Electronic
Second Stage

MSc. Zahraa Niema Kamal Lecture Four First Course

Lecture Four

Diode Application

1. Introduction

The primary goal of this chapter is to develop a working knowledge of the diode in a variety of configurations using models appropriate for the area of application. By chapter's end, the fundamental behavior pattern of diodes in dc and ac networks should be clearly understood.

2. Load line

The applied load will normally have an important impact on the point or region of operation of a device. If the analysis is performed in a graphical manner, a line can be drawn on the characteristics of the device that represents the applied load. The intersection of the load line with the characteristics will determine the point of operation of the system. Consider the network of Fig. (13 a) employing a diode having the characteristics of Fig. (13 b).

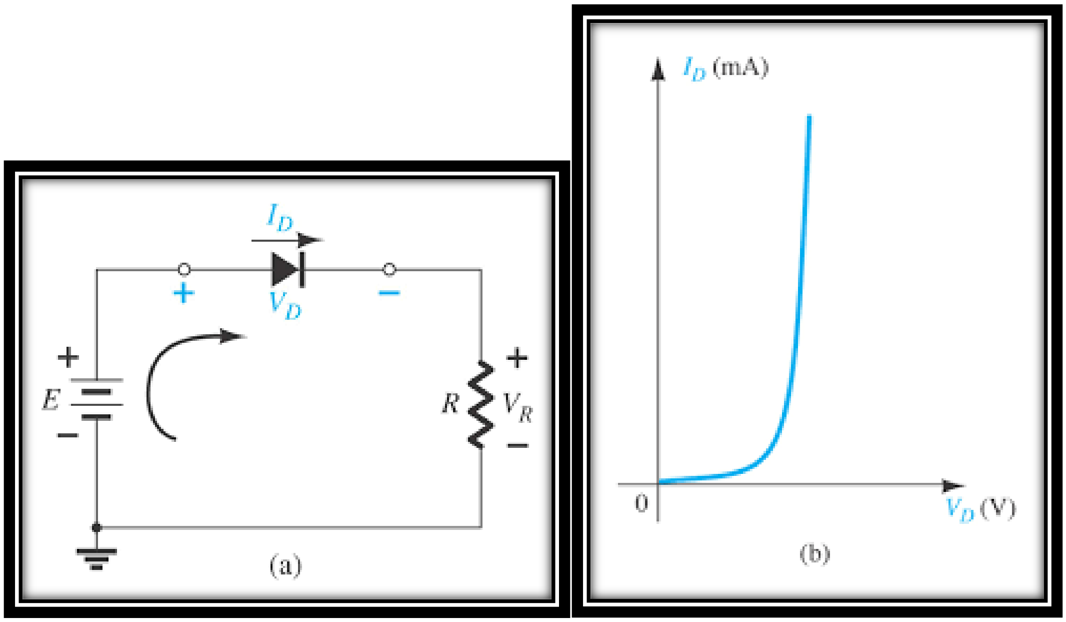


Figure (13): Series diode configuration: (a) circuit; (b) characteristics

Applying Kirchhoff's voltage law to the series circuit of Fig. (13 a) will result in:

$$E - V_D - V_R = 0$$

$$\boxed{E = V_D + I_D R}$$

The two variables (VD and ID) are the same as the diode axis variables of Fig. (13 b). This similarity permits a plotting of last equation on the same characteristics of Fig. (13 b).

If we set VD = 0 V in equation (1) and solve for ID, we have the magnitude of ID on the vertical axis. Therefore, with VD = 0 V, equation (1) becomes:

$$E = V_D + I_D R$$
$$= 0\text{ V} + I_D R$$
$$\boxed{I_D = \frac{E}{R}\bigg|_{V_D = 0\text{ V}}}$$

If we set ID = 0 A in equation (1) and solve for VD, we have the magnitude of VD on the horizontal axis. Therefore, with ID = 0 A, equation (1) becomes:

$$E = V_D + I_D R$$
$$= V_D + (0\text{ A})R$$
$$\boxed{V_D = E\big|_{I_D = 0\text{ A}}}$$

as shown in Fig. (14). A straight line drawn between the two points will define the load line as depicted in Fig. (14). Change the level of R (the load) and the intersection on the vertical axis will change. The result will be a change in the slope of the load line and a different point of intersection between the load line and the device characteristics.

We now have a load line defined by the network and a characteristic curve defined by the device. The point of intersection between the two is the point of operation for this circuit.

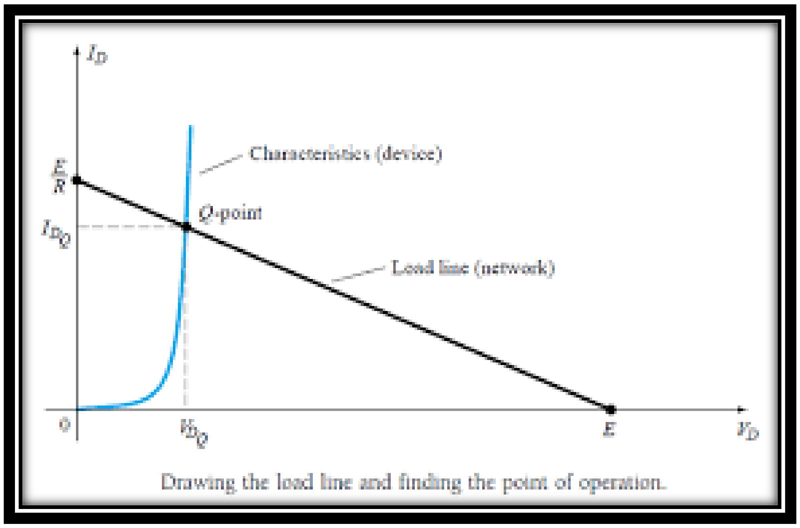


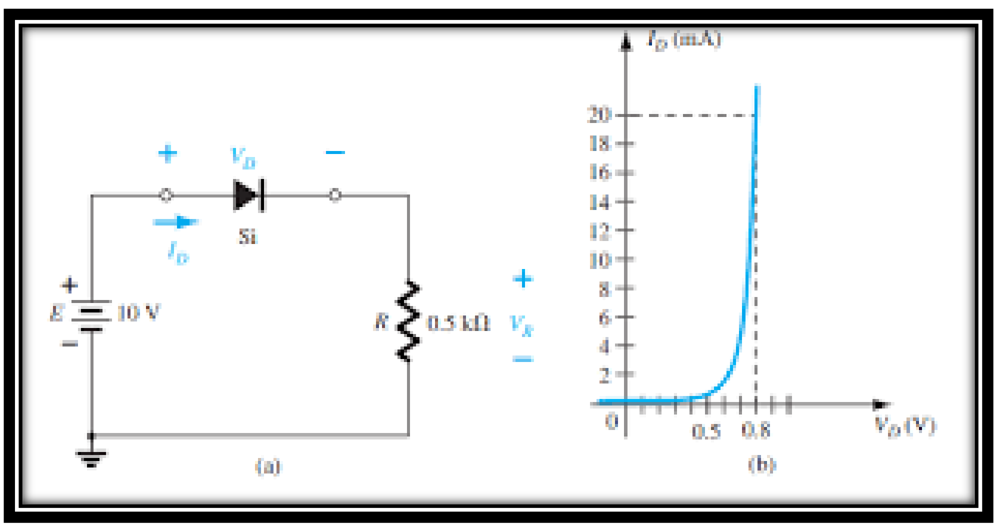
Figure (14) Drawing the load line and finding the point of operation.

Example 1

For the series diode configuration and diode characteristics of Figure below, determine:

(a) V_{DQ} and I_{DQ}.

(b) V_R.



Solution:

(a)

$I_D = \frac{E}{R}(at\ VD = 0v) = \frac{10\ V}{0.5\ K\Omega} = 20mA$

V_D = E (at ID = 0A) = 10V

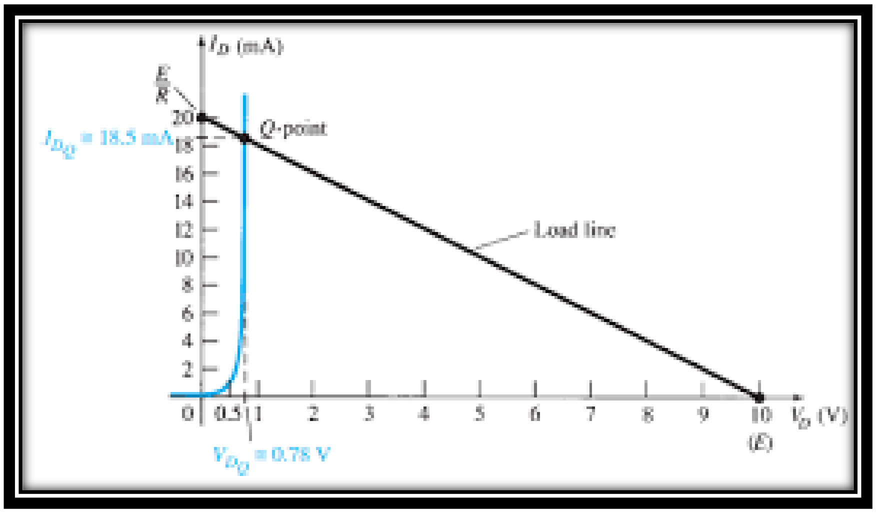
The resulting load line appears in Figure below. The intersection between the load line and the characteristic curve defines the Q-point as:

V_{DQ} = 0.78V

I_{DQ} = 18.5 mA

(b)

$V_R = I_R R = I_{DQ} R$ = (18.5 mA) (0.5K) = 9.25V



H.W: Repeat the analysis of **Example1** with (R =1k Ω) and (R = 2k Ω)

3. Series Diode Configuration with DC Input

In general, a diode is in the ON state if the current established by the applied sources is such that its direction matches that of the arrow in the diode symbol, VD =0.7 for Silicon, and VD=0.3 for germanium.

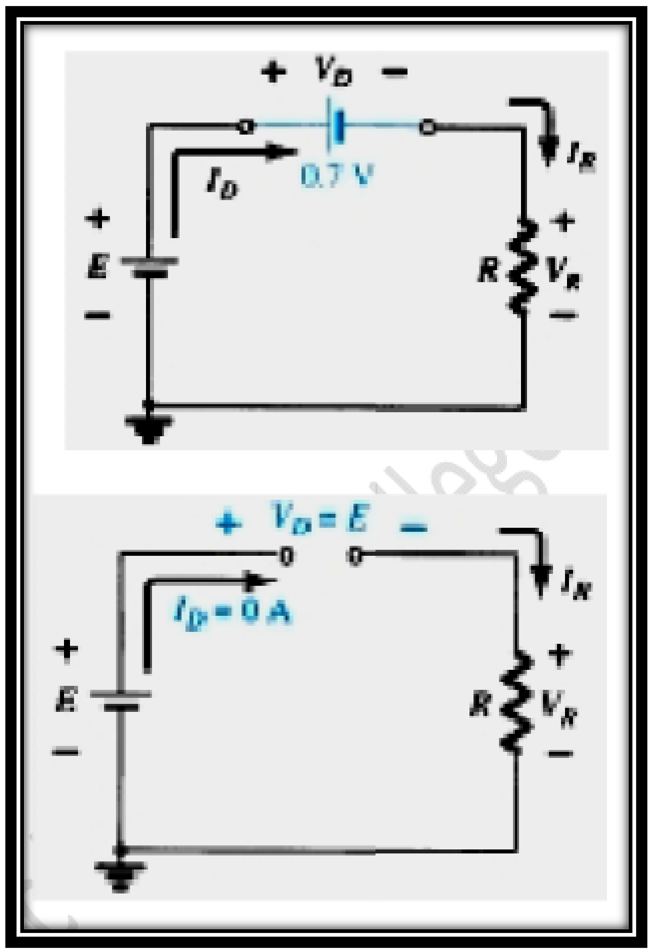
The diode is in the “off” state resulting in the equivalent circuit. Due to the open circuit, the diode current is 0 A and the voltage across the resistor R is as the following:

$V_R = I_R\, R = I_D\, R = (0A)\, R = 0V$

$$V_D = V_T$$

$$V_R = E - V_T$$

$$I_D = I_R = \frac{V_R}{R}$$



Example 2

For the series diode configuration of Fig. determine:

(a) VD, VR, and ID

(b) repeat with the diode reversed.

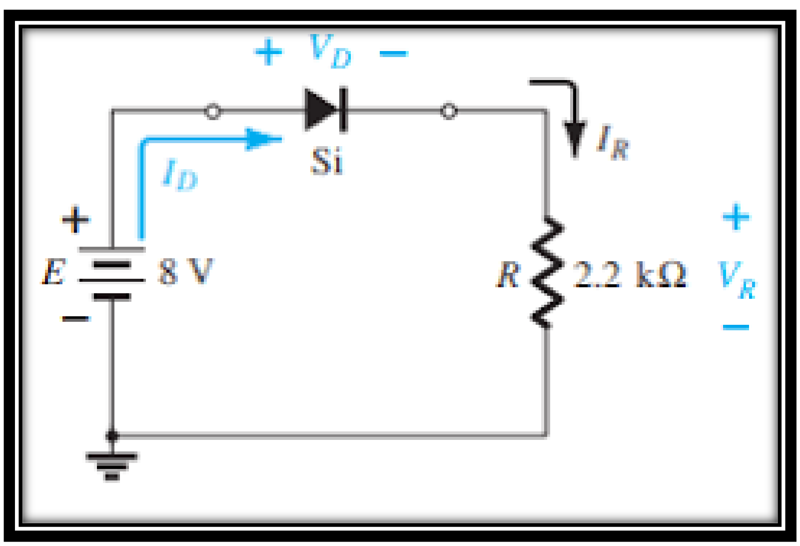
Solution:

(a)

$$V_D = \mathbf{0.7\ V}$$

$$V_R = E - V_D = 8\ \text{V} - 0.7\ \text{V} = \mathbf{7.3\ V}$$

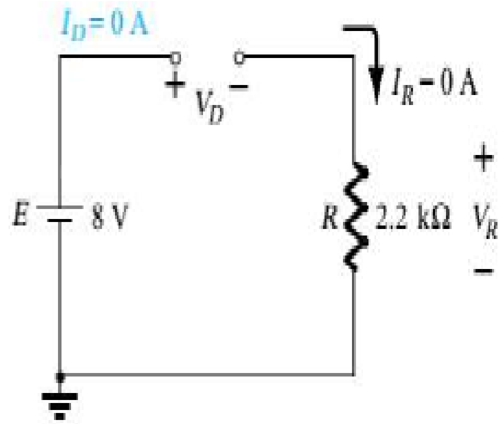
$$I_D = I_R = \frac{V_R}{R} = \frac{7.3\ \text{V}}{2.2\ \text{k}\Omega} \cong \mathbf{3.32\ mA}$$



(b)

$$E - V_D - V_R = 0$$

$$V_D = E - V_R = E - 0 = E = 8\,V$$

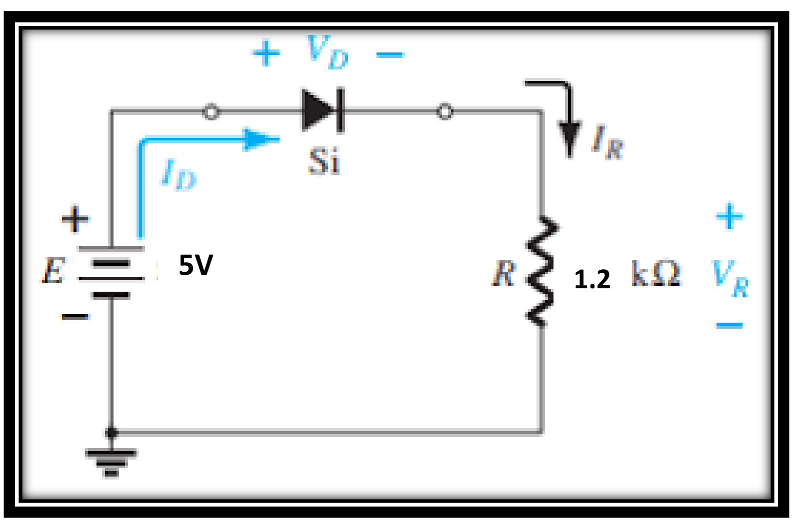


Note:

(a) An open circuit can have any voltage across its terminals, but the current is always 0 A.

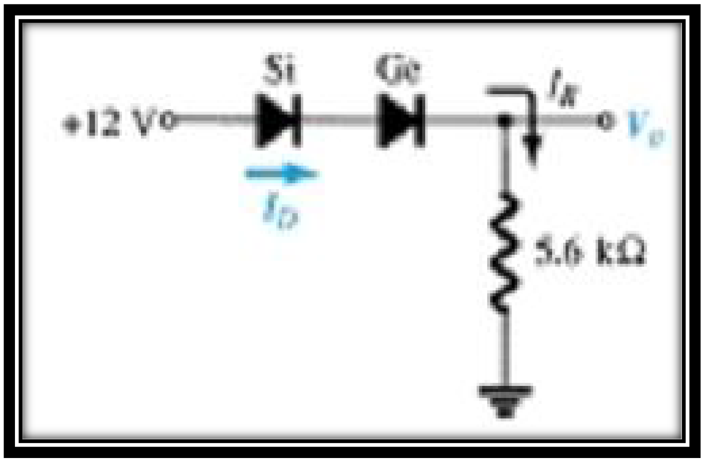
(b) A short circuit has a 0-V drop across its terminals, but the current is limited only by the surrounding network.

H.W: For the series diode configuration of Fig. below, determine VD, VR, and ID.



Example 3

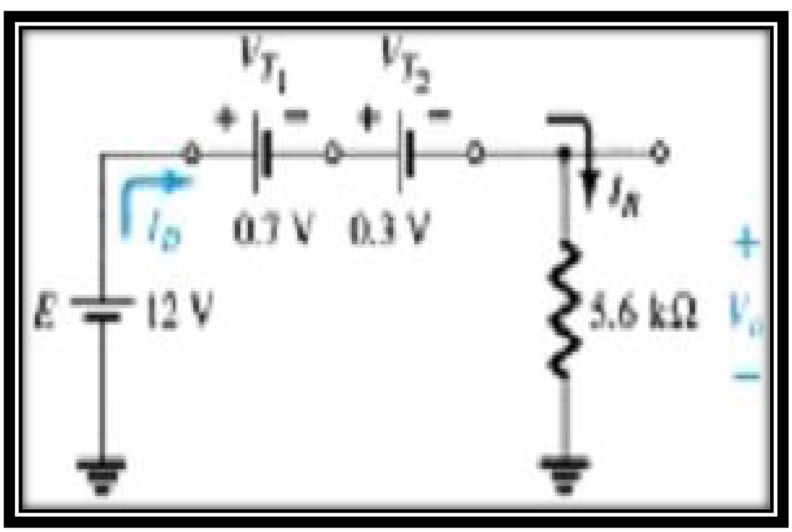
Determine Vo and ID for the series circuit of Fig. below.



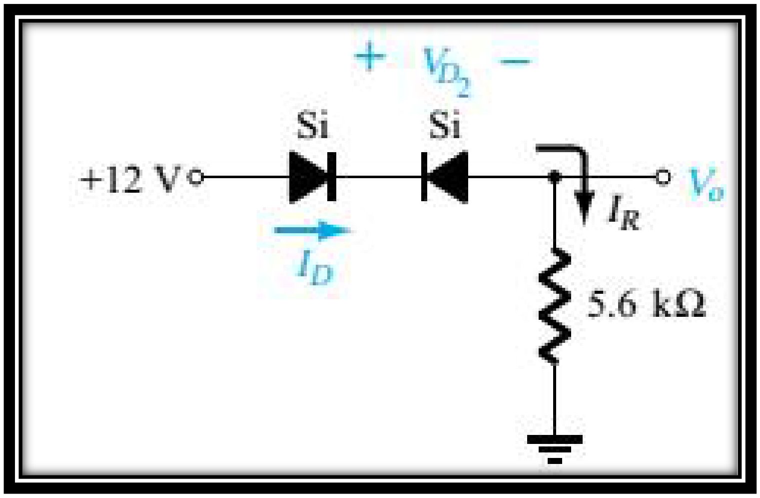
Solution:

$$V_o = E - V_{T_1} - V_{T_2} = 12\text{ V} - 0.7\text{ V} - 0.3\text{ V} = \mathbf{11\text{ V}}$$

$$I_D = I_R = \frac{V_R}{R} = \frac{V_o}{R} = \frac{11\text{ V}}{5.6\text{ k}\Omega} \cong \mathbf{1.96\text{ mA}}$$



H.W: Determine ID, VD2, and Vo for the circuit of Fig. below.



H.W: Determine I, V1, V2, and Vo for the series dc configuration of Fig. below.