



COLLEGE OF ENGINEERING AND TECHNOLOGIES
ALMUSTAQBAL UNIVERSITY

Electronics

CTE 207

Lecture 6

- Resistance levels -

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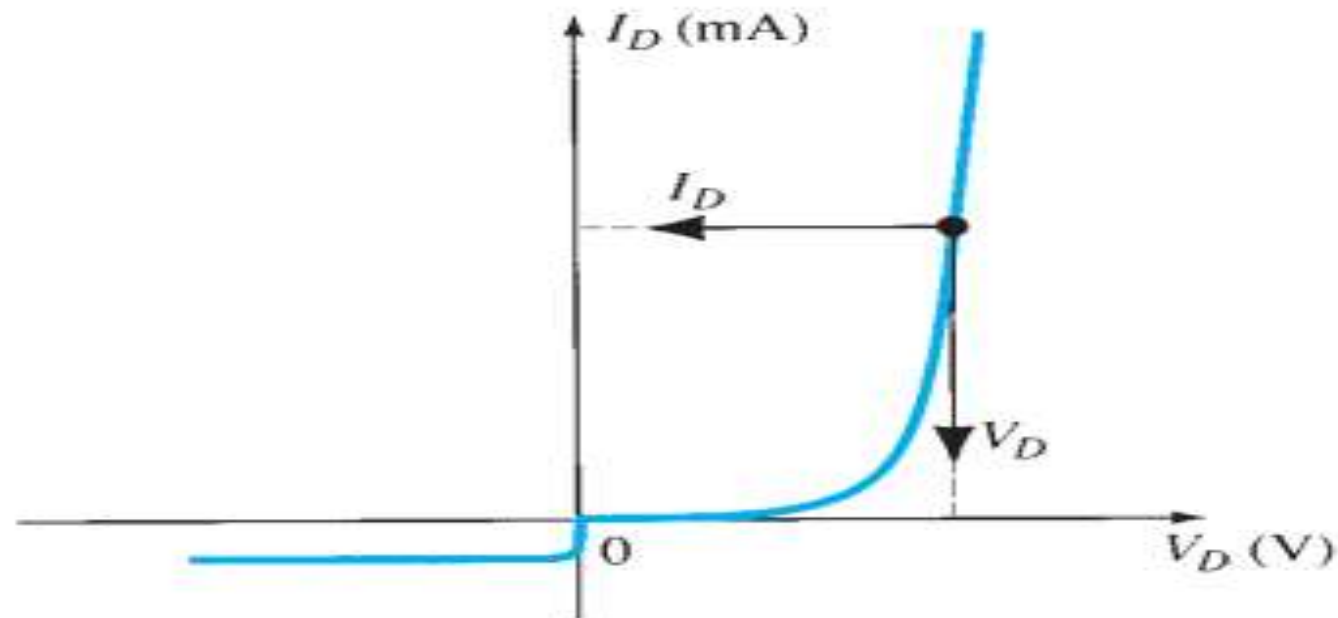
- As the operating point of a diode moves from one region to another the resistance of the diode will also change due to the nonlinear shape of the characteristic curve.
- The type of applied voltage or signal will define the resistance level of interest.
- There are three different levels of diode resistance :
 - DC or Static Resistance.
 - AC or Dynamic Resistance.
 - Average AC Resistance.

- The application of a dc voltage to a circuit containing a semiconductor diode will result in an operating point on the characteristic curve that will not change with time.
- The resistance of the diode at the operating point can be found simply by finding the corresponding levels of V_D and I_D as shown in Figure below and applying the following equation:

$$R_D = \frac{V_D}{I_D}$$

- In general, therefore, the lower the current through a diode the higher the dc resistance level.

DC or static resistance

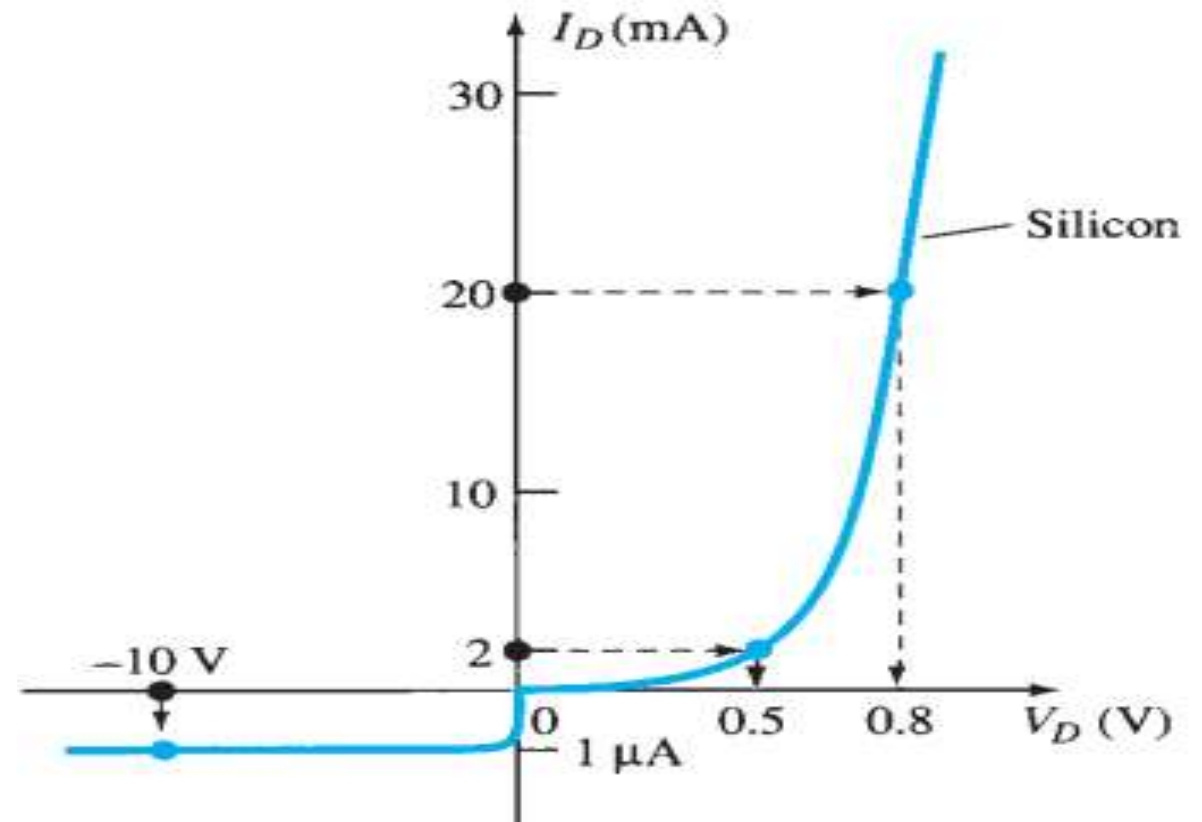


DC resistance of a diode

Example 1

Determine the dc resistance levels for the diode of Figure below at

- $I_D = 2 \text{ mA}$ (low level).
- $I_D = 20 \text{ mA}$ (high level).
- $V_D = 10 \text{ V}$ (reverse-biased).



a. At $I_D = 2 \text{ mA}$, $V_D = 0.5 \text{ V}$ (from the curve) and

$$R_D = \frac{V_D}{I_D} = \frac{0.5 \text{ V}}{2 \text{ mA}} = \mathbf{250 \Omega}$$

b. At $I_D = 20 \text{ mA}$, $V_D = 0.8 \text{ V}$ (from the curve) and

$$R_D = \frac{V_D}{I_D} = \frac{0.8 \text{ V}}{20 \text{ mA}} = \mathbf{40 \Omega}$$

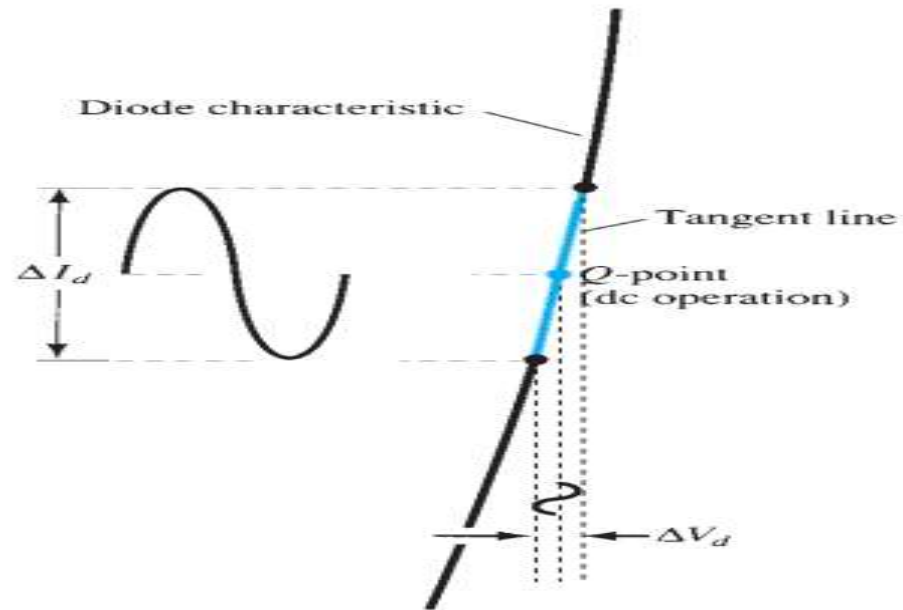
c. At $V_D = -10 \text{ V}$, $I_D = -I_s = -1 \mu\text{A}$ (from the curve) and

$$R_D = \frac{V_D}{I_D} = \frac{10 \text{ V}}{1 \mu\text{A}} = \mathbf{10 \text{ M}\Omega}$$

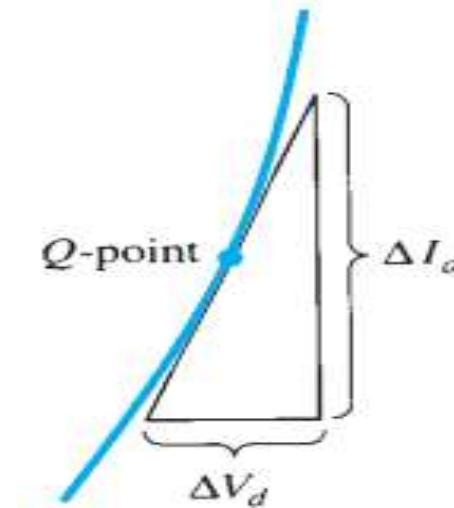
- If a sinusoidal rather than dc input is applied, the situation will change completely.
- The varying input will move the instantaneous operating point up and down a region of the characteristics and thus defines a specific change in current and voltage as shown in Figure below.
- The point of operation would be the Q-point appearing on Figure below.

$$r_d = \frac{\Delta V_d}{\Delta I_d}$$

AC or Dynamic resistance



Dynamic or ac resistance

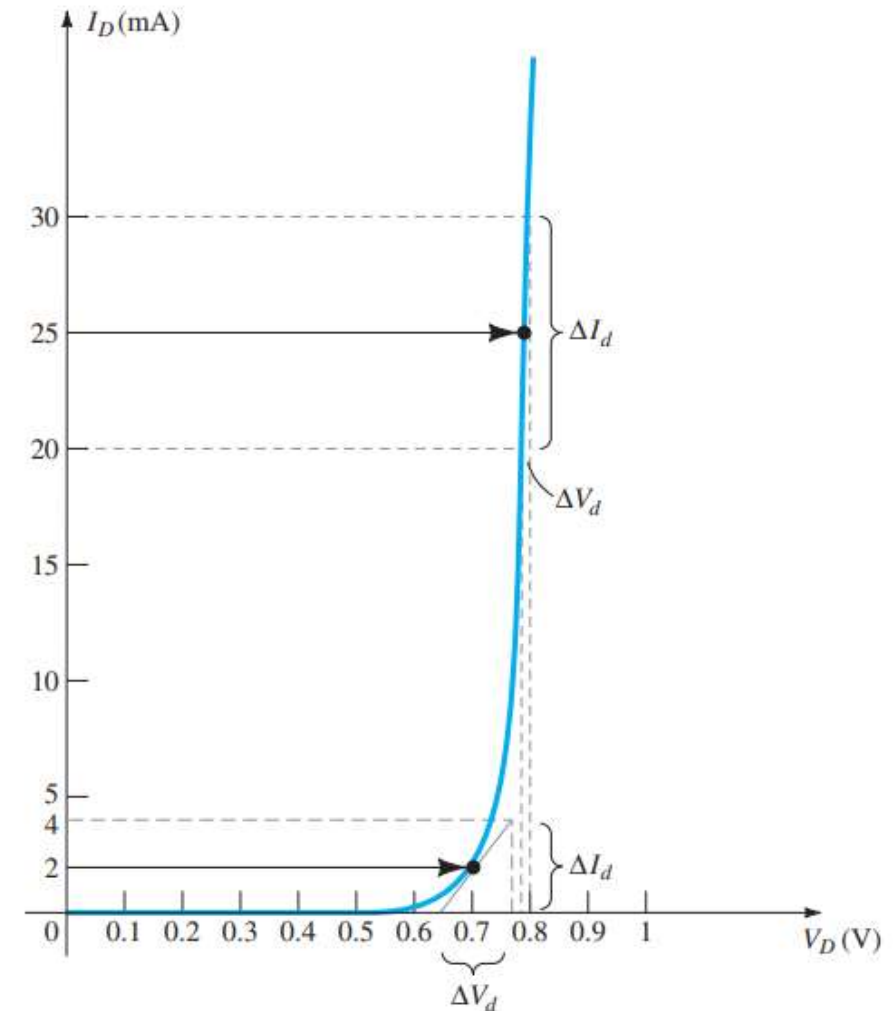


AC resistance at a Q-point.

Example 2

For the characteristics of Figure below :

- Determine the ac resistance at $I_D = 2 \text{ mA}$.
- Determine the ac resistance at $I_D = 25 \text{ mA}$.
- Compare the results of parts (a) and (b) to the dc resistances at each current level.



- a. For $I_D = 2$ mA, the tangent line at $I_D = 2$ mA was drawn as shown in Fig. 1.27 and a swing of 2 mA above and below the specified diode current was chosen. At $I_D = 4$ mA, $V_D = 0.76$ V, and at $I_D = 0$ mA, $V_D = 0.65$ V. The resulting changes in current and voltage are, respectively,

$$\Delta I_d = 4 \text{ mA} - 0 \text{ mA} = 4 \text{ mA}$$

and

$$\Delta V_d = 0.76 \text{ V} - 0.65 \text{ V} = 0.11 \text{ V}$$

and the ac resistance is

$$r_d = \frac{\Delta V_d}{\Delta I_d} = \frac{0.11 \text{ V}}{4 \text{ mA}} = \mathbf{27.5 \Omega}$$

- b. For $I_D = 25$ mA, the tangent line at $I_D = 25$ mA was drawn as shown in Fig. 1.27 and a swing of 5 mA above and below the specified diode current was chosen. At $I_D = 30$ mA, $V_D = 0.8$ V, and at $I_D = 20$ mA, $V_D = 0.78$ V. The resulting changes in current and voltage are, respectively,

$$\Delta I_d = 30 \text{ mA} - 20 \text{ mA} = 10 \text{ mA}$$

and

$$\Delta V_d = 0.8 \text{ V} - 0.78 \text{ V} = 0.02 \text{ V}$$

and the ac resistance is

$$r_d = \frac{\Delta V_d}{\Delta I_d} = \frac{0.02 \text{ V}}{10 \text{ mA}} = \mathbf{2 \Omega}$$

c. For $I_D = 2 \text{ mA}$, $V_D = 0.7 \text{ V}$ and

$$R_D = \frac{V_D}{I_D} = \frac{0.7 \text{ V}}{2 \text{ mA}} = \mathbf{350 \Omega}$$

which far exceeds the r_d of 27.5Ω .

For $I_D = 25 \text{ mA}$, $V_D = 0.79 \text{ V}$ and

$$R_D = \frac{V_D}{I_D} = \frac{0.79 \text{ V}}{25 \text{ mA}} = \mathbf{31.62 \Omega}$$

which far exceeds the r_d of 2Ω .

- If the input signal is sufficiently large to produce a broad swing such as indicated in Fig. 7 , the resistance associated with the device for this region is called the average ac resistance.
- The average ac resistance is, by definition, the resistance determined by a straight line drawn between the two intersections established by the maximum and minimum values of input voltage.

$$r_{av} = \left. \frac{\Delta V_d}{\Delta I_d} \right|_{\text{pt. to pt.}}$$

Average AC Resistance

$$\Delta I_d = 17 \text{ mA} - 2 \text{ mA} = 15 \text{ mA}$$

$$\Delta V_d = 0.725 \text{ V} - 0.65 \text{ V} = 0.075 \text{ V}$$

$$r_{av} = \frac{\Delta V_d}{\Delta I_d} = \frac{0.075 \text{ V}}{15 \text{ mA}} = 5 \Omega$$

