CSE 251

Exp: 01

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Title: STUDY OF DIODE CHARACTERISTICS

Theory: Diode is a semiconductor device that allows current flow in only one direction from p to n or anode to cathode. Ideally we want a diode to behave like an electronic valve. That is it should allow any amount of current in one direction while blocking all the currents in the opposite direction. These can be characterize using the current and voltage relation between the diode which is also known as the IV characteristics of the device. Real diodes are made of semiconductor materials which have highly non linear IV characteristics. It is shown as $I_D = I_S\left(e^{\frac{V_D}{nV_T}} - 1\right)$ - here there are two special cases.

- When $V_D \gg nV_T$ then e^{V_D/nV_T} will be much higher than 1. We can ignore 1.
- When $V_D < 0$! in this e^{V_D/nV_T} will be negligible compared to 1. Hence we can ignore the exp() term.

As the diode IV characteristics is not linear, it will have different resistances at different points on the curve. A dynamic or AC resistance for the diode is is defined as,

$$r_d = \frac{dv}{di} \simeq \frac{nV_T}{ID}$$

Materials and Methods:

Materials used are

i) p-n junction diode (IN4007) - x1
ii) Resistor (1 kΩ) - x1
iii) DC power supply
iv) Breadboard
v) wire
vi) Digital multimeter.

The methods we used are:

i) Measuring resistance accurately using a digital multimeter.
ii) Constructing the circuit as shown in the figure. Vary input voltage V_{dc} from 0v to 14v and measure V and V_D. Increase V_{dc} in 0.1v steps for 0v to 1v. and then in 1v steps for 1v to 14v.
iii) For each value of V_{dc}. also calculated the diode current using $I_R = V_R$.
iv) Plotted diode IV characteristics of the diode for different reading obtained
v) Calculating the diode ideality factor, and the reverse Saturation current I_s, using the diode equation assuming $V_D >> V_T$
vi) Calculating Static and dynamic resistance for I_D = 2.8 and 12 mA.

Data Table

$R = 1k\Omega$ (measure the accurate resistance using the digital multi-meter)

Supply Voltage, V_{DC} (v)	Diode Voltage, V_D (v)	Voltage across the Resistor, V_R (v)	Diode Current, $I_D = I_R = V_R/R$ (mA)
0	0	0	0
0.1	91.4×10^{-3}	0	0
0.2	150.2×10^{-3}	0	0
0.3	270.3×10^{-3}	0.1×10^{-3}	2.703×10^{-5}
0.4	372.3×10^{-3}	1.8×10^{-3}	4.835×10^{-3}
0.5	0.455	21.9×10^{-3}	0.048
0.6	0.494	63.2×10^{-3}	0.128
0.7	0.522	135.9×10^{-3}	0.262
0.8	0.544	236.9×10^{-3}	0.435
0.9	0.553	302.1×10^{-3}	0.546
1	0.566	370.2×10^{-3}	1.16
2	0.614	1.304	2.124
4	0.626	2.201	3.659
6	0.670	5.22	7.79
8	0.682	6.73	9.37
10	0.692	8.88	12.83
12	0.699	11.08	15.85
13	0.703	11.75	16.714
14	0.706	13	18.414

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Calculation

Determining Ideality Factor, n

Let, $\alpha = \frac{1}{nV_T}$

Take any two data from the table: $I_{D1} = I_S \exp(\alpha V_{D1})$ and $I_{D2} = I_S \exp(\alpha V_{D2})$

Taking ratio of I_{D1} and I_{D2},

$$\Rightarrow \frac{I_{D1}}{I_{D2}} = \exp(\alpha(V_{D1} - V_{D2}))$$

$$\Rightarrow \alpha = \frac{\ln\left(\frac{I_{D1}}{I_{D2}}\right)}{V_{D1}-V_{D2}} = \frac{1}{nV_T} \qquad \Rightarrow n = \frac{1}{\alpha V_T}$$

Determining Static (R_D) and Dynamic (r_D) Resistance

$$R_D = V_D/I_D$$

$$r_D \approx \frac{nV_T}{I_D}$$

0.988Ω

$I_{D_1} = 16.714\ mA$

$I_{D_2} = 18.414\ mA$

We know,

$$I_D = I_S \exp(\alpha V_D)$$

$$I_{D_1} = I_S \exp(\alpha V_{D_1})$$

$$I_{D_2} = I_S \exp(\alpha V_{D_2})$$

now,

$$\frac{I_{D_1}}{I_{D_2}} = \frac{I_S \exp(\alpha V_{D_1})}{I_S \exp(\alpha V_{D_2})}$$

$$\alpha (V_{D_1} - V_{D_2}) = \ln\left(\frac{I_{D_1}}{I_{D_2}}\right)$$

$$\Rightarrow \alpha = \frac{\ln\left(\frac{I_{D_1}}{I_{D_2}}\right)}{V_{D_1} - V_{D_2}}$$

$$= \frac{\ln\left(\frac{16.714}{18.414}\right)}{(0.703 - 0.706)}$$

$$= 32.1703$$

$$\alpha = \frac{1}{n V_T}$$

$$n = \frac{1}{32.1703 \times 0.025}$$

$$\therefore n = 1.239$$

$$\alpha = \frac{1}{n V_T}$$

$$\alpha = \frac{1}{\alpha \times V_T}$$

$$= \frac{1}{32 \times 0.025}$$

$$=$$

Discussion :

While doing the experiment there was fluctuation of voltage source. We also faced problem in the voltage meter. There were also problem when implementing the circuit in bread board.