Negative Clipper Circuit**

Channel 1 represents the output of the clipper circuit, and channel 2 shows the input signal of the circuit.

**Figure 12. Design Challenge, Negative Clipper Circuit V-I load plot**

**Chart, line chart

Description automatically generated**

This is the V-I characteristic curve of my clipper circuit. The V-I relationship is linear due to the currents being taken off a 1kΩ resistor.

1. **MEASUREMENTS**

**Table 3. R1 and R2 Nominal vs. Real values**

|  |  |  |
| --- | --- | --- |
| **Component** | **Nominal Value** | **Measured Value** |
| R1 | 330Ω | 325.15Ω |
| R2 | 1MΩ | 993.57KΩ |

Real values of R1 and R2

**Table 4. Voltage drops across Forward-Biased D1**

|  |  |  |
| --- | --- | --- |
| **VF** | **VR1** | **ID (Calculated)** |
| 0.45v | 400mV | 1.2mA |
| 0.50v | 480mV | 1.5mA |
| 0.55v | 480mV | 1.5mA |
| 0.60v | 560mV | 1.7mA |
| 0.65v | 560mV | 1.7mA |
| 0.70v | 640mV | 2mA |
| 0.75v | 640mV | 2mA |

VS was slowly increased until the voltage dropped across D1 was 0.45v and then incremented to the remaining VF voltages listed in the table.

**Table 5. Measurements Across Figure 3**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **V1**  **(Measured)** | **VR**  **(Measured)** | **VD**  **(Measured)** | **Resistance**  **(Measured)** | **Id**  **(Calculated)** |
| 0 | 0.9mV | 0.9mV | 0.99MΩ | .909nA |
| 2 | 2.8mV | 1.8v | 0.99MΩ | 2.8nA |
| 4 | 3.6mV | 3.6v | 0.99MΩ | 3.6nA |
| 6 | 4.0mV | 5.41v | 0.99MΩ | 4.04nA |
| 8 | 4.6mV | 7.216v | 0.99MΩ | 4.646nA |
| 10 | 5.0mV | 9.022v | 0.99MΩ | 5.0505nA |
| 12 | 5.3mV | 10.916v | 0.99MΩ | 5.3535nA |

Test to see if voltmeter has high impedance. Meaning if the voltage measured across the resistor is accurate, the meter has a high impedance.

**Table 6. Red LED vs. Green LED vs. Zener Diode vs. D1 Diode**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | **Dynamic Resistance (Measured)** | **Threshold Voltage, VTH (Measured)** | **Id** | **VTH**  **(From the datasheet)** | **Calculated Dynamic Resistance using (VT – 25mV)/ Id** |
| **Red LED** | 931.995Ω | 2.4189v | 2.5954mA | N/A | N/A\*\* |
| **Green LED** | 1056.626Ω | 2.5769v | 2.4388mA | N/A | N/A\*\* |
| **Zener Diode** | 176.494Ω | 0.75167v | 4.2589mA | 0.7v | 158.49Ω\*\* |
| **D1** | 16.0369Ω | 0.69291v | 4.3207mA | 1v | 225.657Ω\*\* |

**\*\***Could not find VT in the datasheets, used VTH instead, which would cause the discrepancies.

1. **DISCUSSION**

Multimeters today have diode tests built into them. When performing these tests on a diode, the meter provides a voltage across the device being tested. If the diode is in forward bias, the meter will make a noise or give another indication that there is continuity between the positive and ground probes. However, if the diode is in reverse bias, there should be no continuity between the two multimeter probes. In section one of this laboratory procedure, we performed a similar test by construction figure 2. With the diode in forward bias, the voltage drops across it is measured, recorded, then the current across the diode is calculated by dividing the forward voltage by the measured value of R1. This allows the observation of the diode slowly turning on and working properly. In part g of section one, figure 3 is built by rotating the diode into reverse bias and swapping the 330Ω resistor for a 1MΩ one. From there VS is incremented from 0 to 12v in 2v increments while taking the rest of the measurements in table 5. Here we see the diode was a very large resistance and extremely low current through it, showing that it functions as expected in reverse bias.

In section two of the procedure four different types of diodes and their characteristics as compared using the circuit in figure 4b. These diodes include a signal diode, red LED, green LED, and Zener diode. The results can be seen in table 6. The comparison between the two like diodes, the red and green LEDs is the most interesting. The red LED had a 124.631Ω lower resistance, 0.159v lower voltage, and a 0.1566mA higher current than the green LED. These differences are due to green being a higher frequency than red, drawing a small amount more of power.

For the design challenge portion of the lab, I chose to design a negative clipper circuit. This circuit clips the negative portion of an input signal. The circuit works by placing a diode in reverse bias after an input resistance and then a load resistance in parallel with the diode. The diode pushes the positive portion of the input through the load resistor. When the source begins its negative sweep, the diode turns on at 0.7v (in my case) and shorts the input from the load. Due to the load being in parallel with the diode, during the negative source sweep, the load is clipped to the diodes turn on voltage of 0.7v. If one wanted to increase or decrease this clipping voltage, place a positive or negative voltage source on the cathode of the diode and that will “change” the diodes turn on voltage. This circuit can be used as a type of rectifier, called a half-wave rectifier. Adding three more diodes in a certain configuration with a load between them would make a full wave bridge rectifier; a circuit that can be seen in a car’s alternator.

1. **CONCLUSION**

The objective of this laboratory was to see the physical use of diodes and how they interact in different configuration. During this lab we saw the differences between signal diodes, light emitting diodes, and Zener diodes, as well as designing our own circuit. All in all, each type of diode works in similar ways, but achieve different goals. For example, the LED emits light, the signal diode prevents current flowing against it in reverse bias, and the Zener diode allows a set amount of voltage, called the Zener voltage, to pass through, acting like a voltage regulator.

1. **QUESTIONS**

**N/A**

1. **REFERENCES**

Figure pictures were taken from lab procedure document