CalPolyPomona

College of Engineering

Lab 1

Current - Voltage Characteristics of the PN Junction Diode

By:
Brandon Contreras
Daniele Ricciardelli

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Introduction

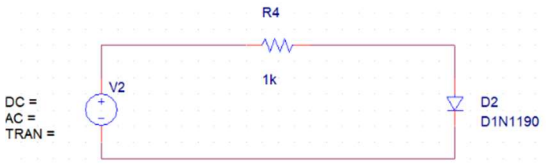
Objective:

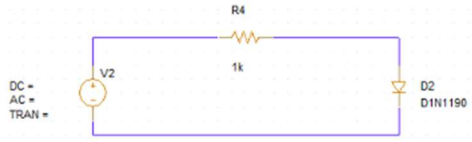
The objective is to analyze the current-voltage characteristics of semiconductor PN diodes and to calculate the reverse saturation current and diode ideality factor based on the I-V characteristic curve of the diodes.

Prelab:

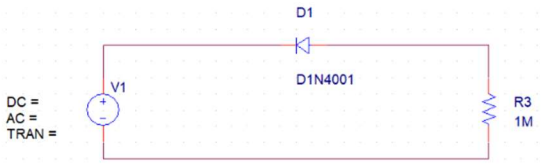
Capture schematics of Figure 1 and Figure 2 in PSpice.

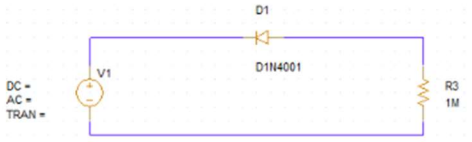
D1N1190





D1N4001





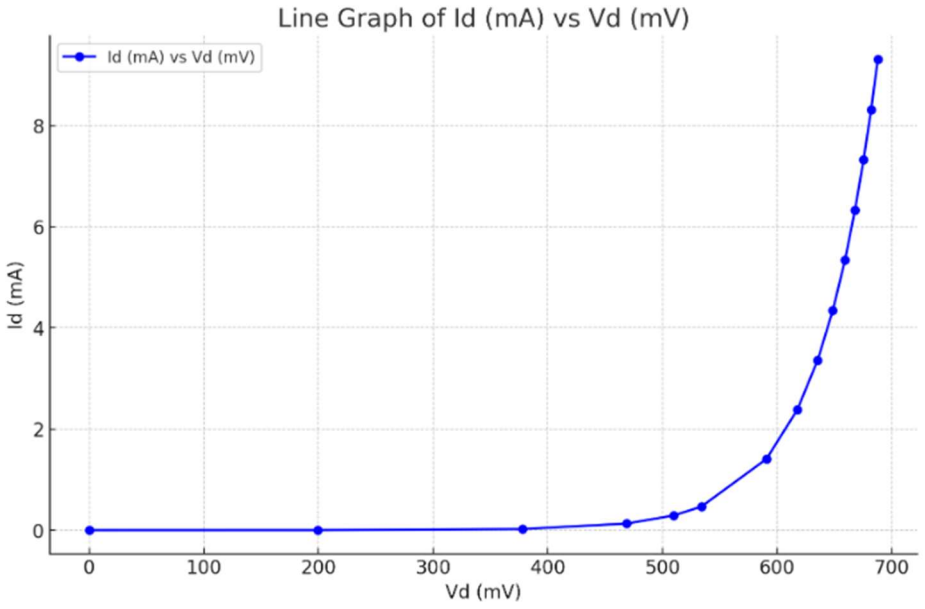
Pspice parts:

- D1N4001 PN Junction diode.
- A second diode D1N1190.
- Resistors of both 1K and 100K Ohms.

Data:

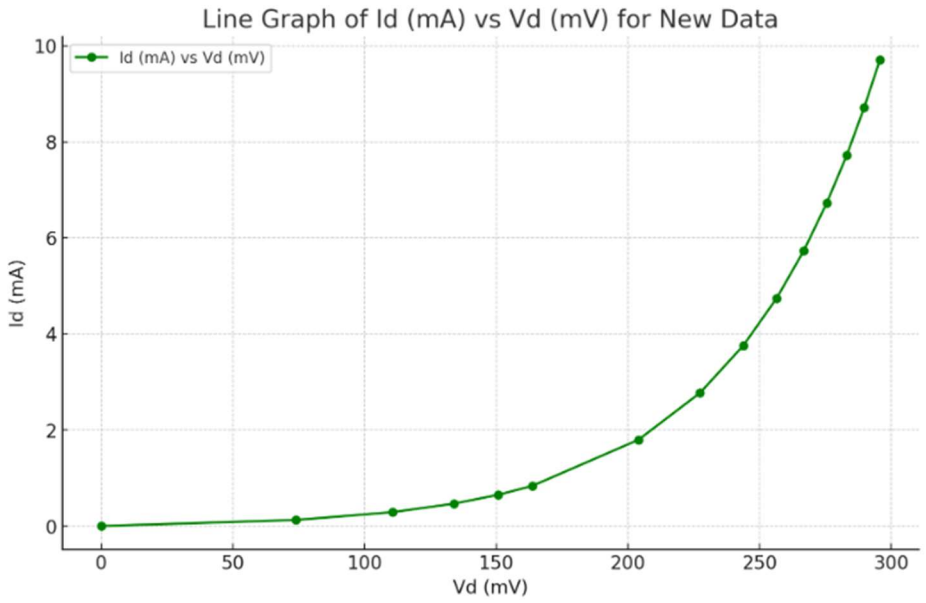
Forward Bias: D1N4001

Vs (V)	Id (mA)	Vd (mV)
0	0	0
0.2	0.0006722	199.3
0.4	0.02221	377.8
0.6	0.1311	468.9
0.8	0.2903	509.7
1	0.466	534
2	1.409	590.8
3	2.382	617.7
4	3.365	635.5
5	4.351	648.7
6	5.341	659.3
7	6.332	668
8	7.325	675.5
9	8.318	682.1
10	9.312	687.9



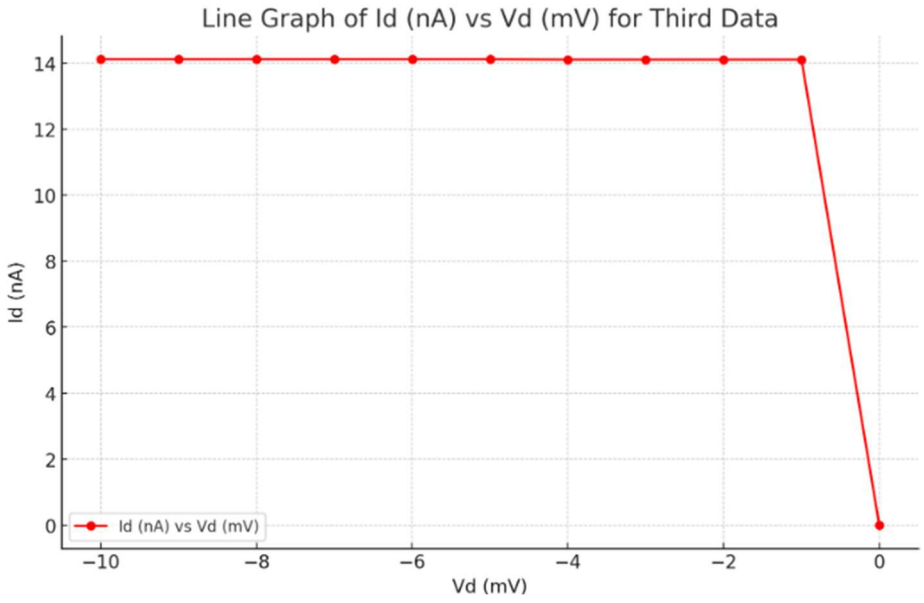
Forward Bias: D1N1190

Vs (V)	Id (mA)	Vd (mV)
0	0	0
0.2	0.1261	73.86
0.4	0.2893	110.7
0.6	0.4661	133.9
0.8	0.6493	150.7
1	0.8363	163.7
2	1.796	204
3	2.773	227.4
4	3.756	243.8
5	4.744	256.5
6	5.733	266.8
7	6.725	275.5
8	7.717	283.1
9	8.71	289.7
10	9.704	295.7



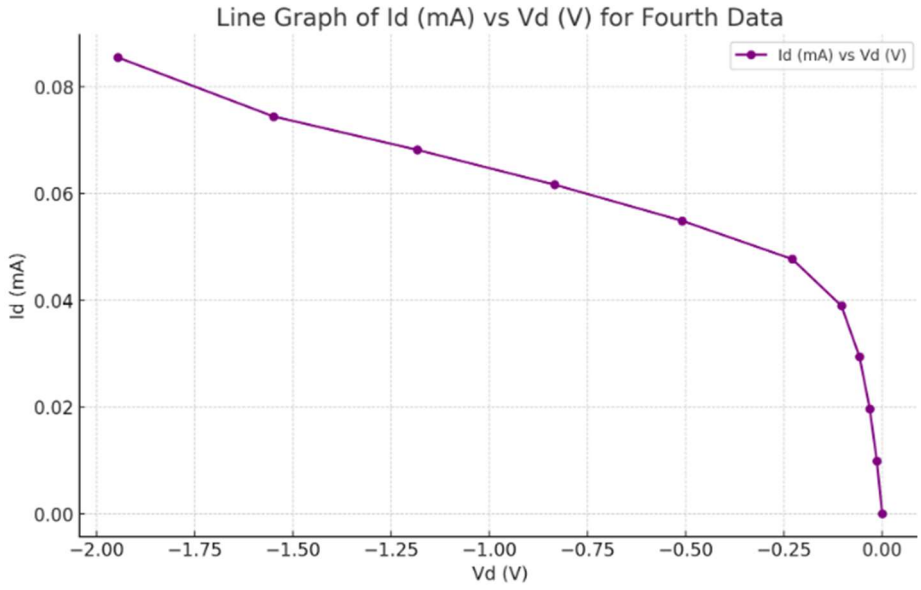
Reverse Bias: D1N4001

Vs (V)	Id (nA)	Vd (mV)
0	2.00E-17	2.01E-21
1	14.11	-0.999
2	14.11	-1.999
3	14.11	-2.999
4	14.11	-3.999
5	14.12	-4.999
6	14.12	-5.999
7	14.12	-6.999
8	14.12	-7.999
9	14.12	-8.999
10	14.12	-9.999



Reverse Bias: D1N1190

Vs (V)	Id (mA)	Vd (V)
0	4.677e-18	-4.024e-18
1	0.009863	-0.01368
2	0.01968	-0.03168
3	0.02942	-0.0578
4	0.03896	-0.1038
5	0.04771	-0.2289
6	0.0549	-0.5096
7	0.06166	-0.834
8	0.06817	-1.183
9	0.07446	-1.55
10	0.0855	-1.946



Postlab

1) From the data, calculate and tabulate the reverse saturation current Is, and the turn-on voltage Von for both diodes.

For the reverse bias in D1N4001
Id ≈ Is = 14.12 nA and for the Voltage: 0.534 V

While for the reverse bias in D1N1190: Id ≈ Is

$$I_s = \frac{i_D(-1)+i_D(-10)}{2} = \frac{0.009863 + 0.0855}{2} = 47.6815\ \mu A$$

	Von	Is
D1N4001	0.534 V	14.12 nA
D1N1190	0.204 V	47.6815 uA

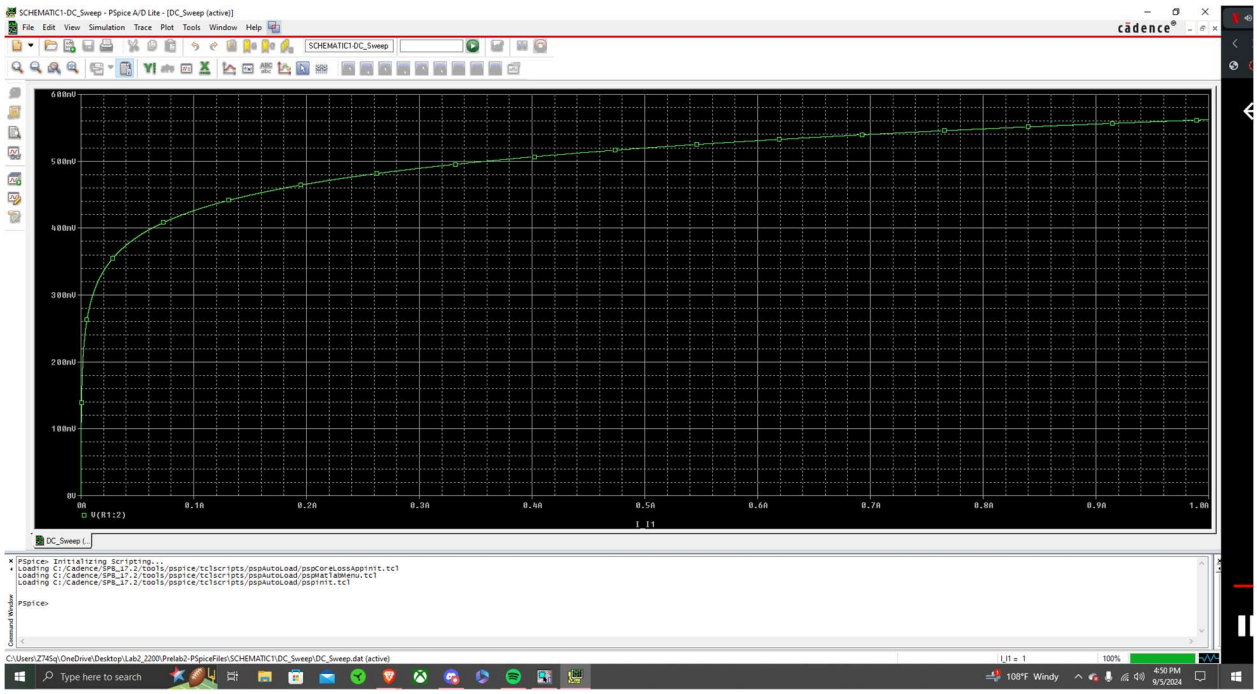
2) From the collected data, determine the type of the PN Junction diode (Si or Ge?)

D1N4001 is a Silicon Diode while the D1N1190 is Germanium Diode

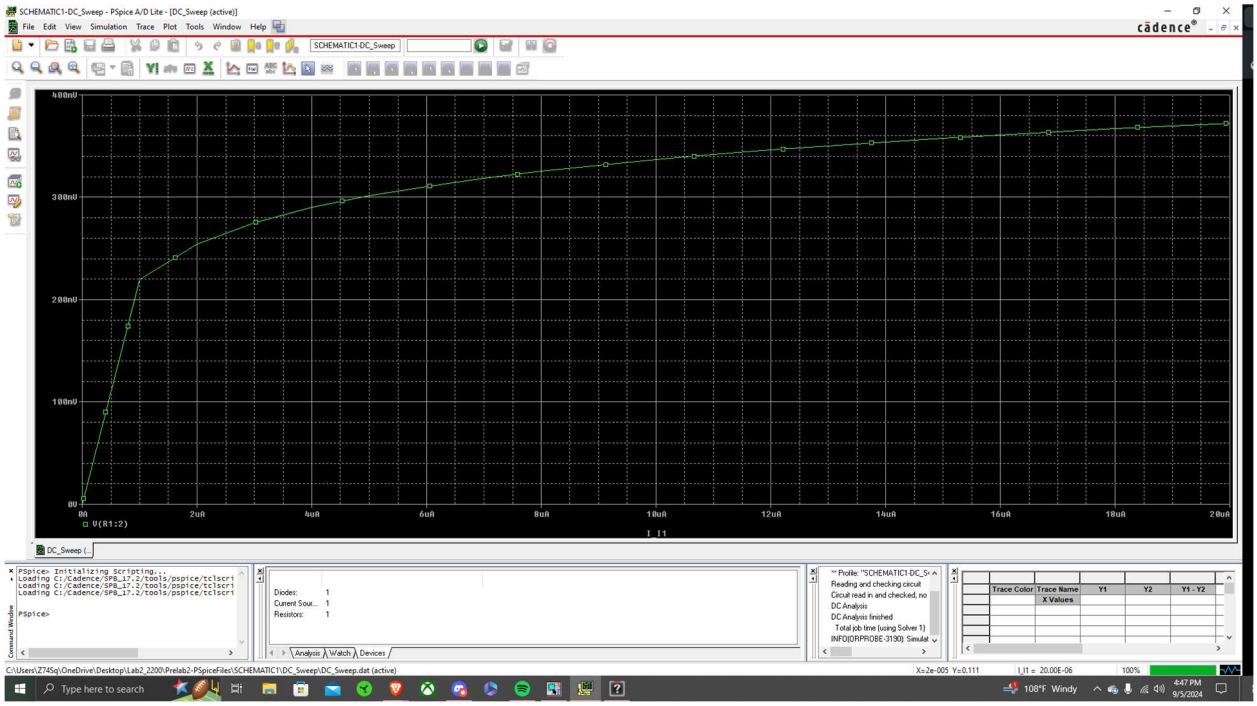
Part 2

Prelab:

D1N1190 Simulation



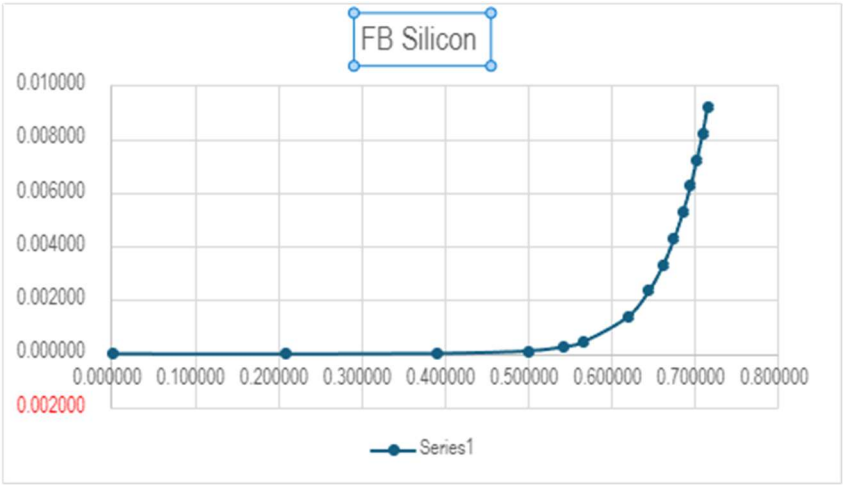
D1N4001

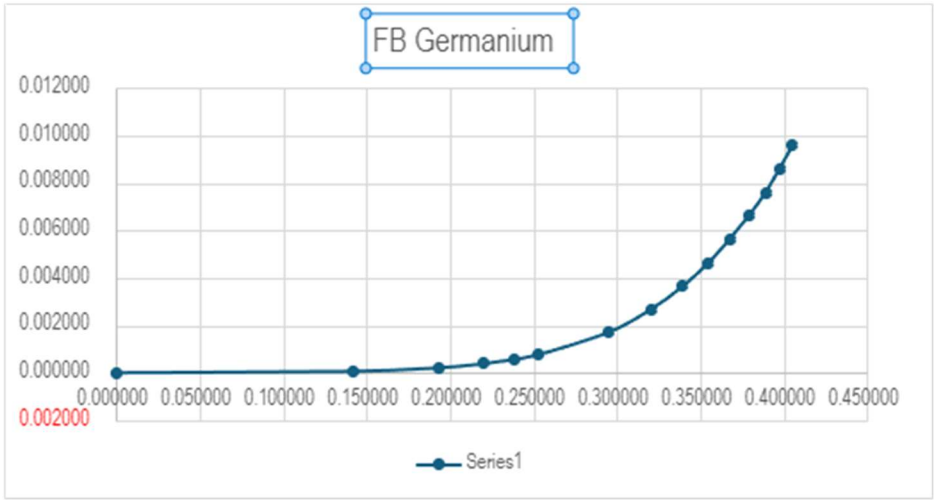


Lab

R			
1009.100000			
F.B_Silicon			
Vs	Vr	Vd	Id
0.000000	0.003100	0.003100	0.000003
0.200000	0.010300	0.210300	0.000010
0.400000	0.009200	0.390800	0.000009
0.600000	0.100000	0.500000	0.000099
0.800000	0.256500	0.543500	0.000254
1.000000	0.434000	0.566000	0.000430
2.000000	1.380300	0.619700	0.001368
3.000000	2.354800	0.645200	0.002334
4.000000	3.337700	0.662300	0.003308
5.000000	4.324700	0.675300	0.004286
6.000000	5.314100	0.685900	0.005266
7.000000	6.304900	0.695100	0.006248
8.000000	7.297500	0.702500	0.007232
9.000000	8.290400	0.709600	0.008216
10.000000	9.284600	0.715400	0.009201

R			
1000.900000			
F.B_Germaniuim			
Vs	Vr	Vd	Id
0.000000	0.000450	0.000450	0.000000
0.200000	0.058500	0.141500	0.000058
0.400000	0.206810	0.193190	0.000207
0.600000	0.380250	0.219750	0.000380
0.800000	0.561170	0.238830	0.000561
1.000000	0.747650	0.252350	0.000747
2.000000	1.705120	0.294880	0.001704
3.000000	2.679680	0.320320	0.002677
4.000000	3.660500	0.339500	0.003657
5.000000	4.645300	0.354700	0.004641
6.000000	5.632670	0.367330	0.005628
7.000000	6.621250	0.378750	0.006615
8.000000	7.611100	0.388900	0.007604
9.000000	8.602850	0.397150	0.008595
10.000000	9.595000	0.405000	0.009586





R			
1003600			
r.b_slicon			
Vs	Vr	Vd	Id
0.000000	0.002000	0.002000	0.000000
1.000000	0.002120	0.997880	0.000000
2.000000	0.002440	1.997560	0.000000
3.000000	0.003010	2.996990	0.000000
4.000000	0.003030	3.996970	0.000000
5.000000	0.003200	4.996800	0.000000
6.000000	0.003410	5.996590	0.000000
7.000000	0.003540	6.996460	0.000000
8.000000	0.003750	7.996250	0.000000
9.000000	0.003860	8.996140	0.000000
10.000000	0.004050	9.995950	0.000000

R			
1003300			
r.b_germanium			
Vs	Vr	Vd	Id
0.000000	0.020000	0.020000	0.000000
1.000000	0.616000	0.384000	0.000001
2.000000	0.690000	1.310000	0.000001
3.000000	0.760000	2.240000	0.000001
4.000000	0.779000	3.221000	0.000001
5.000000	0.835000	4.165000	0.000001
6.000000	0.860000	5.140000	0.000001
7.000000	0.895000	6.105000	0.000001
8.000000	0.931000	7.069000	0.000001
9.000000	0.982000	8.018000	0.000001
10.000000	1.020000	8.980000	0.000001

Post lab

1. Using the data (obtained from the measurement on the forward biased diode in Figure 1), calculate and tabulate the reverse saturation current Is and the ideality factor n for each diode.

How does this value of Is compares to the measured values in the circuit in Figure 2?

We have two equations we can divide, ID1 by ID2

$$I_{D1} = I_s e^{\frac{V_{D1}}{\eta V_T}}$$

$$I_{D2} = I_s e^{\frac{V_{D2}}{\eta V_T}}$$

The result of this is:

$$e^{\frac{V_{D1}-V_{D2}}{\eta V_T}}$$

Where our n is

$$\eta = \frac{V_{D1} - V_{D2}}{V_T . \ln\left(\frac{I_{D1}}{I_{D2}}\right)}$$

And our Vs's are 1V and 2V
Thus, n would be equal to 1.747, which happens to be similar to n_Ge = 1.849

Therefore, the Is for both silicon and germanium are:

$$\frac{I_D}{e^{\frac{V_D}{\eta V_T}}}$$ silicon is going to be 0.412nA

and

$$\frac{I_D}{e^{\frac{V_D}{\eta V_T}}}$$ germanium is 3.362uA

2. How does this value of Is compares to the measured values in the circuit in Figure 2?

Based on our measured values, Is is approximately zero, as it is negligible for both the germanium and silicon diodes. This indicates that the experiment was carried out successfully.

Conclusion

Based on the objectives and findings presented in this lab report, it can be concluded that the analysis of the current-voltage characteristics of PN junction diodes has been successfully performed. However, one issue we encountered during our experiments on the first part of the lab is that we were getting Vs measurements wrong due to a probe-contact issue we were able to quickly fixed after our instructor suggested possible troubleshoots. Through experimentation, we calculated key parameters such as the reverse saturation current (Is) and diode ideality factor (n) for both silicon (D1N4001) and germanium (D1N1190) diodes. The data demonstrated the distinct electrical behavior between silicon and germanium diodes, aligning with theoretical expectations. These results not only validate the experimental procedure but also provide a comprehensive understanding of diode characteristics in forward and reverse bias conditions. Overall, the experiment reinforced fundamental semiconductor concepts, highlighting the practical applications of diodes in electronic circuits.