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|---|---|
| كلية الهندسة | الكلية |
| قسم الهندسة الكهربائية | القسم |
| Fundamentals of Electronics I | المادة باللغة الانجليزية |
| أسس الإلكترونيك ١ | المادة باللغة العربية |
| الثانية | المرحلة الدراسية |
| حامد ردام حسين | اسم التدريسي |
| SEMICONDUCTOR DIODES | عنوان المحاضرة باللغة الانجليزية |
| ثنائيات أشباه الموصلات | عنوان المحاضرة باللغة العربية |
| 8 | رقم المحاضرة |
| Electronic Devices and Circuit Theory 11thEdition by Robert L. Boylestad, Louis Nashelsky | المصادر والمراجع |
| Electronic Devices 9th Edition by Thomas L. Floyd | |
| | |

# Lecture 6: Load Line Analysis

## 1. Diode Applications

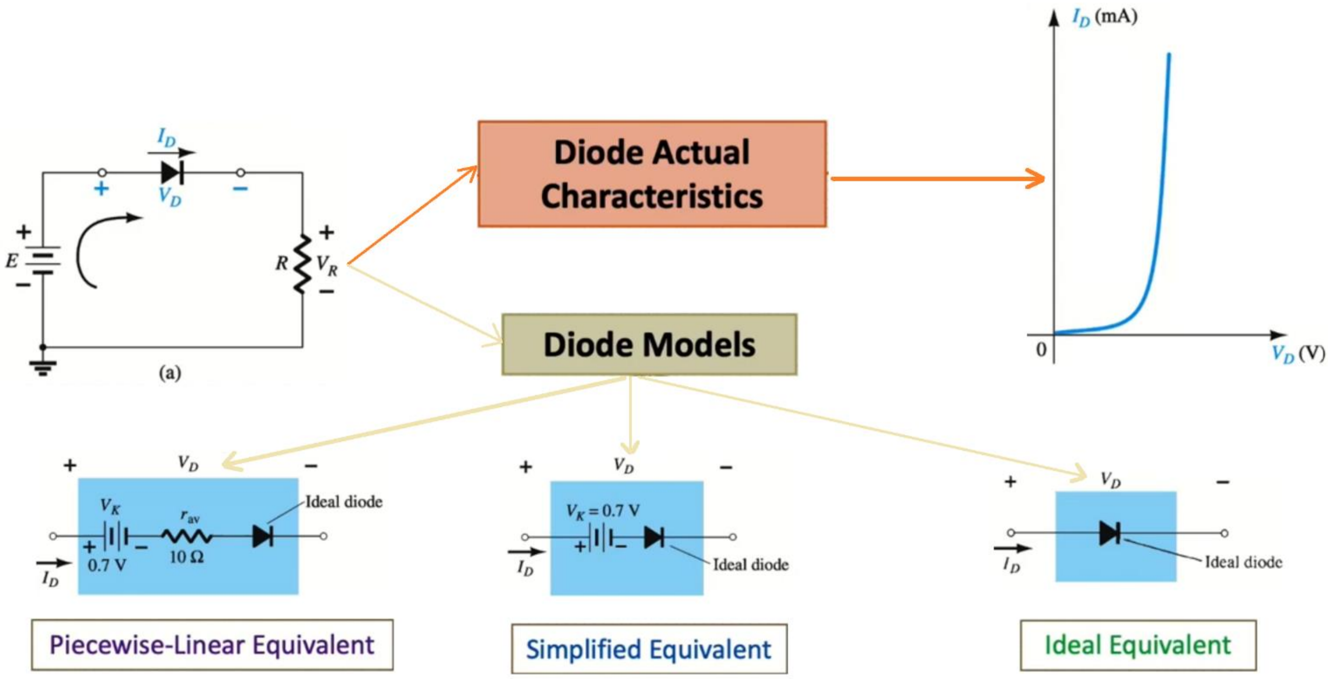
- Load-Line Analysis.
- Series Diode Configuration.
- Series-Parallel Configuration.
- Half-Wave Rectification.
- Full-Wave Rectification.
- Clippers.
- Clampers.
- Networks with a dc and ac Source.
- Zener Diodes.
- Voltage-Multiplier Circuits.

## 2. Unit Two Objectives

- Understand the concept of Load-Line analysis and how it is applied to diode networks.
- Become familiar with the use of equivalent circuits to analyze series and series-parallel diode networks.
- Understand the process of rectification to establish a dc level from a sinusoidal ac input.
- Be able to predict the output response of clipper and clamper diode configuration.
- Became familiar with the analysis, and the range of applications for Zener diode.

## 3. Analysis of a Diode Circuit

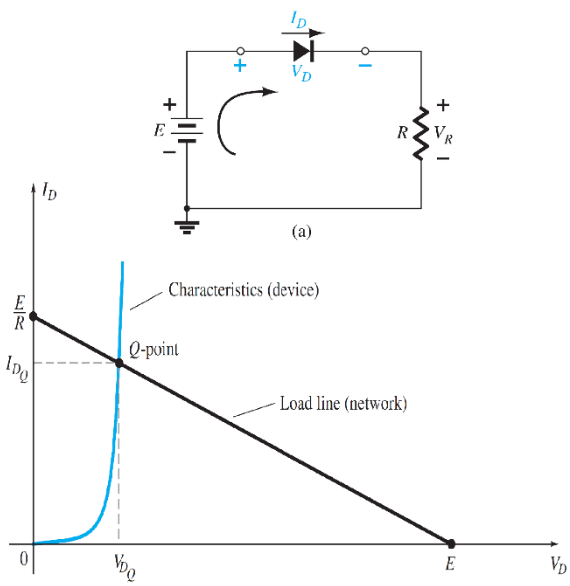
- Finding the current and voltage levels that will satisfy both the characteristics of the diode and the chosen network parameters.




## 4. Drawing the Load Line

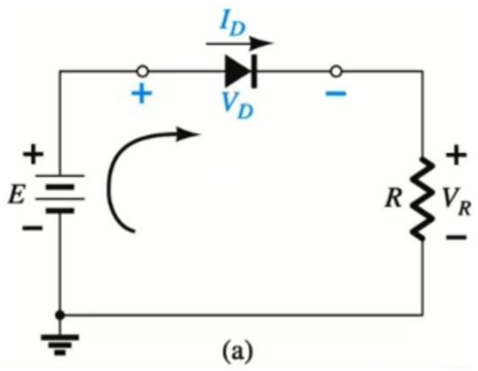
- The straight line intersect with the diode characteristic curve is called a load line because the intersection on the vertical axis is defined by the applied load R. The analysis called Load-Line analysis.

- The intersection of the two curves will define the solution for the network and define the current and voltage levels for the network.




- Let's see how we draw the load line of the forward biased diode on its characteristic curve.

## 5. Load Line Analysis




Diode Circuit

- The diode in the circuit is in the forward-bias state.

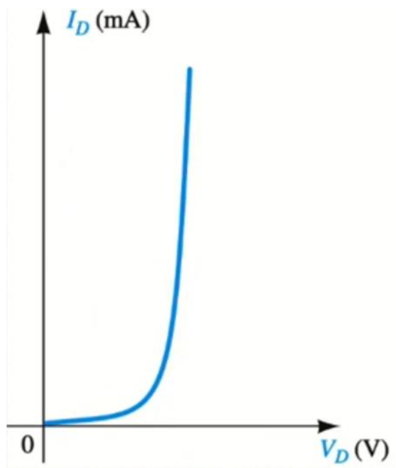
- A Voltage across the diode is 0.7 V.

- The intersection of the load line on the characteristics can be determined by applying Kirchhoff's voltage law (KVL):

$$-E + V_D + V_R = 0$$

$$E = V_D + I_D R$$

The two variables of $V_D$ *and* $I_D$, are the same as the diode axis variables of characteristics curve.




Diode characteristics

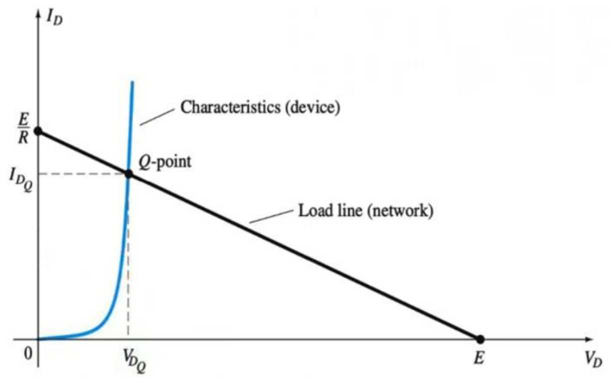
- The intersections of the Load line on the characteristics can be determined from the equation $E = V_D + I_D R$

If we set $V_D = 0\ V$ and solve for $I_D$

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

If we set $I_D = 0\ A$ and solve for $V_D$

$$V_D = E\big|_{I_D = 0\,\text{A}}$$



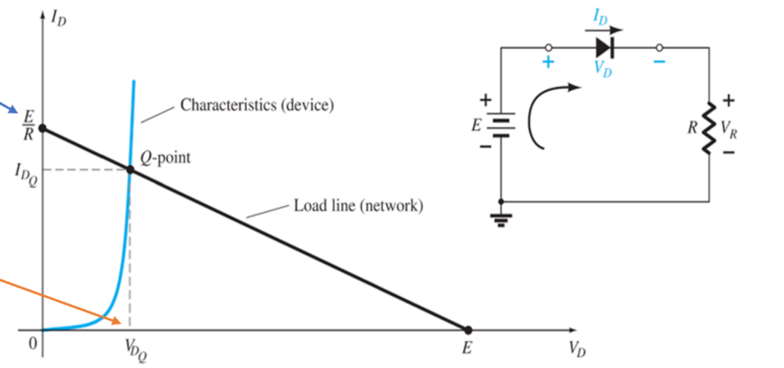

Change the level of the load (R), the intersection on the vertical axis will change. The result will be a change in the slope of the Load line and a different point of intersection between the load line and the device characteristics.

# 6. Operation Point (Q Point)

The point of intersection between the Load line and the characteristic curve is the point of operation of the diode and is called the quiescent point (Q-point), which is $V_{D_Q}$ and $I_{D_Q}$.

**$I_{D_Q}$ by drawing a horizontal line from the point of intersection to the Y-axis.**

**$V_{D_Q}$ by drawing a vertical line from the point of intersection to the X-axis.**

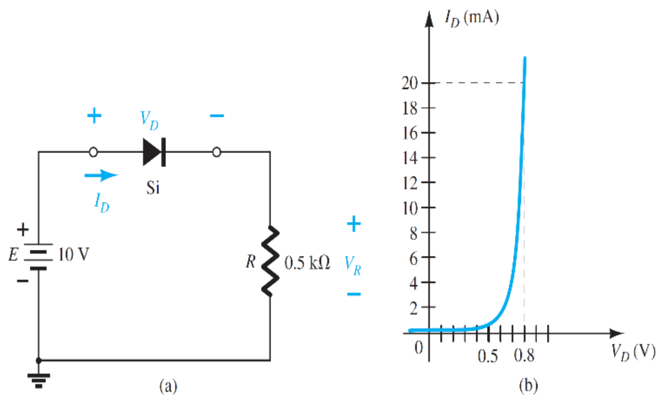



## Example 2.1

For the series diode configuration of Figure (a), employing the diode characteristics of Figure (b) determine:

a. $V_{D_Q}$ and $I_{D_Q}$

b. $V_R$




**Solution:**

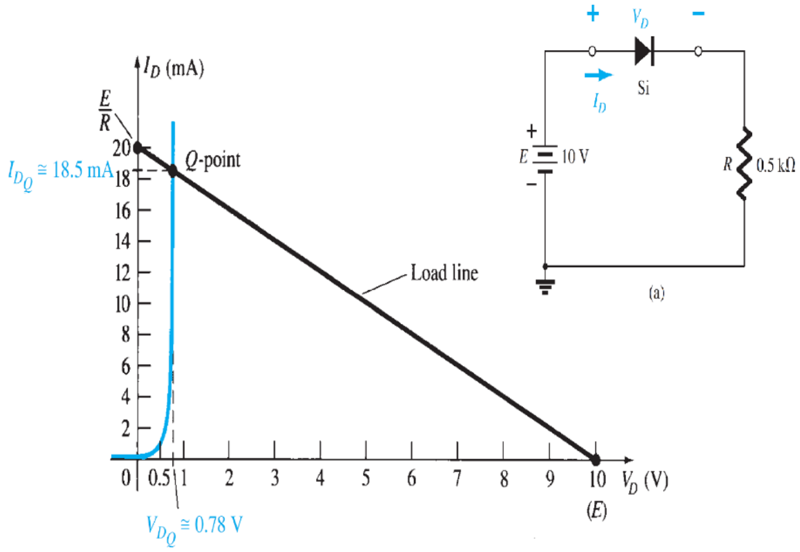
a. $V_{D_Q}$ and $I_{D_Q}$ **We need to draw the load line**

$$I_D = \frac{E}{R}\bigg|_{V_D = 0\,\text{V}} = \frac{10\ \text{V}}{0.5\ \text{k}\Omega} = 20\ \text{mA}$$

$$V_D = E\big|_{I_D = 0\,\text{A}} = 10\ \text{V}$$

The intersection between the load line and the characteristic curve defines the $Q$-point as

$$V_{D_Q} \cong \mathbf{0.78\ V}$$
$$I_{D_Q} \cong \mathbf{18.5\ mA}$$




b. $V_R = E - V_D = 10\ \text{V} - 0.78\ \text{V} = \mathbf{9.22\ V}$

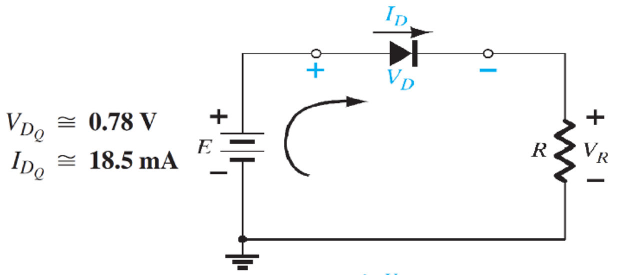
Note: The load line is determined by the applied network, whereas the characteristics are defined by the chosen device.

## 7. Working with equivalent network (Diode models)

We will replace the diode with dc resistance.

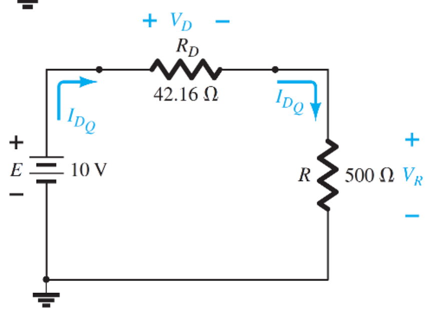
$R_{DC} = V_D / I_D$

Using the Q-point values (0.78 V, 18.5 mA), the dc resistance for Example. 2.1 is:




$$R_D = \frac{V_{D_Q}}{I_{D_Q}} = \frac{0.78\ V}{18.5\ mA} = 42.16\ \Omega$$

The current and voltage are:




$$I_D = \frac{E}{R_D + R} = \frac{10\ V}{42.16\ \Omega + 500\ \Omega}$$

$$= \frac{10\ V}{542.16\ \Omega} \cong 18.5\ mA$$

$$V_R = \frac{R.E}{R_D + R} = \frac{(500\ \Omega)(10\ V)}{42.16\ \Omega + 500\ \Omega} = 9.22\ V$$

Once a dc Q-point has been determined the diode can be replaced by its dc resistance equivalent.

## Example 2.2:

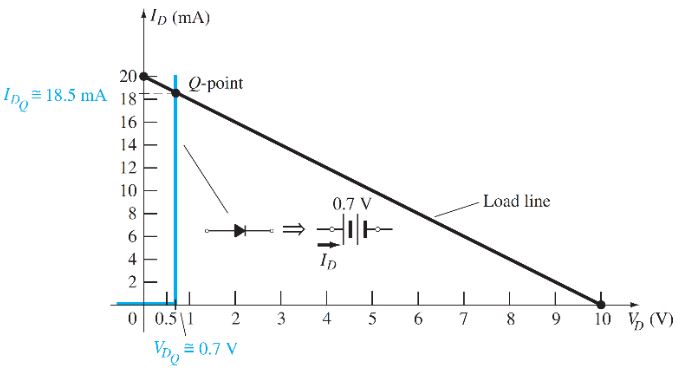
Repeat example 2.1 using the approximate equivalent model for the Si diode.

Solution: The Load line is redrawn as shown, with the same intersections as defined in Example 2.1. The resulting in Q-point is:

$$V_{D_Q} = 0.7\ V$$

&

$$I_{D_Q} = 18.5\ mA$$

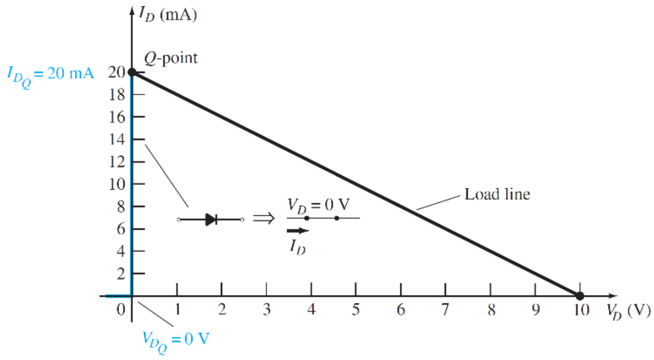



The dc resistance of the Q-point is:

$$R_D = \frac{V_{D_Q}}{I_{D_Q}} = \frac{0.7\ V}{18.5\ mA} = 37.84\ \Omega$$

Which is still relatively close to that obtained for the full characteristics.

# Example 2.3




Repeat example 2.1 using the ideal diode model.

Solution: The Load line is the same as in Example 2.1, but the ideal characteristics now intersect the Lord line on the vertical axis.

The Q-point is therefore defined by:

$V_{D_Q} = 0\ V$ & $I_{D_Q} = 20\ mA$

The results are sufficient different from the solution of example 2.1.

$$R_D = \frac{V_{D_Q}}{I_{D_Q}} = \frac{0\ V}{20\ mA} = 0\ \Omega$$

**Note:** Use of the ideal diode model should be reserved for those situations where the applied voltages are considerably larger than the threshold voltage $V_k$ .

## 8. Problems to Solve by Yourself

**In your textbook solve problems under**

**sections 2.2 Load-Line Analysis**

1, 2, 3 and 4

Pages 119 and 120