Lab Report 1
Single PN - Junction

Performed by:

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1 Introduction

The behavior of a single PN-junction of two semiconductors, also called diode, was experimentally analyzed. A diode is an electrical device allowing current to move through it in one direction with far greater ease than in the other. When the polarity of the battery is such that the current is allowed to flow through the diode, the diode is said to be forward-biased. One of the common examples is silicon diodes, the typical forward voltage is 0.7V. Moreover, a Zener Diode was shown. The Zener Diode is a special type of rectifying diode that can handle breakdown die to reverse breakdown voltage without failing completely. Theoretically, if we connect a diode and resistor in series with a DC voltage source so that the diode is forward-biased, the voltage drop across the diode will remain fairly constant over a wide range of power supply voltages.

2 Determine Anode and Cathode

2.1 Objective

In this part, anode and cathode of the diode was determined. Anode is a p-type silicon, while cathode is a n-type silicon.

2.2 Experimental Set-up and Preparation

The following circuit was constructed. First, the polarity of the diode was ignored. However, the orientation was noted with a ring in the diode.

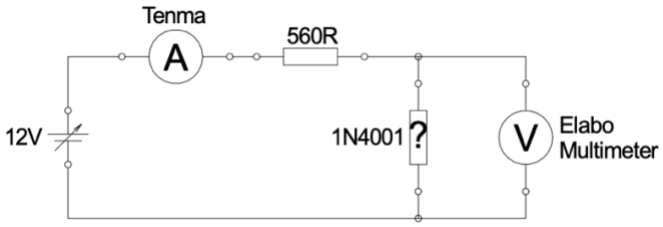


Figure 1

Then, all data was recorded. Second, the diode was reversed and again voltage and current were documented. In Table 1, all values are shown.

Another way to find out the orientation of the diode is to use the Tenma multimeter. Connecting lab wires with crocodile clips to the 'COM' and the 'V Ω …' plug gives positive polarity at the 'V Ω …' relative to the 'COM'. In this case, the 'COM' and the ring of the diode were used to determine the orientation. The data was recorded in both directions and given in Table 2.

2.3 Results

	The ring is closer to the resistor	The ring is far away from the resistor
Reading Voltage, V	12.090	0.728
Reading Current, A	0.000	0.020

Table 1

	The ring is closer to the 'COM'	The ring is far away from the 'COM'
Reading Voltage, V	0.000	0.585

Table 2

3 Forward V-I-Curve of a general purpose diode

3.1 Objective

In this part, the diagram $I_F = f(U_F)$ was constructed. By looking at the diagram, the process of working diode can be seen.

3.2 Experimental Set-up and Preparation

The following circuit was wired-up with the voltage source.

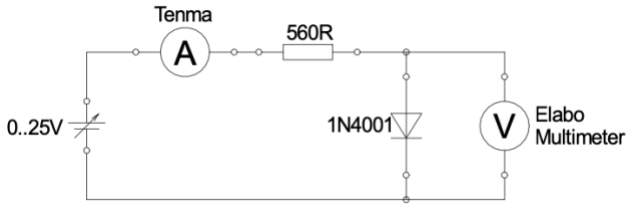


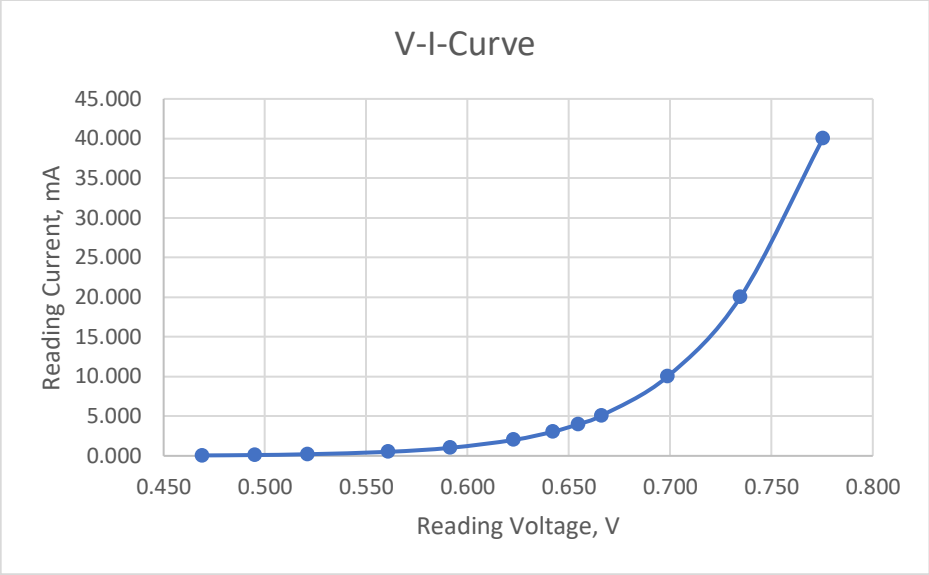
Figure 2

By adjusting the voltage source, the current through the diode was changed in the range 0 - 40mA. 12 different current values in this range gave different voltages. All data was documented in Table 3 and based on these values the graph was constructed in Graph 1.

3.3 Results

Supplied Voltage, V	Reading Current, mA	Reading Voltage, V
0.4	0.052	0.469
0.5	0.103	0.495
0.6	0.203	0.521
1.0	0.506	0.561
1.6	1.010	0.591
1.7	2.000	0.623
2.3	3.039	0.642
2.8	3.985	0.655
3.4	5.070	0.666
6.3	9.993	0.699
12.0	20.024	0.735
23.3	40.010	0.775

Table 3



Graph 1

4 Reverse and Forward Characteristics of a Z-Diode

4.1 Objective

The current and voltage in both direction for a Z-Diode were recorded. To see the influence of the orientation of a diode, the graphs from these values will be demonstrated.

4.2 Experimental Set-up and Preparation

The following circuit was built. As in the previous section, voltage and current were documented for the range of 0 – 45mA and a graph based on these values is shown in Graph 2.

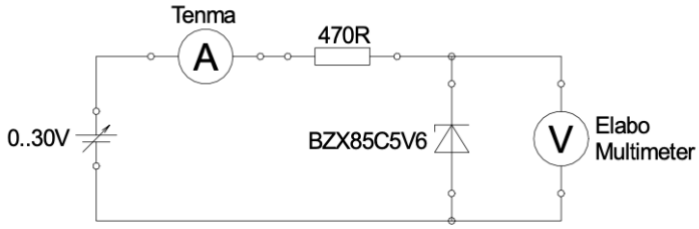


Figure 3

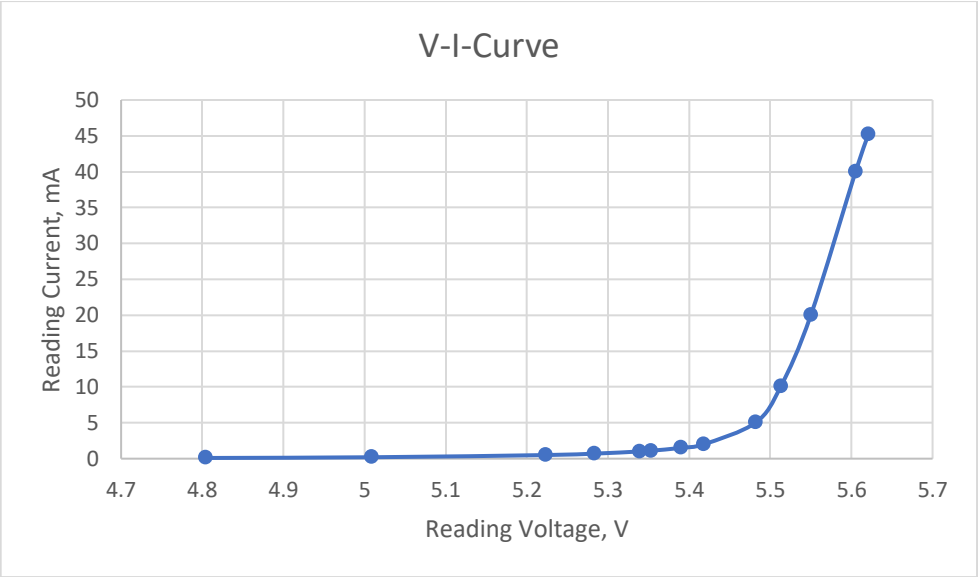
Then, the diode was inverted and the same procedure was applied in the range of 0 – 30mA. All values are shown in Table 5 and the graph of these values is demonstrated in Graph 3.

4.3 Results

Supplied Voltage, V	Reading Current, mA	Reading Voltage, V
4.8	0.098	4.804
5.1	0.200	5.009
5.6	0.502	5.223
5.9	0.699	5.283
6.2	1.004	5.339
6.4	1.108	5.353

6.0	1.504	5.390
6.3	2.000	5.418
7.8	5.034	5.482
10.2	10.071	5.513
15.0	20.001	5.550
24.6	39.970	5.605
27.1	45.230	5.621

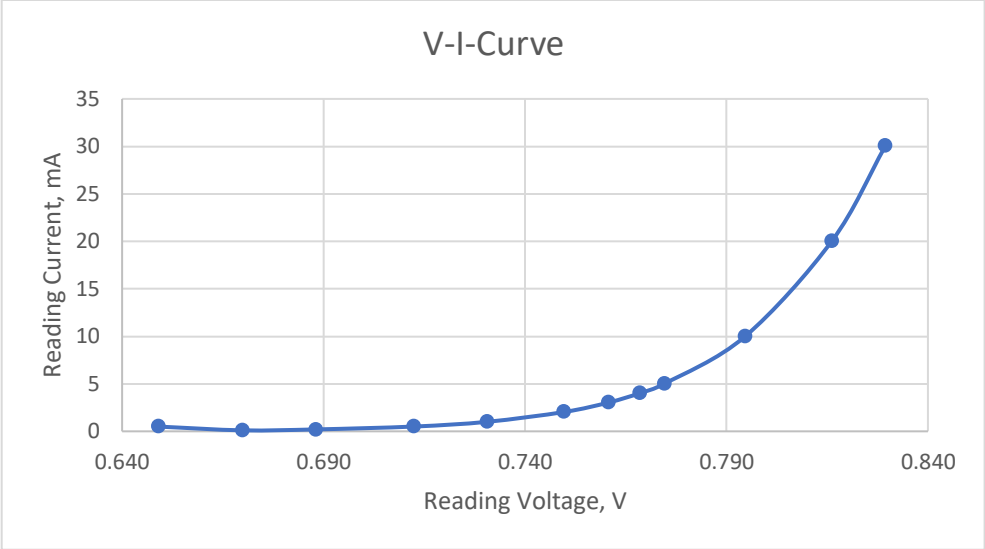
Table 4



Graph 2

Supplied Voltage, V	Reading Current, mA	Reading Voltage, V
0.6	0.050	0.649
0.7	0.103	0.670
0.8	0.202	0.688
1.1	0.505	0.713
1.6	1.001	0.731
1.6	2.036	0.750
2.1	3.029	0.761
2.6	4.015	0.769
3.1	5.031	0.775
5.5	9.983	0.795
10.3	20.060	0.816
15.1	30.093	0.830

Table 5



Graph 3

5 A Zener Shunt Regulator

5.1 Objective

In this part, a Zener-Diode was used to analyze its behavior. Unlike the normal diode, a Zener-Diode is used in the reverse direction. The Zener-Diode supplies almost a constant voltage to a load. Therefore, in the circuit, the Zener-Diode can be used to limit or stabilize the voltage.

5.2 Experimental Set-up and Preparation

The following circuit was constructed. In this case, the circuit works like a current divider. Given that the load current should be 10mA at 5.6V. R_V is calculated for two cases: $I_Z = 1\text{mA}$ and $I_Z = 10\text{mA}$.

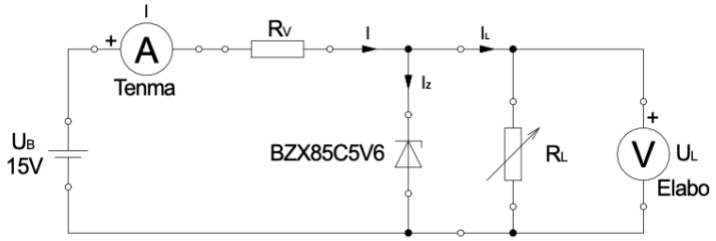


Figure 4

$$R_V = \frac{U_B - U_L}{I} = \frac{U_B - U_L}{I_L + I_Z}$$

Formula 1

So, for the $I_Z = 1\text{mA}$, $R_V = 854.55\Omega$ and for the $I_Z = 10\text{mA}$, $R_V = 470.00\Omega$.
First, R_V was set to the value calculated for $I_Z = 1\text{mA}$. Then, the current and the voltage for $R_L = 56\text{R}, 560\text{R}, 5\text{K}60$, and without R_L were recorded and shown in Table 6. Second, the same procedure repeated for R_V, which was calculated for $I_Z = 10\text{mA}$, and demonstrated in Table 7.

5.3 Results

R_L, Ohm	Reading Current, mA	Reading Voltage, V
56	16.45	0.93
560	11.26	5.40
5600	11.13	5.52
Open-circuit	11.12	5.53

Table 6

R_L, Ohm	Reading Current, mA	Reading Voltage, V
56	28.24	1.59
560	20.03	5.52
5600	19.95	5.56
Open-circuit	19.95	5.56

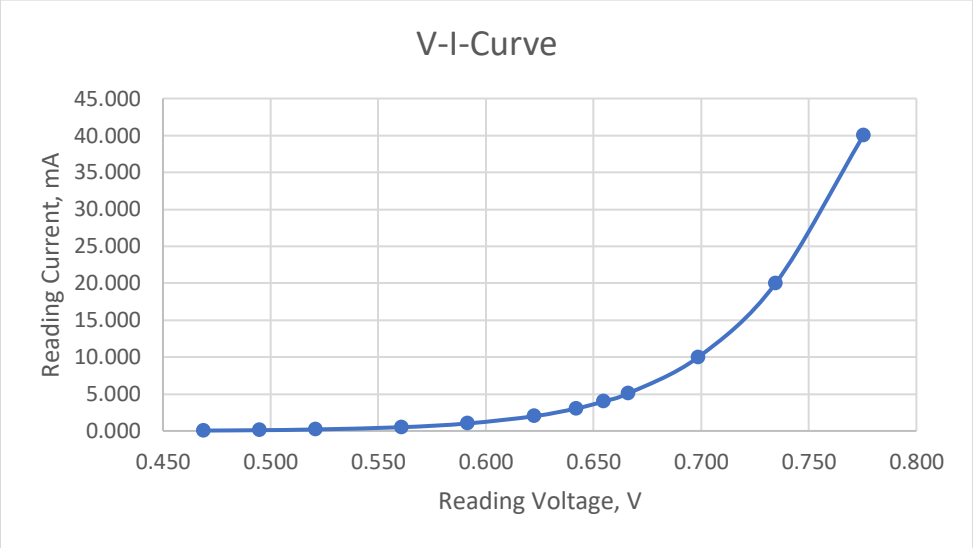
Table 7

6 Evaluation

6.1 Determine Anode and Cathode

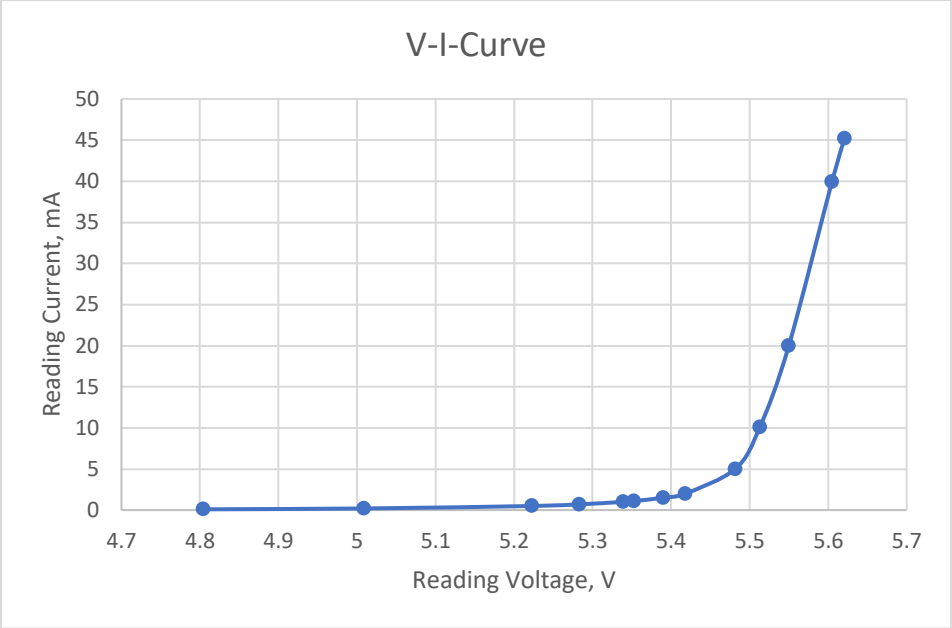
From the results, it is seen that when the ring is far away from the resistor, no current goes through the diode. Therefore, it can be concluded that the diode has the ring near the cathode (negative side), while another side is the anode (positive side).

6.2 Forward I-V-Curve of a general purpose diode

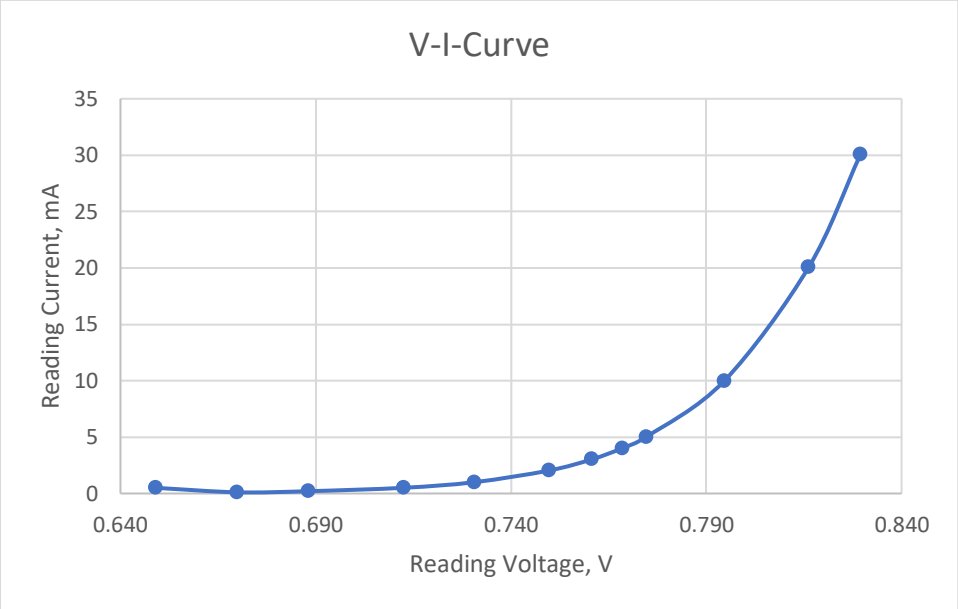


Graph 4

6.3 Reverse and Forward Characteristics of a Z-Diode



Graph 5



Graph 6

To calculate the resistance of the diode, two values close to the 45mA and 1mA will be taken from Table 4. So, for the $I_{ZT} = 45\text{mA}$:

$$Z_{ZT} = \frac{V_1 - V_2}{I_1 - I_2} = \frac{5.621\text{V} - 5.605\text{V}}{45.230\text{mA} - 39.970\text{mA}} = 3.041\Omega$$

and for the $I_{ZK} = 1\text{mA}$:

$$Z_{ZK} = \frac{V_1 - V_2}{I_1 - I_2} = \frac{5.353\text{V} - 5.339\text{V}}{1.108\text{mA} - 1.004\text{mA}} = 143.62\Omega$$

For the diode, which was used in the circuit, the voltage range is 5.2V – 6V, and from Table 4 and Table 5, it can be seen that all reading voltage values are in the range. Moreover, for the $I_{ZT} = 45\text{mA}$, the maximum resistance of the diode is 7Ω and our calculation shows that the resistance was 3.041Ω. At $I_{ZK} = 1\text{mA}$, the maximum resistance of the diode is 400Ω and we calculated that the resistance was 143.62Ω, which is also in the range. Overall, since the data sheet gives only maximum resistance, values from both calculations are accurate. However, there are still relative and methodical errors.

Since Ohm's Law says that resistance is the ratio of a voltage to a current, the resistance, in this case, can give information about the slope of the graph $I = f(U)$. It means that the more resistance is high, the more graph at that point close to the straight line. It can be verified from Graph 5.

6.4 A Zener Shunt Regular

To calculate R_V, Formula 1 was used.

$$R_V = \frac{U_B - U_L}{I} = \frac{U_B - U_L}{I_L + I_Z}$$

So, for the $I_Z = 1\text{mA}$:

$$R_V = \frac{15V - 5.6V}{1\text{mA} + 10\text{mA}} = 854.55\Omega$$

And for the $I_Z = 10\text{mA}$:

$$R_V = \frac{15\text{V} - 5.6\text{V}}{10\text{mA} + 10\text{mA}} = 470.00\Omega$$

R_L, Ohm	Reading Current, mA	Reading Voltage, V
56	16.45	0.93
560	11.26	5.40
5600	11.13	5.52
Open-circuit	11.12	5.53

Table 8

R_L, Ohm	Reading Current, mA	Reading Voltage, V
56	28.24	1.59
560	20.03	5.52
5600	19.95	5.56
Open-circuit	19.95	5.56

Table 9

The Zener Shunt is used to regulate the voltage across the load. It is seen from Table 8 and Table 9 that the voltage across the load is not higher than 5.56V. Moreover, for load resistance with the resistance of 560Ω and 5600Ω, and an open-circuit, the voltage is about 5.56V.

However, it can be seen that for the low load resistance, the voltage and the current are very different. Since at very low resistance, the whole current goes through the resistance, and the diode is ignored. Thus, at very low resistances, the true behavior of the diode cannot be observed.

7 Conclusion

In conclusion, we have observed the behavior of the different diodes. First, we experimentally find the anode and cathode of the diode, observed how the diode works by drawing the graph. Then, the influence of the

orientation of the diode was studied. Finally, the behavior of the Zener Shunt Regulator was observed. Overall, analyzing different diodes gave me a clear picture of how diodes are used in real-life.

8 Reference

Pagel, U., & Joodaki, M. (Fall Semester 2020). *Lab Manual General Electrical Engineering.* Jacobs University Bremen.