National University of Sciences and Technology (NUST)
School of Electrical Engineering and Computer Science

Department of Electrical Engineering

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EE215: ELECTRONIC DEVICES AND CIRCUITS

Lab 03: IV Characteristics of pn-junctions

		PLO4/CLO4		PLO5/CLO5	PLO8/CLO6	PLO9/CLO7
Name	**Reg. No**	**Viva /Quiz / Lab Performance** **5 marks**	**Analysis of data in Lab Report** **5 marks**	**Modern Tool Usage** **5 marks**	**Ethics and Safety** **5 marks**	**Individual and Teamwork** **5 marks**
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Lab 03: IV Characteristics of pn-junctions

Objective: To Study the Characteristics & Applications of Diodes

1. The primary purpose of this lab is to develop a working knowledge of diode. Diodes can be used in variety of circuits for various applications such as rectifiers, clippers/clampers and voltage regulators.

EQUIPMENT REQUIRED

2. The following components and test equipment is required.
   - PN Diode (D1N4002 or any other diode of the same family)
   - Oscilloscope
   - Function Generator
   - Resistors (1k)
   - Capacitors
   - Power Supply

The Experiment:

3. The experiment is broken down into two exercises. Each exercise has further been divided into parts. Part I involves the simulation of the circuit on PSpice using Orcad-Capture module. The second part involves the practical setup of this circuit and making required measurements, tabulation and its analysis.

Exercise – I (Part A) [Simulation]

4. The first part of the experiment is to draw a graph of the I-V relationship of a diode using PSpice; this may be .accomplish by using the DC sweep analysis mode of the simulation.

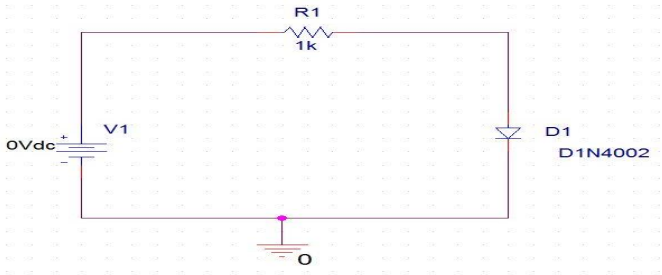


Figure-1A_1

- Draw the circuit shown in figure 1A_1 on OrCad capture. Please make sure you have saved the file.
- Since we are analyzing a diode, we would need to draw its I-V characteristic curve. To do that, we need to simulate our circuit using DC Sweep profile settings.

- Change the profile setting as shown in figure 1A_3. Please make sure that you know what do we mean by DC Sweep and how various value changes would affect the graph obtained.
- You should make sure that the name of the voltage source is V1. If there is a different name then you should change it accordingly.
- Place the current marker/probe at the anode(upper pin) of the diode and run the simulation.
- Observe the plot.

Simulation Curve for I-V:

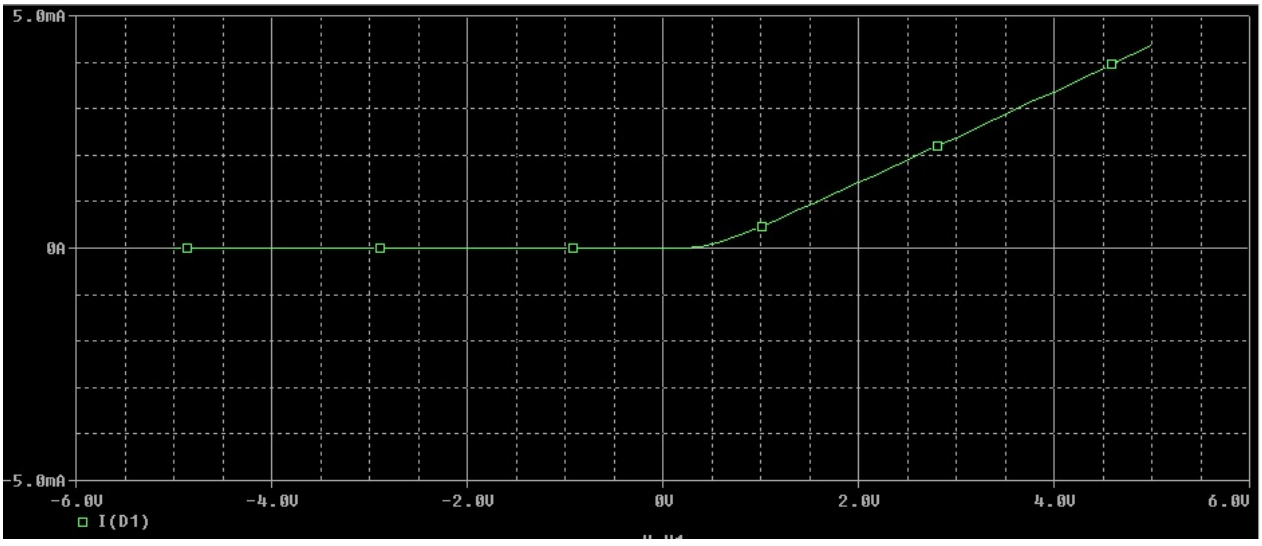


Figure 1: Straight Line Curve of Vd Vs Id

Now Change the Values of DC Sweep and enter **0.1** for **Start Value.**

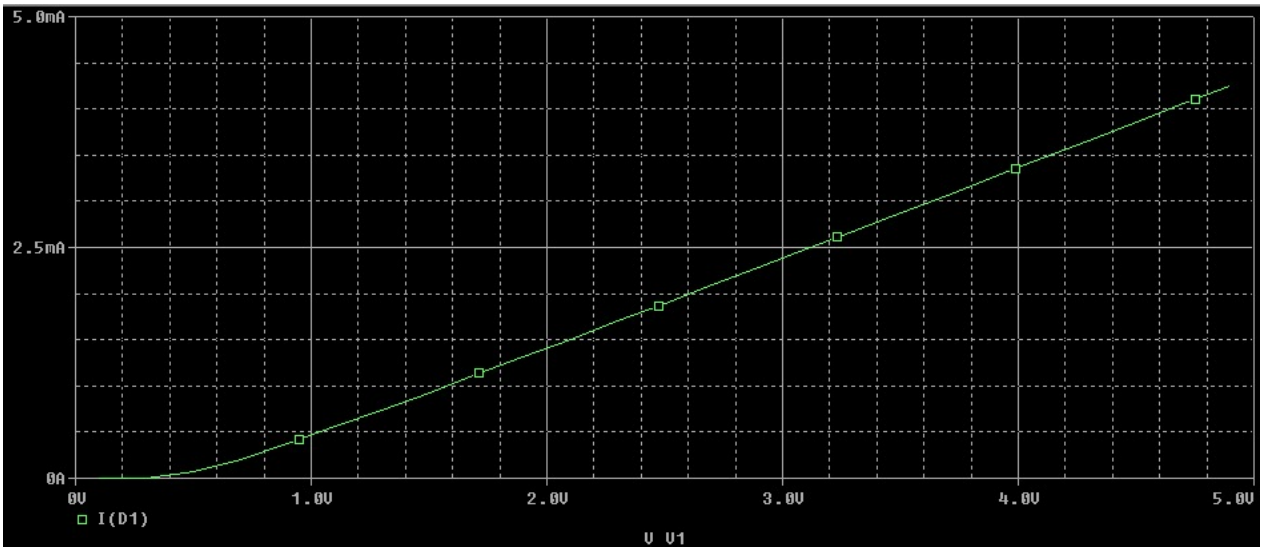
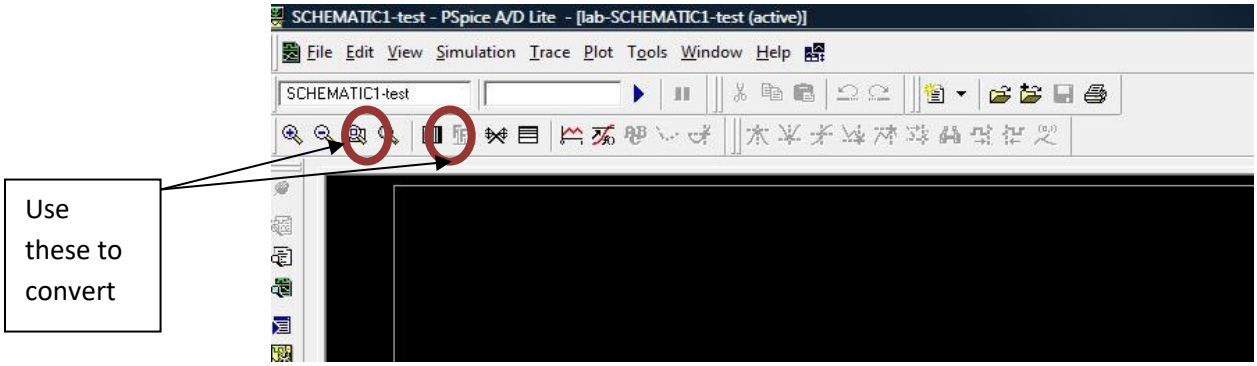
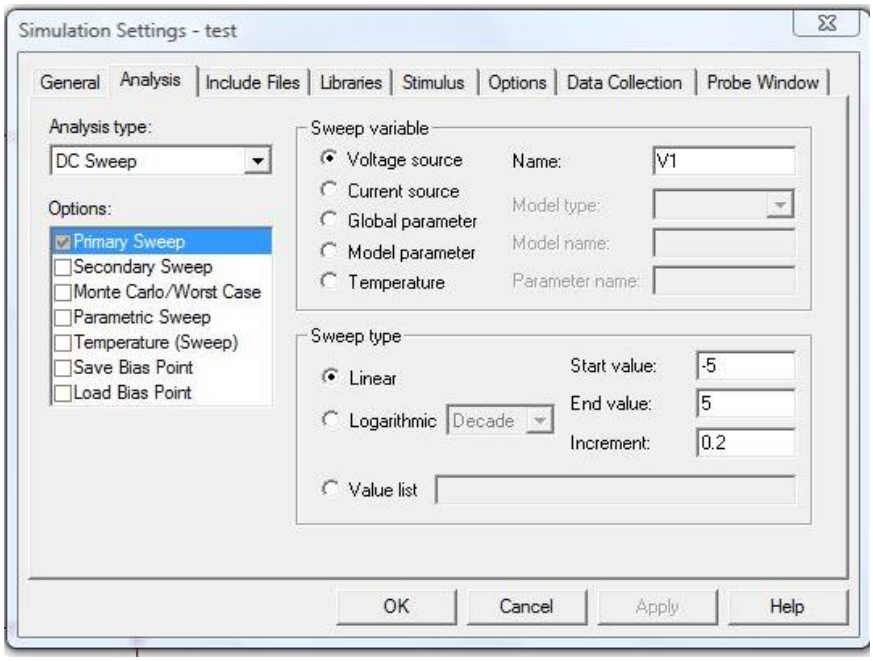


Figure 2: Linear Curve of Vin Vs Id

- Repeat the experiment by selecting logrithmic scale. This can be done by simply selecting the options shown in the given figure 1A_2.
- Note: Only change the scale on the X-Axis to log this can be done by pressing the button with **Vertical lines** as shown in figure 1A_2.



(Figure 1A_2)



(Figure 1A_3)

Logarithmic Curve:

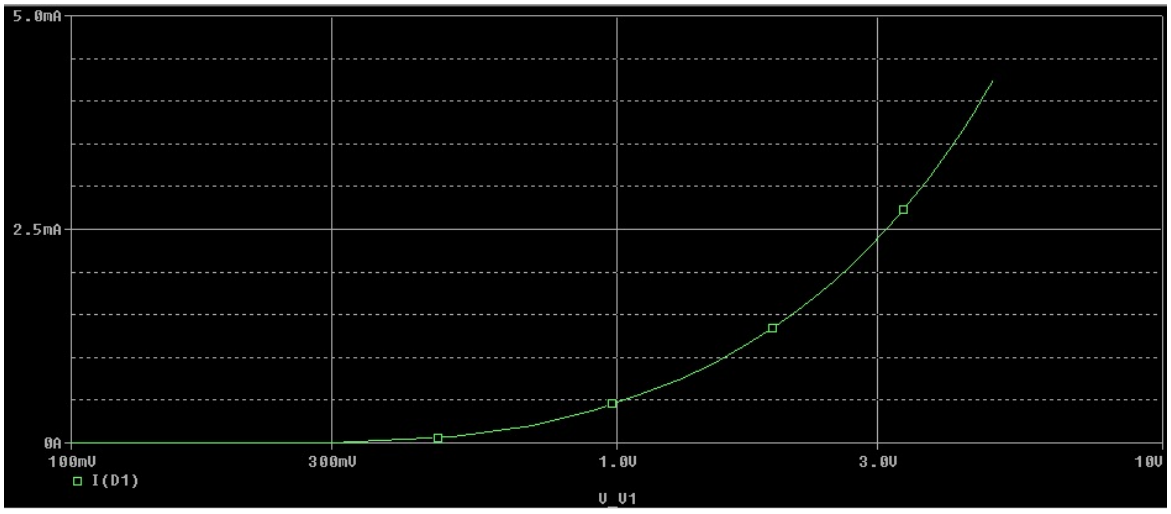


Figure 3: Logarithmic Curve

- Save both graphs and sketch them with explanation. Also, answer the following questions:

Q- How can you explain the behavior of the diode by looking at the logarithmic curve?

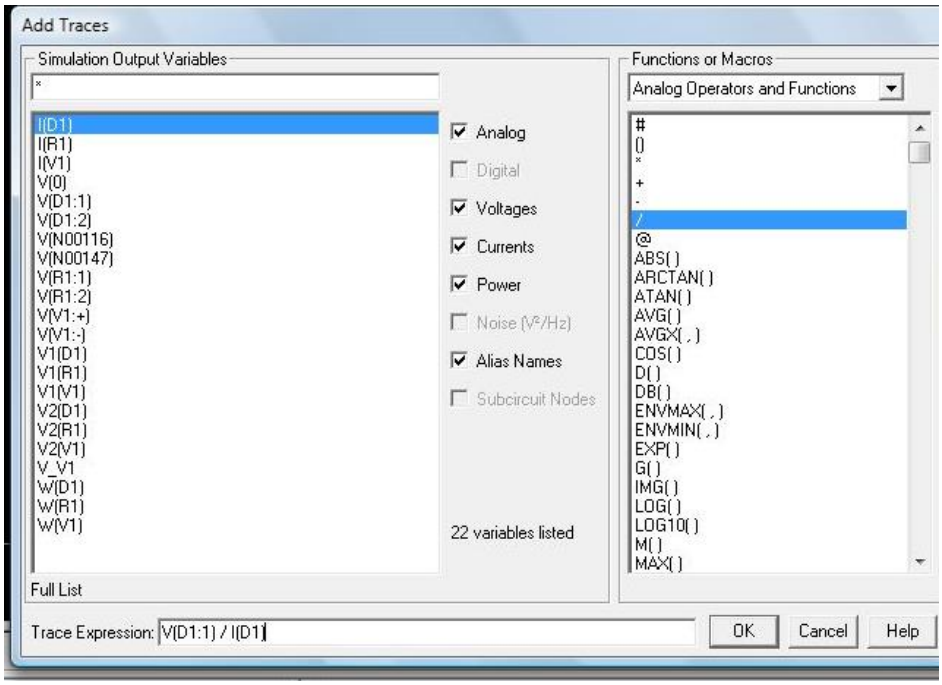
Ans: A diode displays uneven conductive properties, permitting current flow primarily in one direction (forward bias) while impeding it in the opposite direction (reverse bias). This phenomenon is delineated through its characteristic curve, portraying an exponential correlation between current and voltage. When depicted logarithmically, the curve exhibits a linear segment during forward bias, saturation during reverse bias, and a sharp rise in reverse current at breakdown voltages.

Q- What differences do you observe in the logarithmic curve and linear curve? Which scale would help you understand the diode behavior better?

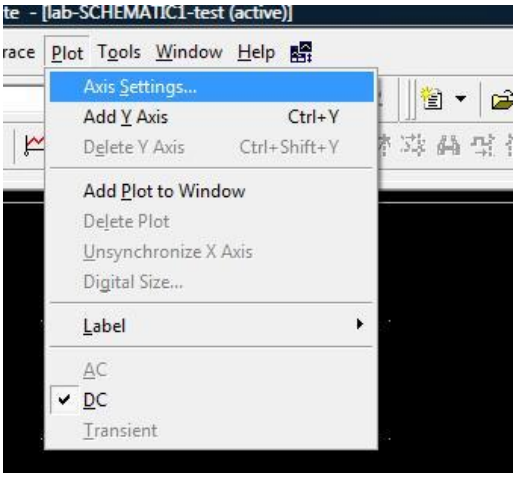
Ans: Linear curves depict the direct relationship between current and voltage, reflecting changes proportionally. Conversely, logarithmic curves exponentially compress the scale, highlighting the diode's behavior across a broader voltage range. Logarithmic representations are especially valuable for illustrating the exponential characteristics of the diode, notably in the forward bias region, where current escalates swiftly with minor voltage alterations. They offer clearer comprehension of the different operational states of the diode, encompassing forward bias, reverse bias, and breakdown.

Diode resistance is an important parameter of the diode. To observe the change in R_D with reference to increasing voltage, you need to follow the following steps:

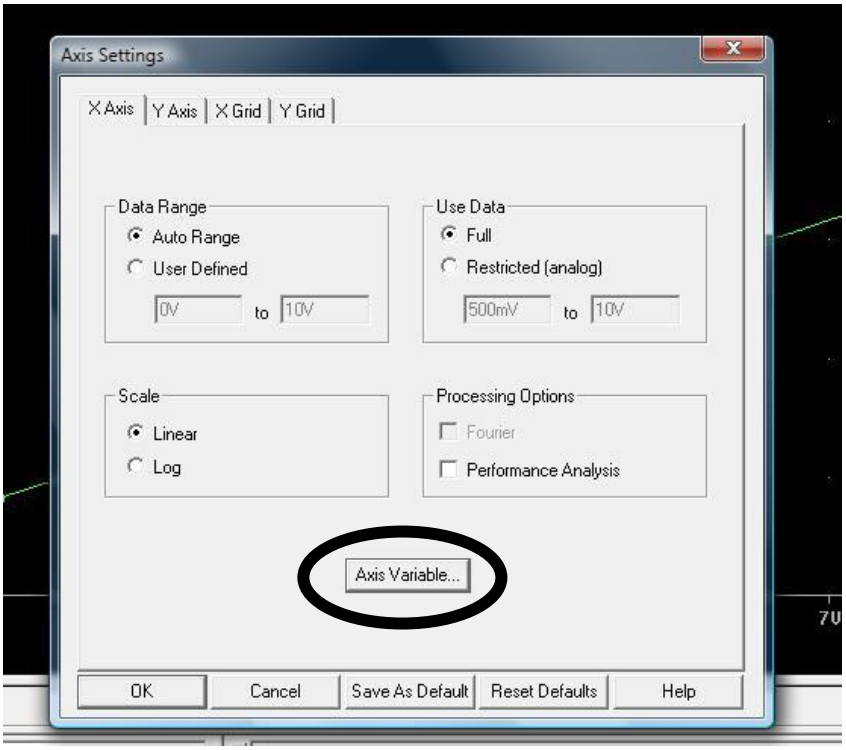
- Simulate the circuit given in figure 1A_1 using **linear scale** DC sweep simulation profile.
  Start Value:0
  End Value:5
  Increment:0.2
- After simulation, add trace as shown in the given figure 1A_4:
- Change the X-Axis to V_D or V(D1:1)
- Observe the graph obtained



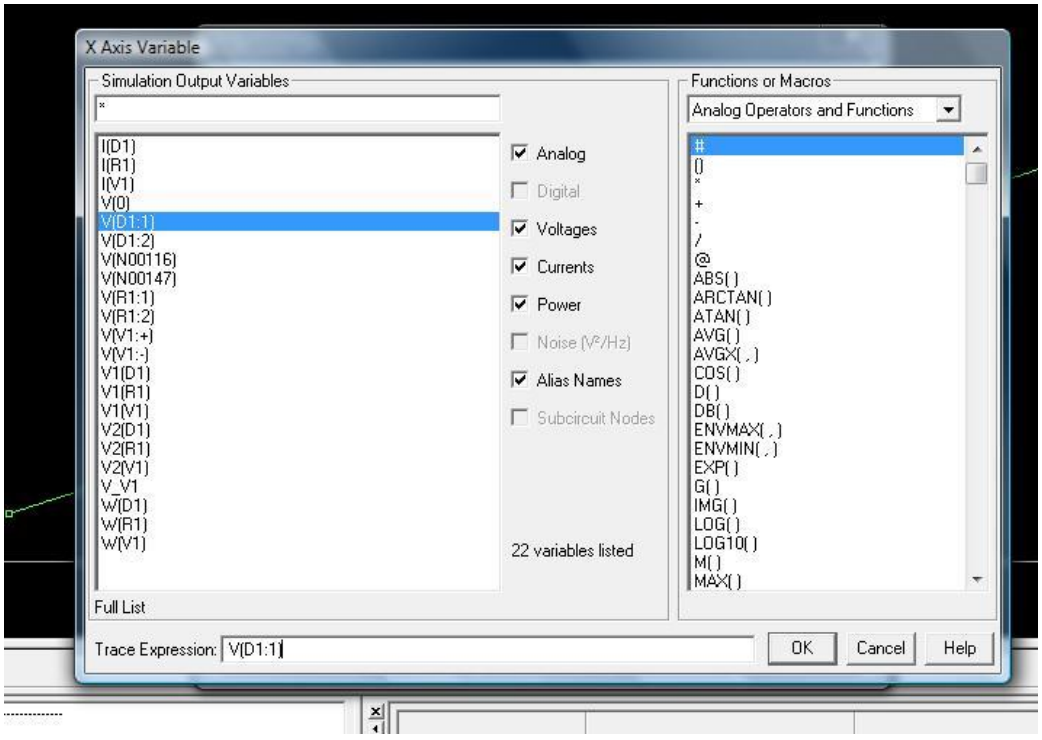
- The graph that you had seen so far was between V_{in} and I_D. Now change the x-axis variable by following the steps as shown in figure 1A_5, figure 1A_6 and figure 1A_7. This would be I_D vs V_D curve of the diode. How can you explain the behavior of the diode from this curve?



(Figure 1A_5) – Go to axis settings



(Figure 1A_6) – Here select the option "Axis Variable"



(Figure 1A_7) – Add V(D1:1) as your x-axis variable

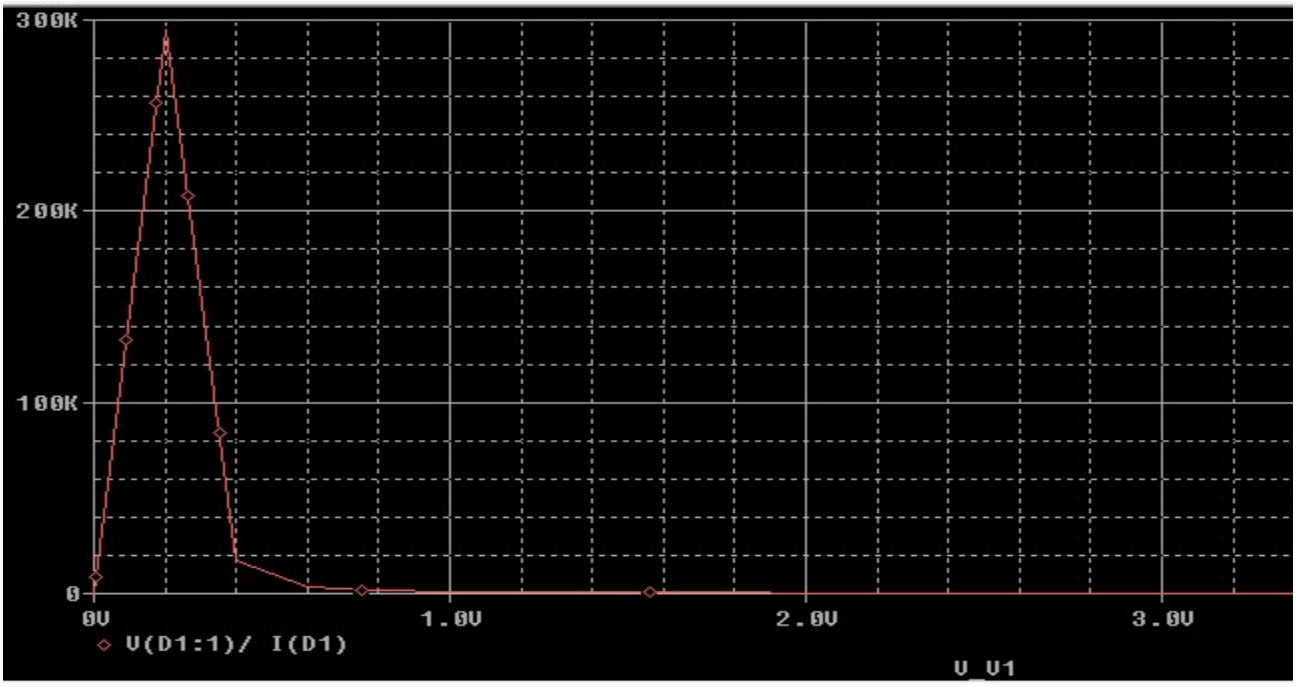


Figure 4: Rd Vs Vin

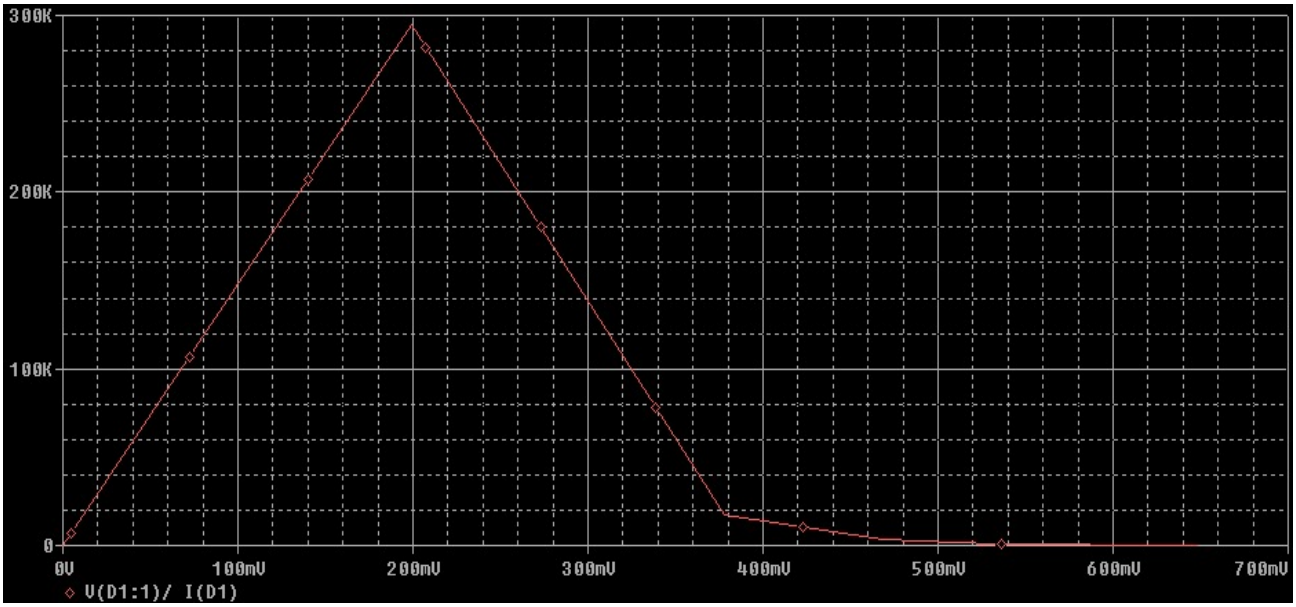


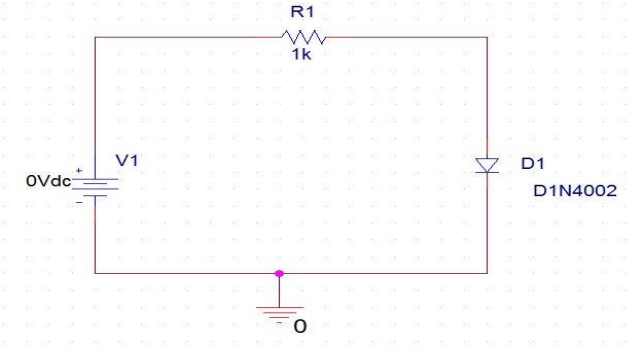
Figure 5: Rd Vs Vd

- Answer the following questions

Q- Spot the threshhold/cut-in voltage of the diode from the I-V characteristic graph? Do you think it is a silicon based diode or germanium based diode? Explain your answer.
Ans: From the graph the cut off voltage is about 0.6V and from experimental data it is understandable that it's a silicon diode which will start conducting current after forward voltage reaches 0.6V

Explain the behaviour of R_D with respect to V_D as observed in the graph drawn.
Ans: The graph indicates an initial rise in resistance, attributed to the kinetic energy causing electrons and holes to vibrate as voltage increases. Consequently, the resistance to current flow also increases. However, upon reaching the cutoff voltage, the resistance begins to decline, allowing current to flow through the diode.

Exercise – I (Part B) [Implementation]



(Figure 1B_1)

5. This part of the experiment helps the students to set a simple diode circuit and take measurements for drawing the I-V curves.

Procedure

- On a breadboard, setup the circuit given as shown in figure 1B_1.
- Apply the input voltage gradually increasing it from 0V and onwards, in steps of 0.2 volts.
- Measure and tabulate the values of I_D and V_D until V_D becomes almost constant.

Observations/Measurements:

- Plot I_D vs V_D forward characteristics using both linear scale and logarithmic scale. Please make sure that you use MS Word/excel features for both linear scale and logarithmic scale plot and include the plot in your lab report. Please follow the lab report format provided by the instructor.

- Determine the threshold voltage of the diode and explain if it is Silicon or Germanium based diode.
- Calculate the values of R_D at different input voltages. Plot the graph and explain.

Hardware Patching:

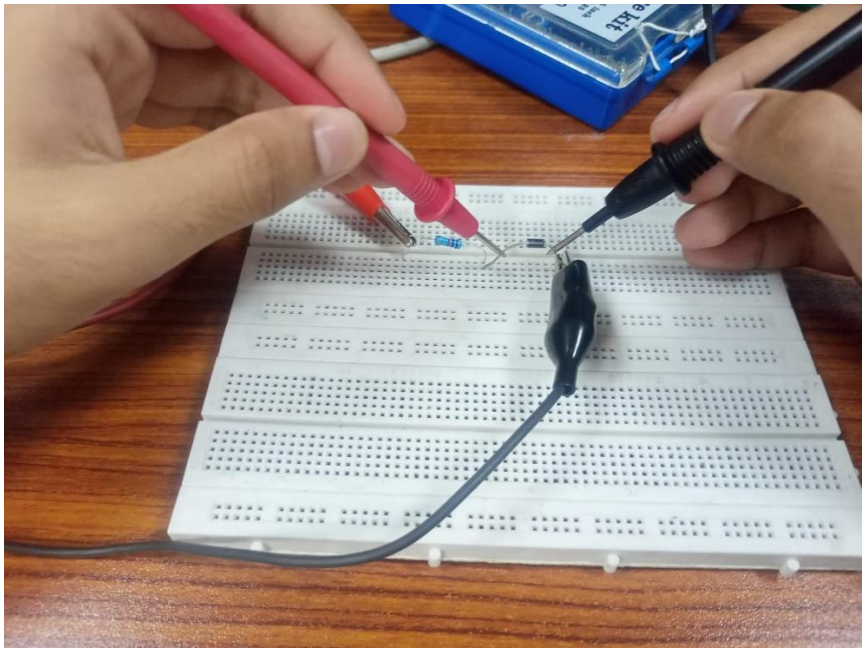


Figure 6: Patched Hardware

	A	B	C	D
1	Vin	Rd	Vd	Id
2	0	0	0.108	0
3	0.2	4348.33	0.261	0.00006
4	0.4	15.79	0.3104	0.019
5	0.6	4.826242	0.4503	0.092
6	0.8	2.75	0.4801	0.173
7	1	1.82	0.4902	0.27
8	1.2	1.34	0.5002	0.38
9	1.4	0.61	0.5173	0.87
10	1.6	0.52	0.5201	1.03
11	1.8	0.44	0.53	1.22
12	2	0.395	0.54	1.38
13	2.2	0.352	0.553	1.57
14	2.4	0.325	0.5595	1.723
15	2.6	0.291	0.5646	1.938
16	2.8	0.2728	0.5702	2.09
17	3	0.255	0.5801	2.26

Figure 7: Values Obtained from Hardware

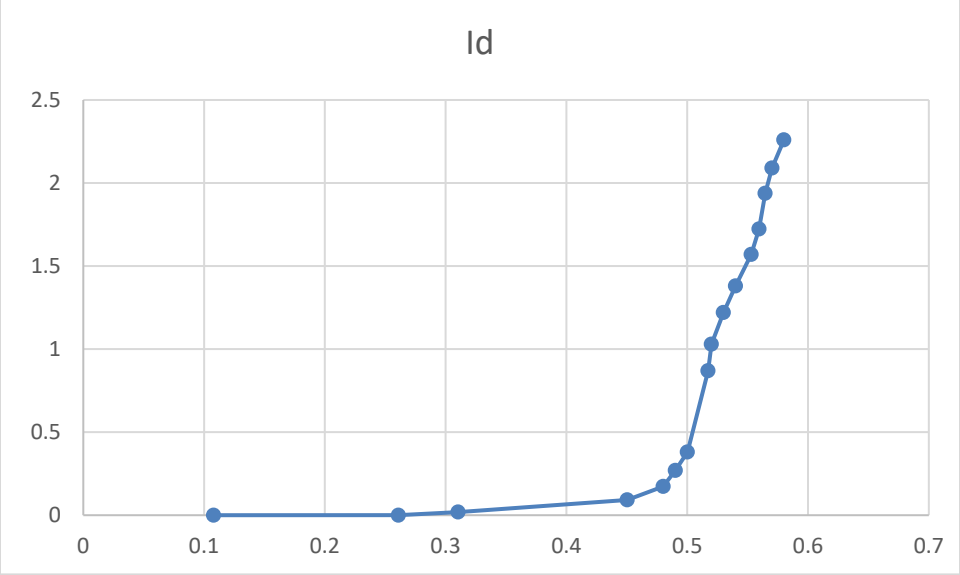


Figure 8: Vd Vs Id

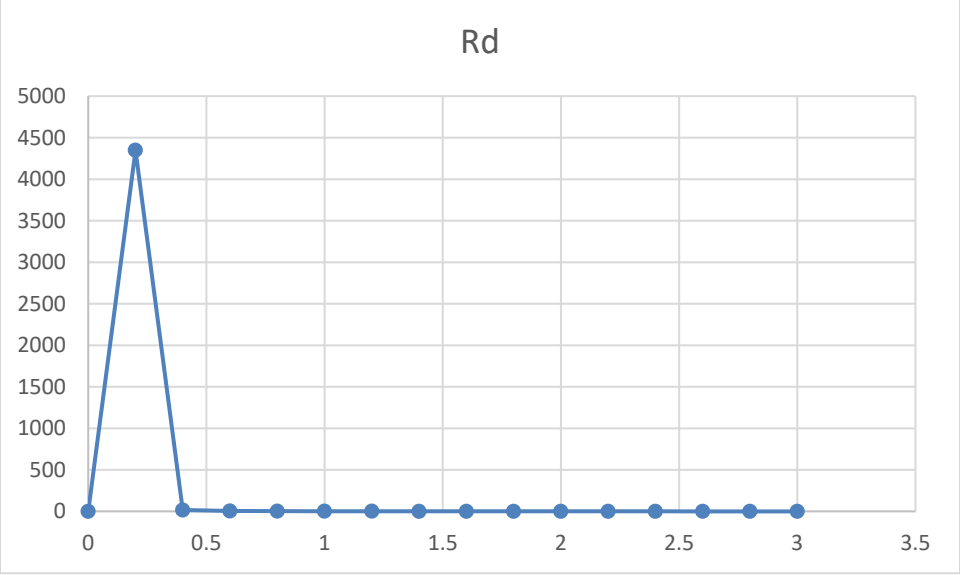


Figure 9: Vin Vs Rd

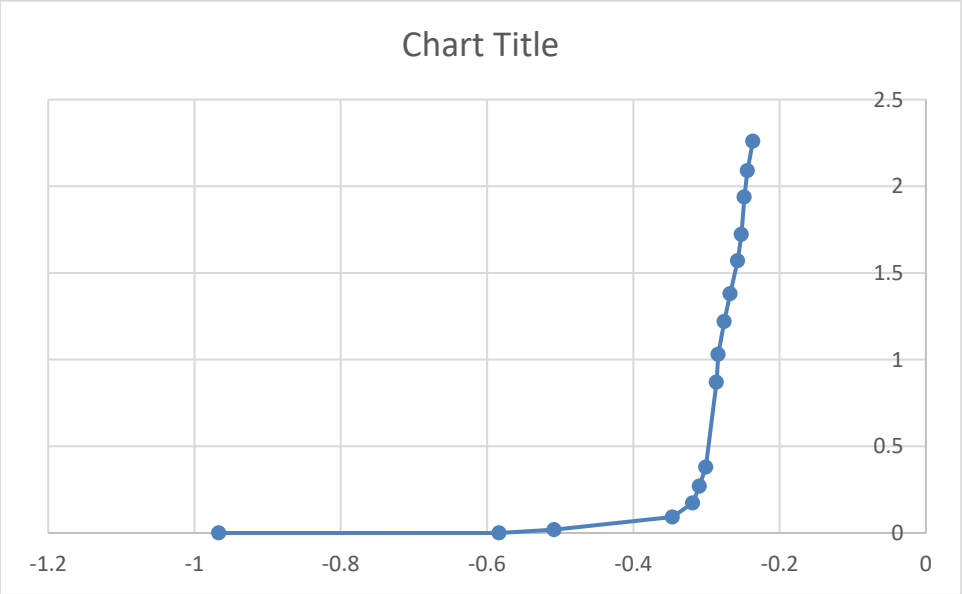


Figure 10: Logarithmic Curve

Conclusion:

In conclusion, this lab has been instrumental in cultivating a practical understanding of diodes and their versatile applications.

- Through hands-on experimentation, participants delved into the fundamental characteristics of diodes, witnessing their behavior in rectifiers, clippers/clampers, and voltage regulators.
- The exploration of current-voltage characteristics shed light on the exponential and logarithmic nature inherent in the Shockley diode equation, offering valuable insights into diode functionality.
- The acquired knowledge extends beyond theoretical concepts, emphasizing the practical relevance of diodes in real-world circuit design scenarios.

Moving forward, the skills honed in this lab are poised to contribute to future endeavors in electronic circuit design, marking this experience as a pivotal step in the journey towards mastering the intricacies of semiconductor devices and their applications.