ELEC-313
Lab 2: Diode Characterization

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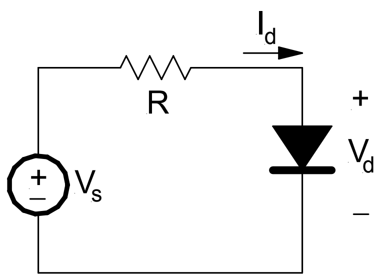
1 Objective

The objective is to observe the basic operation of a diode. In addition, the Schockley equation (Eq 2) is used to find the diode's reverse saturation current (I_S) and thermal voltage (V_T) using values measured in the lab.

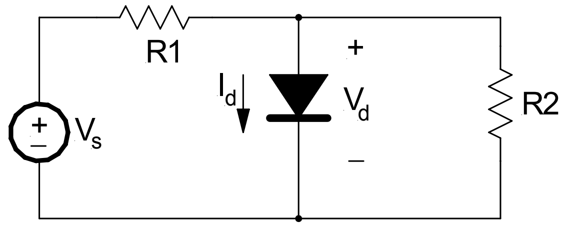
2 Equipment

Diode: 1N4002
Resistors: $330\,\Omega$, $470\,\Omega$, $680\,\Omega$
Resistive decade box: HeathKit IN-3117
Power supply: HP E3631A
Multimeter: Fluke 8010A (x2)

3 Schematics



(a) Circuit used for Parts A and Part B.



(b) Circuit used for Part C.

Figure 1: Circuits used in this lab.

4 Procedure

4.1 Part A

The circuit in Figure 1a was constructed with $R = 470\,\Omega$ and the power supply as V_s. The actual resistance was measured with one a multimeter and recorded in Table 1 along with the percent difference calculated (Eq 1). Next, the multimeters were used to measure voltage across and current through the diode (V_d and I_d, respectively) while V_s was swept from $-5\,\mathrm{V}$ to $10\,\mathrm{V}$. The step size from $-5\,\mathrm{V}$ to $0\,\mathrm{V}$ and from $5\,\mathrm{V}$ to $10\,\mathrm{V}$ was $0.5\,\mathrm{V}$, and $0.25\,\mathrm{V}$ from $0\,\mathrm{V}$ to $5\,\mathrm{V}$. These values were recorded in Table 2 and plotted in Figure 2.

4.2 Part B

The circuit in Figure 1a was constructed with the resistive decade box as R and the power supply as V_s. The multimeters were again used to measure diode voltage (V_d) and current (I_d). This time V_s was held at 10 V and R varied: 200 Ω, 500 Ω, 1 kΩ, 2 kΩ, 5 kΩ, 10 kΩ, 20 kΩ, 50 kΩ, 100 kΩ. These values were recorded in Table 3 and plotted in Figure 2.

4.3 Part C

The circuit in Figure 1b was constructed with $R_1 = 330\,\Omega$, $R_2 = 680\,\Omega$, and the power supply as $V_s = 10\,\text{V}$. The multimeters were again used to measure diode voltage (V_d) and current (I_d). Finally, the diode was removed and a multimeter was used to measure the voltage at that node (V_{OC}). These values were recorded in Table 4.

5 Results

	Nominal (Ω)	**Measured** (Ω)	**% Difference**
R_1	470	465.3	1.00

Table 1: Comparison of nominal and measured resistance in Part A.

V_s (V)	V_d (V)	I_d (mA)
-5.00	-5.000	0.01
-4.00	-4.000	0.01
-3.00	-3.000	0.01
-2.00	-2.000	0.01
-1.00	-1.000	0.01
-0.50	-0.500	0.01
0.00	0.277	0.010
0.25	0.254	0.010
0.50	0.461	0.105
0.75	0.536	0.469
1.00	0.570	0.922
1.25	0.591	1.40
1.50	0.606	1.89
1.75	0.618	2.39
2.00	0.627	2.90
2.25	0.635	3.41
2.50	0.642	3.92

V_s (V)	V_d (V)	I_d (mA)
2.75	0.648	4.44
3.00	0.653	4.95
3.25	0.658	5.47
3.50	0.662	5.99
3.75	0.666	6.51
4.00	0.670	7.03
4.25	0.673	7.55
4.50	0.676	8.08
4.75	0.679	8.60
5.00	0.682	9.13
5.50	0.687	10.18
6.00	0.692	11.23
6.50	0.696	12.30
7.00	0.699	13.36
8.00	0.706	15.49
9.00	0.712	17.66
10.00	0.717	19.84

Table 2: Diode characteristics measured in Part A.

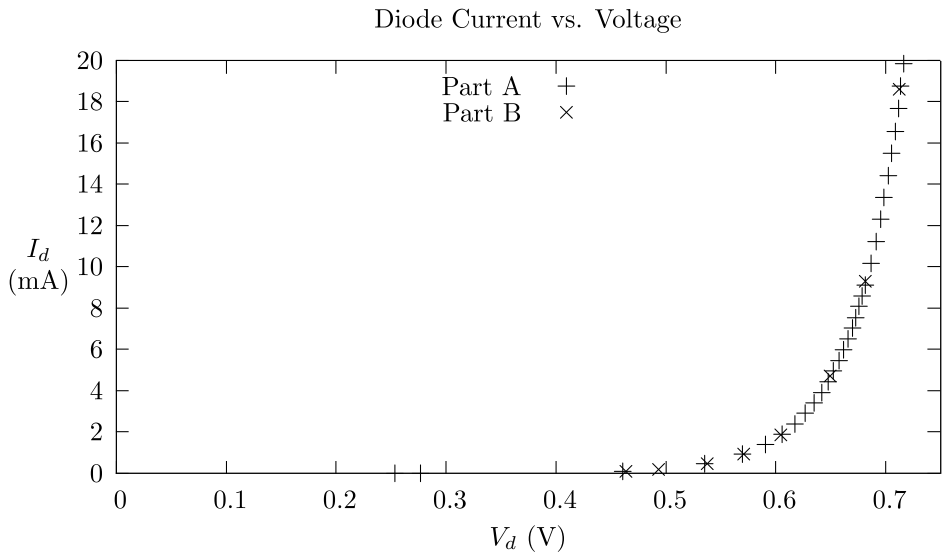


Figure 2: Diode characteristics measured in Parts A and B.

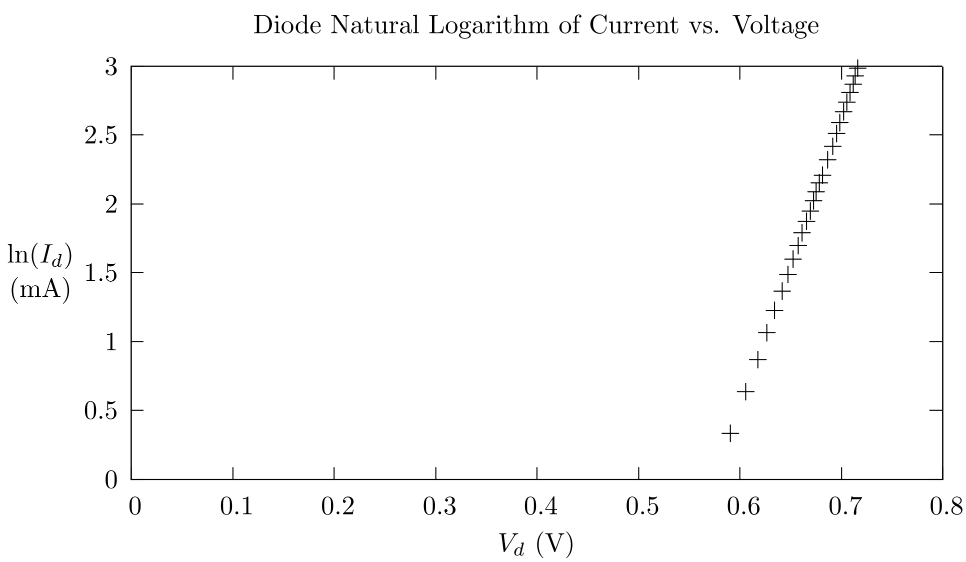


Figure 3: $\ln(I_d)$ vs. V_d.

R (Ω)	V_d (V)	I_d (mA)
200	0.751	46.00
500	0.713	18.60
1k	0.682	9.30
2k	0.650	4.70
5k	0.605	1.85
10k	0.571	0.94
20k	0.538	0.47
50k	0.494	0.19
100k	0.464	0.10

Table 3: Diode characteristics measured in Part B.

V_d (V)	I_d (mA)	V_{OC} (V)
0.712	27.2	6.70

Table 4: Diode characteristics measured in Part C.

m	V_T (V)	V_d (V)	I_d (mA)	I_s (μA)
21.772	0.046	0.687	10.18	0.325

Table 5: Results from data analysis.

6 Conclusion

As seen in Figure 3, the graph of the natural log of I_d vs. V_d derived from Part A data (Table 2) generates a linear plot. The slope (m) of this line was then calculated and used to determine the thermal voltage (V_T) (Eq 3). Two corresponding I_d and V_d values (shown in Table 5) along with V_T were plugged into the Schockley equation (Eq 2) to derive the saturation current (I_S), seen in (Table 5). The value of V_T is very close to the assumed value of 0.026 V. Also the value of I_S seems to be close to what is typically seen in circuits textbooks, thus showing that diode parameters can be calculated with the Schockley equation.

7 Equations

$$\%_{diff} = \frac{|nominal - measured|}{nominal} 100\% \tag{1}$$

$$I_D = I_S \left(e^{\frac{V_D}{V_T}} - 1 \right) \tag{2}$$

$$m = \frac{ln(I_2) - ln(I_1)}{V_2 - V_1} = \frac{1}{V_T} \tag{3}$$