AL MUSTAQBAL UNIVERSITY

COLLEGE OF ENGINEERING AND TECHNOLOGIES

ALMUSTAQBAL UNIVERSITY

Electronics Fundamentals

CTE 204

Lecture 6

- Resistance levels -

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Introduction

- 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.

DC or static resistance

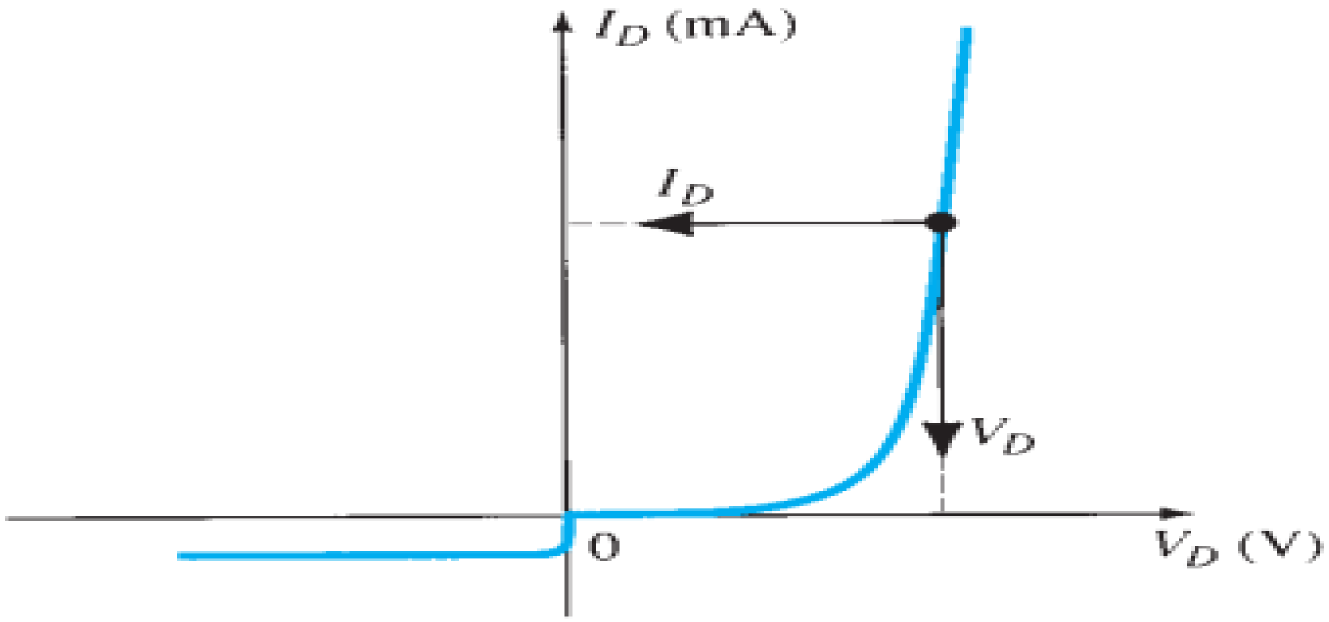
- The application of a dc voltage to a circuit containing a semiconductor diode will result in an operating point on the characteristic curve that will not change with time.

- The resistance of the diode at the operating point can be found simply by finding the corresponding levels of VD and ID 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

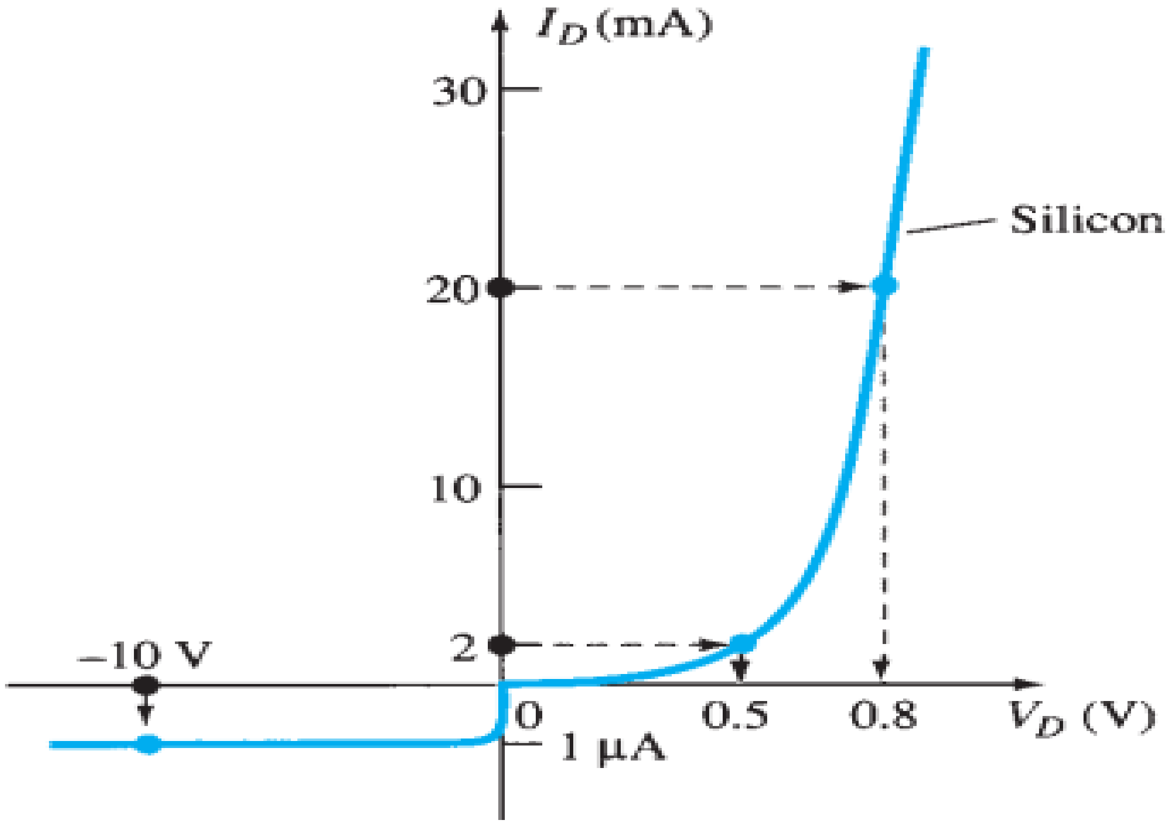
Example 1

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

a. ID = 2 mA (low level).

b. ID = 20 mA (high level).

c. VD = 10 V (reverse-biased).



Solution

a. At $I_D = 2$ mA, $V_D = 0.5$ 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 $I_D = 20$ mA, $V_D = 0.8$ 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 $V_D = -10$ V, $I_D = -I_s = -1\ \mu$A (from the curve) and

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

AC or Dynamic resistance

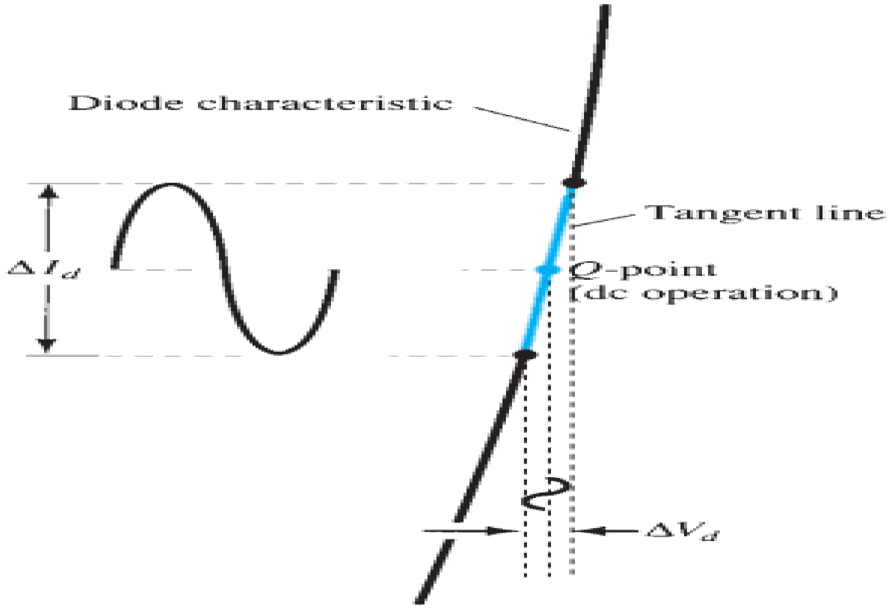
- If a sinusoidal rather than dc input is applied, the situation will change completely.

- 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.

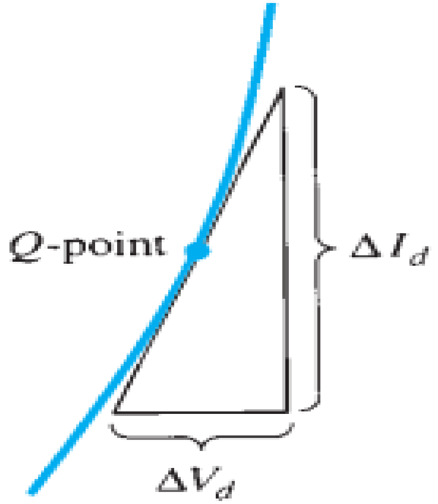
- The point of operation would be the Q-point appearing on Figure below.

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

AC or Dynamic resistance



Dynamic or ac resistance



AC resistance at a Q-point.

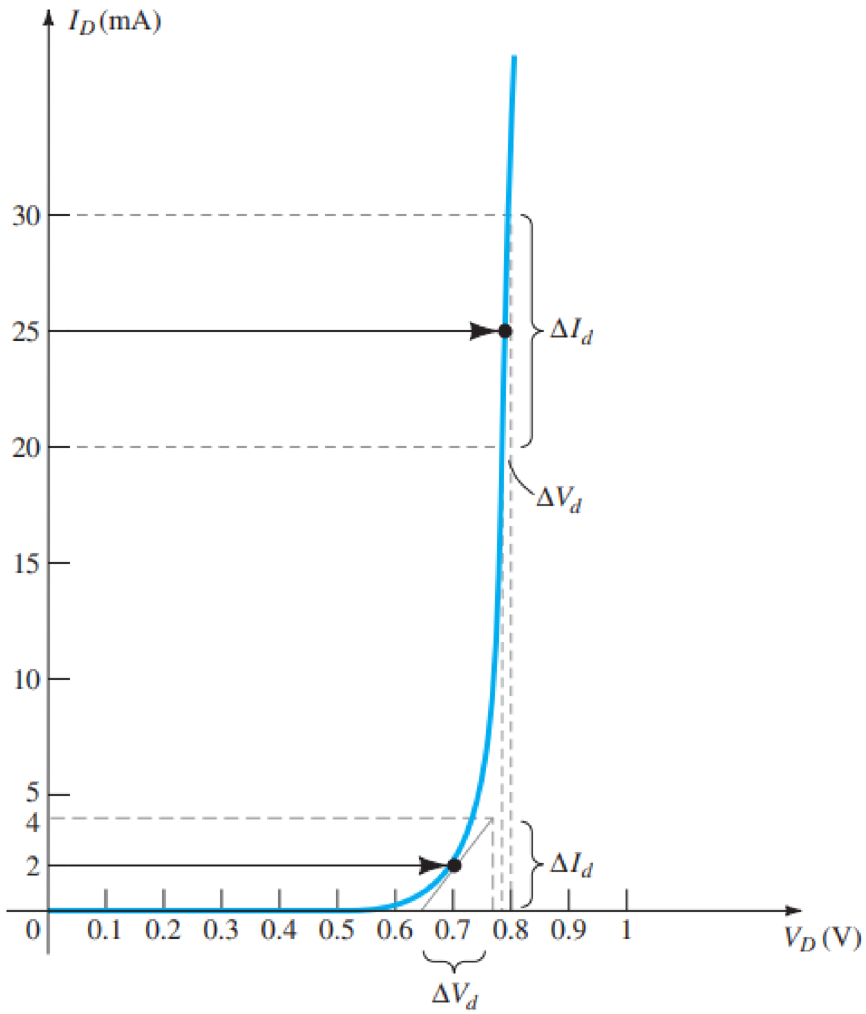
Example 2

For the characteristics of Figure below :

a. Determine the ac resistance at ID = 2 mA.

b. Determine the ac resistance at ID = 25 mA.

c. Compare the results of parts (a) and (b) to the dc resistances at each current level.



Solution

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

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

Solution

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

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

Solution

c. For $I_D = 2$ mA, $V_D = 0.7$ 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 27.5 Ω.

For $I_D = 25$ mA, $V_D = 0.79$ 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 2 Ω.

Average AC Resistance

- 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

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

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

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