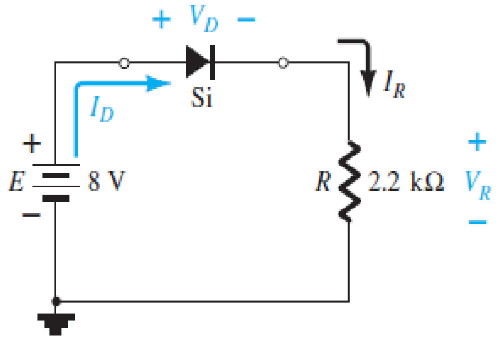
SERIES DIODE CONFIGURATIONS

EXAMPLE 1:

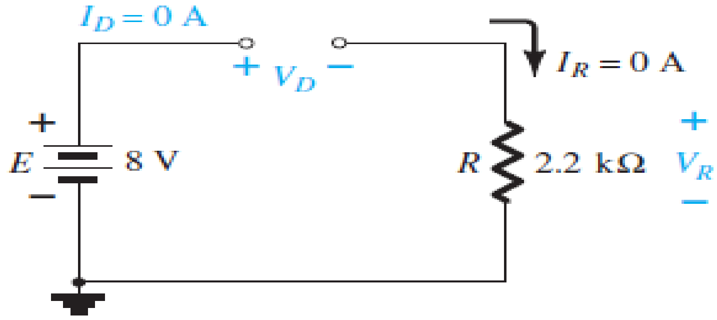
For the series diode configuration of Figure determine VD, VR, and ID.

$$V_D = 0.7\text{ V}$$
$$V_R = E - V_D = 8\text{ V} - 0.7\text{ V} = 7.3\text{ V}$$
$$I_D = I_R = \frac{V_R}{R} = \frac{7.3\text{ V}}{2.2\text{ k}\Omega} \cong 3.32\text{ mA}$$



Repeat the Example with the diode reversed.

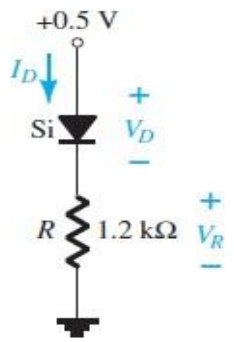
$$E - V_D - V_R = 0$$
$$V_D = E - V_R = E - 0 = E = 8\text{ V}$$



EXAMPLE 2:

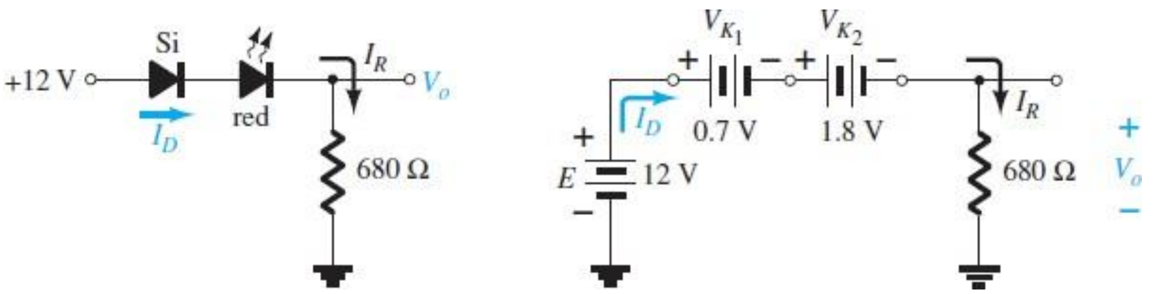
For the series diode configuration of Figure, determine VD , VR , and ID.

$$I_D = 0\text{ A}$$
$$V_R = I_R R = I_D R = (0\text{ A})\,1.2\text{ k}\Omega = 0\text{ V}$$
$$V_D = E = 0.5\text{ V}$$



EXAMPLE 3:

Determine Vo and ID for the series circuit of the figure.



$$V_o = E - V_{K_1} - V_{K_2} = 12\text{ V} - 2.5\text{ V} = \mathbf{9.5\ V}$$

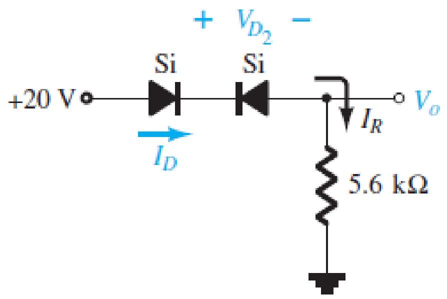
$$I_D = I_R = \frac{V_R}{R} = \frac{V_o}{R} = \frac{9.5\text{ V}}{680\ \Omega} = \mathbf{13.97\ mA}$$

EXAMPLE 4:

Determine ID , VD2, and Vo for the circuit

$$V_o = I_R R = I_D R = (0\text{ A})R = \mathbf{0\ V}$$

$$V_{D_2} = V_{\text{open circuit}} = E = \mathbf{20\ V}$$

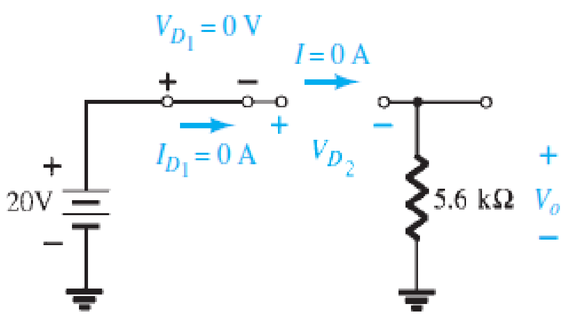


$$E - V_{D_1} - V_{D_2} - V_o = 0$$

$$V_{D_2} = E - V_{D_1} - V_o = 20\text{ V} - 0 - 0$$

$$= \mathbf{20\ V}$$

$$V_o = \mathbf{0\ V}$$



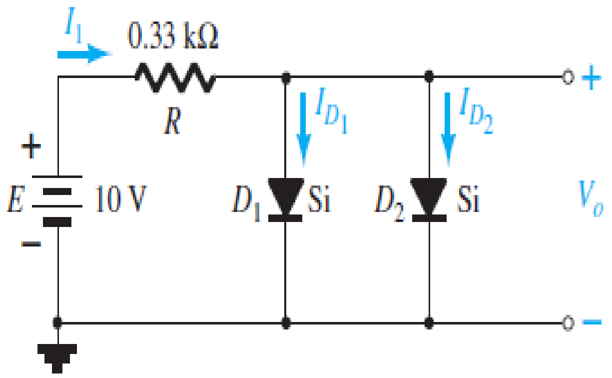
PARALLEL AND SERIES–PARALLELCONFIGURATIONS

EXAMPLE 5:

Determine Vo, I1, ID1, and ID2 for the parallel diode configuration

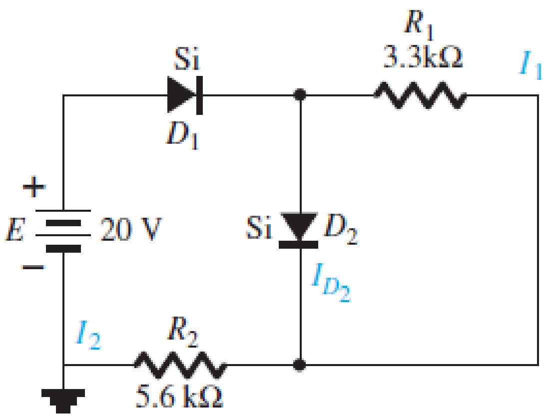
$$I_1 = \frac{V_R}{R} = \frac{E - V_D}{R} = \frac{10\text{ V} - 0.7\text{ V}}{0.33\text{ k}\Omega} = 28.18\text{ mA}$$

$$I_{D_1} = I_{D_2} = \frac{I_1}{2} = \frac{28.18\text{ mA}}{2} = 14.09\text{ mA}$$



H.W:

Determine the currents I1 , I2 , and ID2 for the network

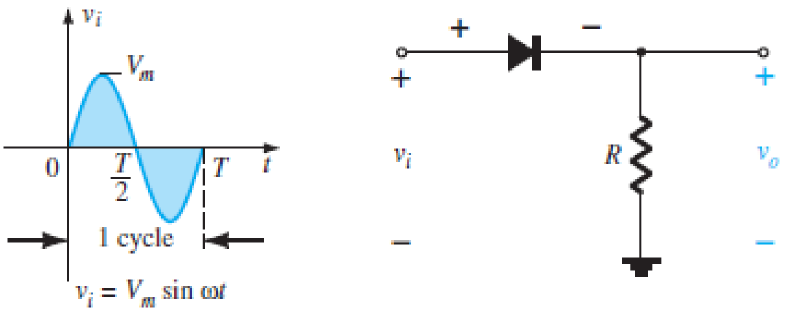


Sinusoidal Inputs

1.HALF-WAVE RECTIFICATION

The diode analysis will now be expanded to include time-varying functions such as the sinusoidal waveform and the square wave. There is no question that the degree of difficulty will increase, but once a few fundamental maneuvers are understood, the analysis will be fairly direct and follow a common thread.

The simplest of networks to examine with a time-varying signal appears in figure. For the moment we will use the ideal model (note the absence of the Si, Ge, or GaAs label) to ensure that the approach is not clouded by additional mathematical complexity.



Over one full cycle, defined by the period T of figure, the average value (the algebraic sum of the areas above and below the axis) is zero. The circuit of above figure, called a ***half-wave rectifier***, will generate a waveform *V*o that will have an average value of particular use in the ac- to-dc conversion process. When employed in the rectification process, a diode is typically referred to as a ***rectifier***.

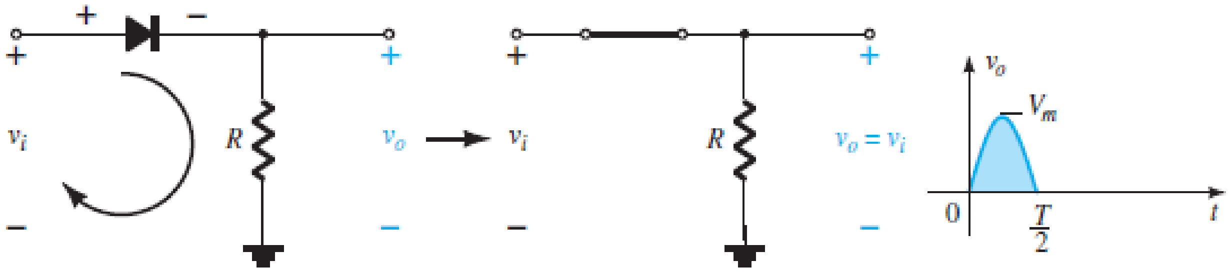
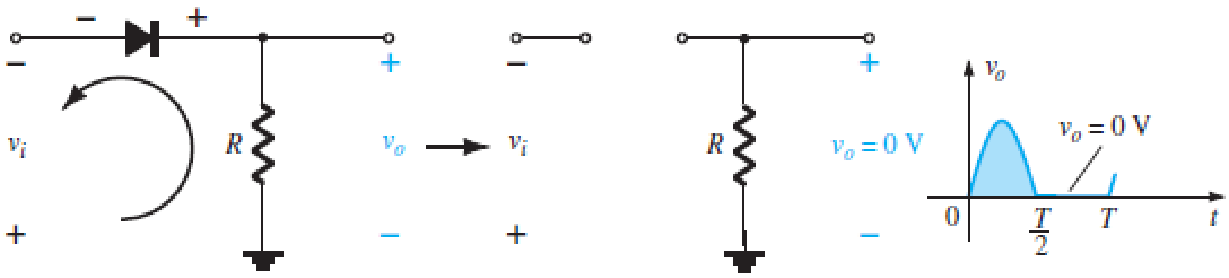
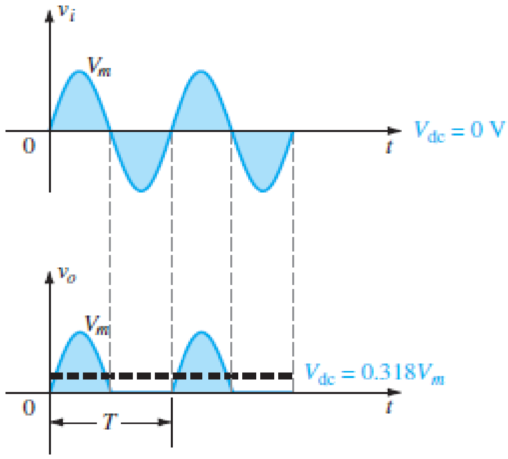


FIG. 2.45
Conduction region (0 → T/2).

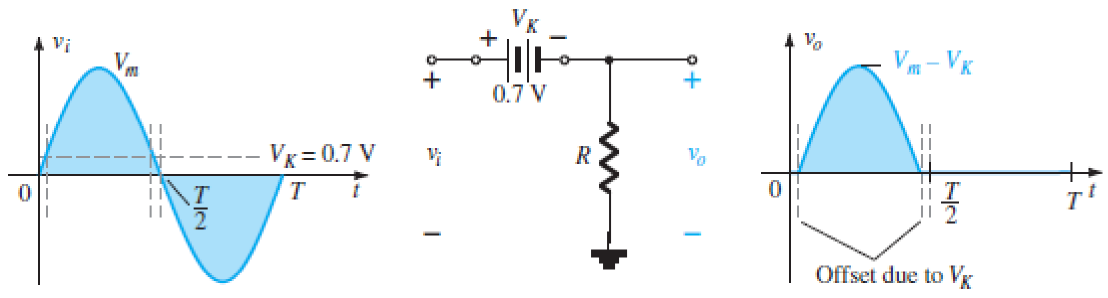




$$V_{dc} = 0.318\ V_m$$ half-wave

if ***Vm*** is sufficiently greater than ***VK***

The effect of using a silicon diode with ***VK*** = 0.7 V is demonstrated in Fig. below for the forward-bias region. The applied signal must now be at least 0.7 V before the diode can turn "on." For levels of ***vi*** less than 0.7V, the diode is still in an open-circuit state and ***vo***=0 V, as shown in the same figure. When conducting, the difference between ***vo*** and ***vi*** is a fixed



level of VK=0.7 V and Vo = Vi -VK, as shown in the figure. The net effect is a reduction in area above the axis, which reduces the resulting dc voltage level. For situations where Vm >> VK, the following equation can be applied to determine the average value with a relatively high level of accuracy.

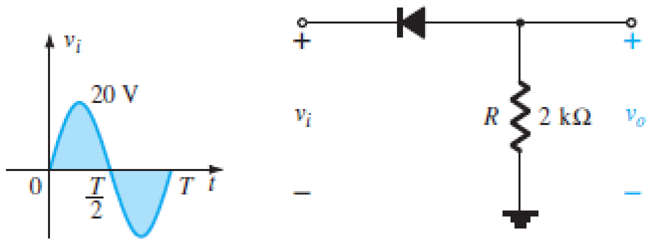
$$V_{dc} \cong 0.318(V_m - V_K)$$

In fact, if ***Vm*** is sufficiently greater than ***VK,*** is often applied as a first approximation for ***Vdc.***

EXAMPLE 6

a. Sketch the output v o and determine the dc level of the output for the network of the figure.

b. Repeat part (a) if the ideal diode is replaced by a silicon diode.

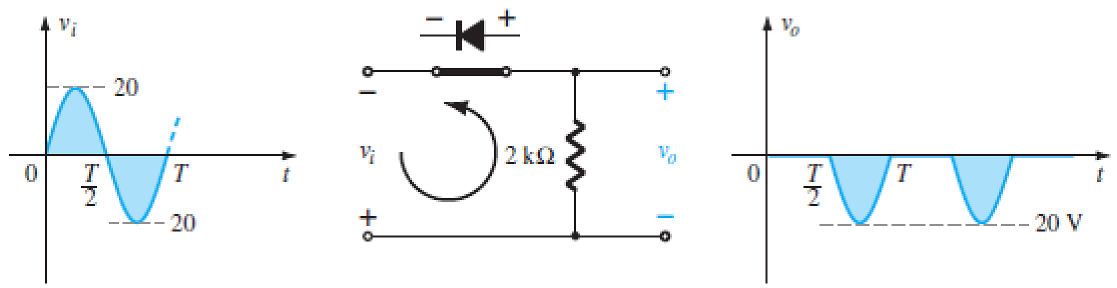


Solution:

a. In this situation the diode will conduct during the negative part of the input as shown in figure below, and vo will appear as shown in the same figure. For the full period, the dc level is

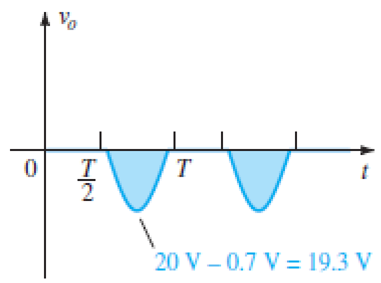
$$V_{dc} = -0.318V_m = -0.318(20\text{ V}) = -6.36\text{ V}$$

The negative sign indicates that the polarity of the output is opposite to the defined polarity.



b. For a silicon diode, the output has the appearance of the figure below.

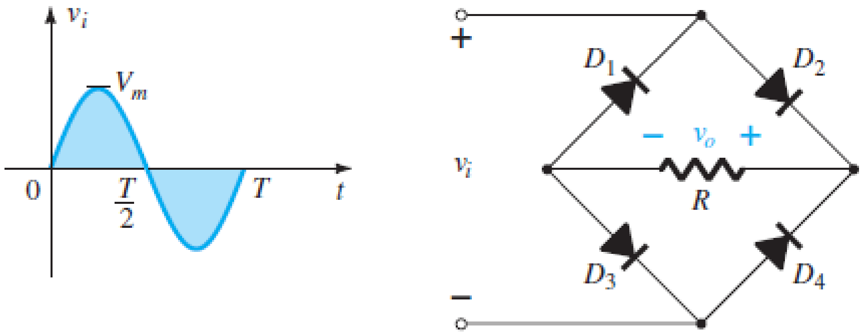
$$V_{dc} \cong -0.318(V_m - 0.7\text{ V}) = -0.318(19.3\text{ V}) \cong -6.14\text{ V}$$



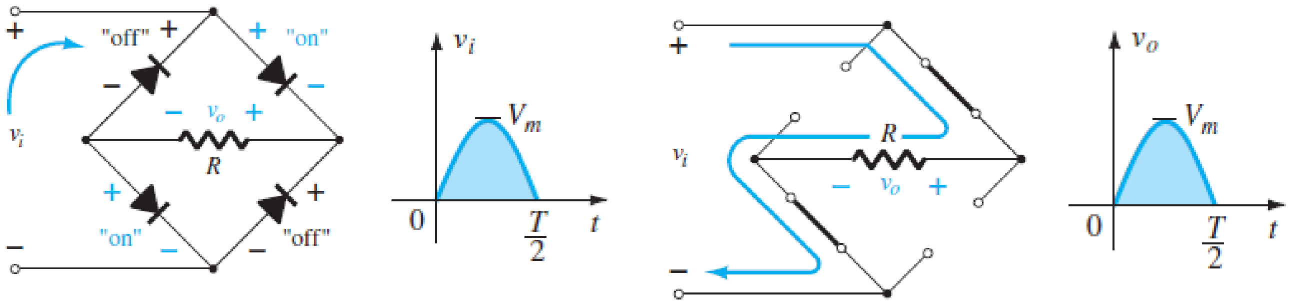
2. FULL -WAVE RECTIFICATION

A-Bridge Network:

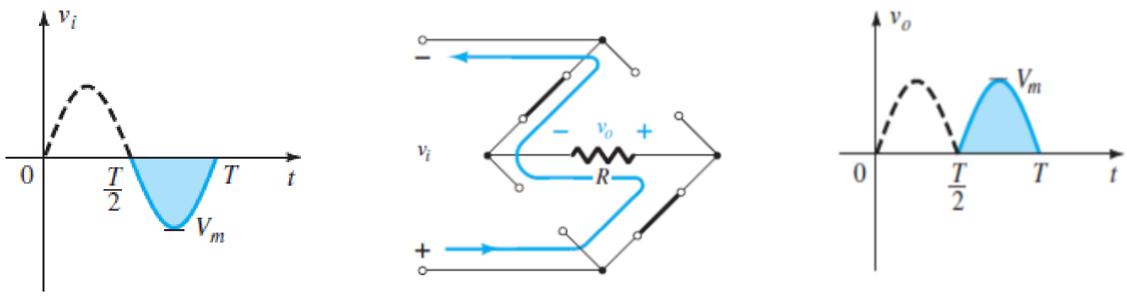
The dc level obtained from a sinusoidal input can be improved 100% using a process called ***full- wave rectification***

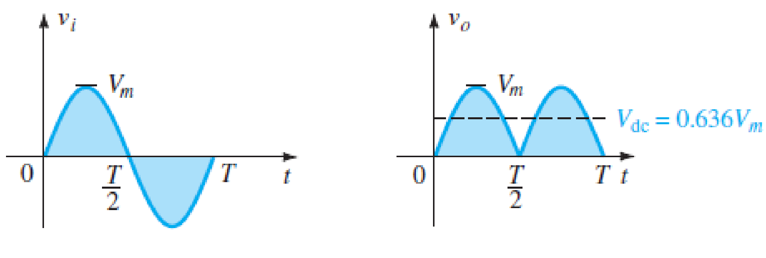


The resulting polarities across the ideal diodes are also shown in figure to reveal that *D2* and *D3* are conducting, whereas *D1* and *D4* are in the "off" state.



For the negative region of the input the conducting diodes are D1 and D4, resulting in the configuration of figure below.





Since the area above the axis for one full cycle is now twice that obtained for a half-wave system, the dc level has also been doubled and

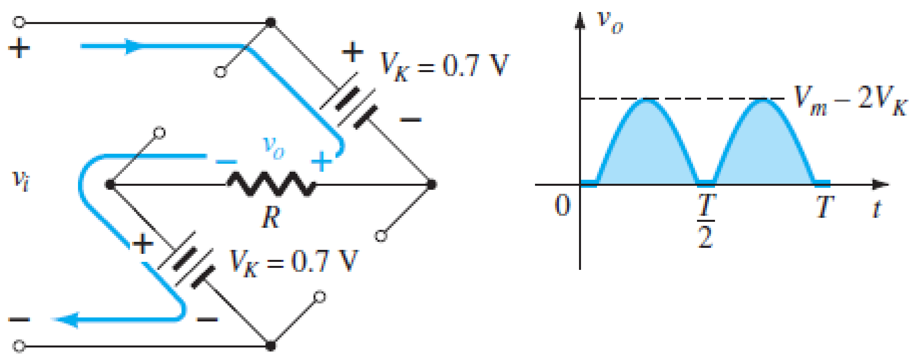
$V_{dc} = 2(0.318V_m)$

$$V_{dc} = 0.636\ V_m$$ full-wave

If silicon rather than ideal diodes is employed as shown in figure below, the application of Kirchhoff's voltage law around the conduction path results in

$v_i - V_K - v_o - V_K = 0$

$v_o = v_i - 2V_K$



The peak value of the output voltage vo is therefore

$V_{o_{max}} = V_m - 2V_K$

For situations where $V_m >> 2V_K$, the following equation can be applied for the average value with a relatively high level of accuracy:

$$V_{dc} \cong 0.636(V_m - 2V_K)$$

Then again, if V_m is sufficiently greater than $2V_K$, then Equation $V_{dc} = 0.636\ V_m$ is often applied as a first approximation for V_{dc}.