ELEKTRONİK DEVRELER DERS NOTLARI
4.HAFTA

Diyot devre örnekleri

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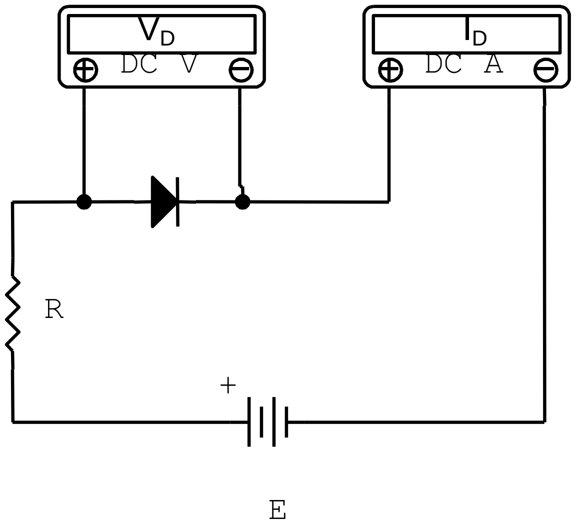


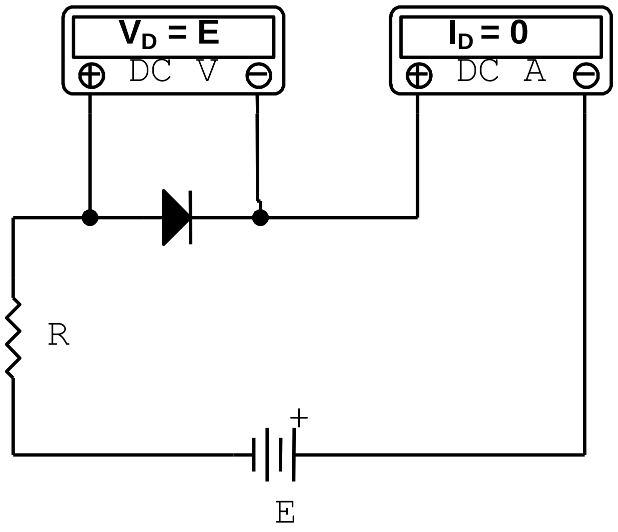
Şekil 1 Doğru polarlanmış bir diyot

$$E = V_D + (I_D xR)$$

Şekil 1 de kullanılan R direnci akım sınırlama direnci olarak görev yapmaktadır. Devrede kullanılan diyot doğru polarma altında çalıştığı zaman, diyot içerisinden akan akımın ifadesi aşağıdaki bağıntıdan bulunur.

$$I_D = \frac{E - V_D}{R} \qquad \text{…………………..(1.1)}$$

Germanyum diyotlar için yaklaşık V_D=0,3V, Silisyum diyotlar için yaklaşık V_D=0,7V kadardır.



Şekil 2 Ters polarlanmış bir diyot

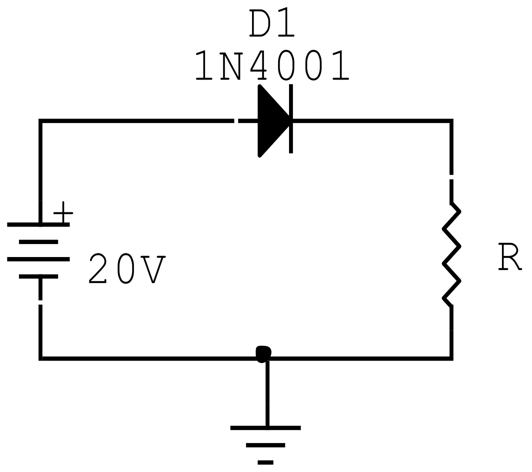
Ters polarlanmış bir diyot devresinde:

I_D = 0 A (Diyot içerisinden akım akmaz)

V_D = E (Diyot üzerindeki gerilim, kaynak gerilimine eşit olur.)

Örnek 1.1

Şekil 3 de verilen devrede kullanılan 1N4001 diyodunun, maksimum ileri yön akımı 1A'dir. Devre akımının, maksimum ileri yön akımının yarısı kadar olabilmesi için gerekli olan akım sınırlama direncinin değerini bulunuz?



Şekil 3

Çözüm 1.1

Şekil 3 de verilen devrede ileri yön akımı 0.5 A veya 500 mA olacaktır.

$$20V = (500\ mA \times R) + 0.7\ V$$

ifadesinden, R değeri

R = = 38.6 Ω olarak bulunur.

■

Örnek 1.2

Şekil 1.26 da verilen devrede, devre akımı 1 mA olabilmesi için V2 kaynağının gerilim değerini bulunuz?

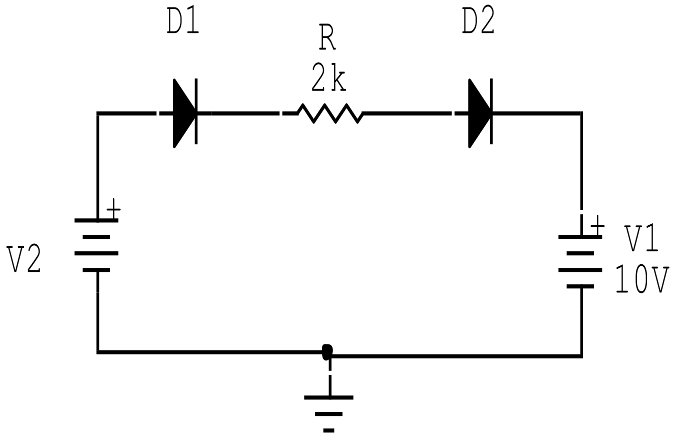
Çözüm 1.2

Şekil 1.26 da verilen devrede diyotlar seri olarak kullanılmışlardır.

Dolayısı ile,

V_2 = (0.7 V + 0.7V) + (1 mA x 2 kΩ) + 10 V = 13.4 V olarak bulunur.

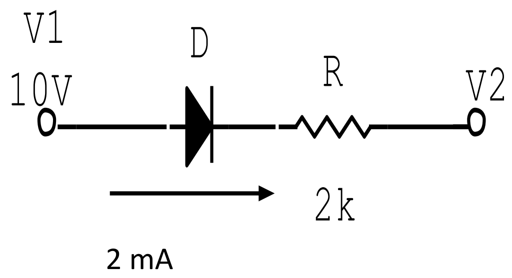
■



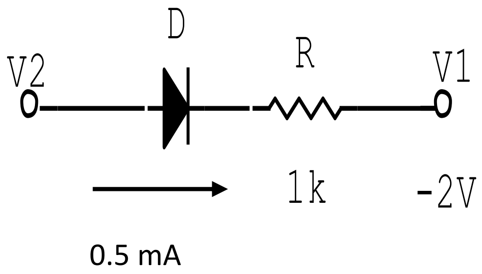
Şekil 1.26

Örnek 1.3

Şekil 1.27 de verilen devrelerin herbirinde kullanılan diyodların, doğru yönde polarlanabilmesi için gerekli olan gerilim değerlerini bulunuz?



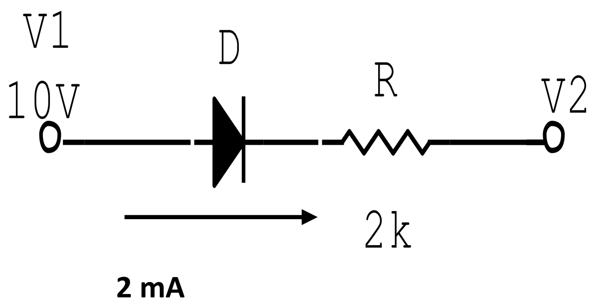
(a)



(b)

Şekil 1.27

Çözüm 1.3

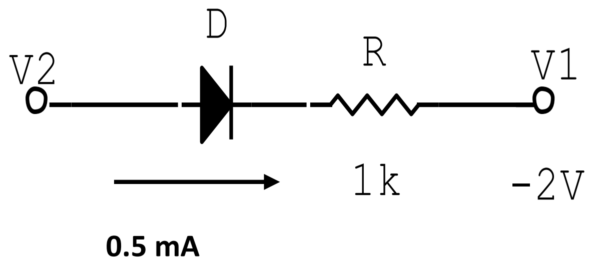


$$10V - V_2 = 0.7V + (2mA \times 2k)$$

$$10V - V_2 = 4.7V$$

$$10V - 4.7V = V_2$$

$$5.3\ V = V_2$$



$$V_2 - (-2V) = 0.7V + (0.5mA \times 1k)$$

$$V_2 + 2V = 1.2V$$

$$V_2 = -\ 2V + 1.2\ V$$

$$V_2 = -\ 0.8\ V$$

SERIES DIODE CONFIGURATIONS

Exp: For the series diode configuration of Fig. 2.3a , employing the diode characteristics of Fig. 2.3b , determine:

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

b. V_R

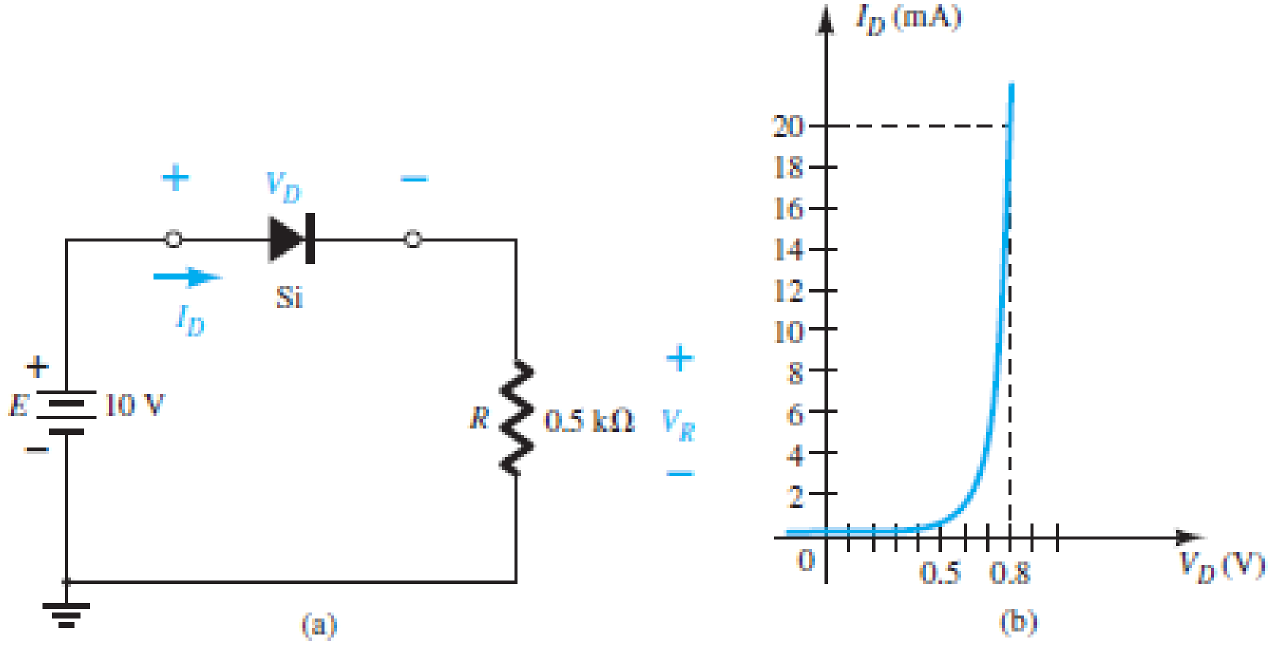


FIG. 2.3
(a) Circuit; (b) characteristics.

- $E = V_D + V_R$
- $E = V_D + I_D \times R$

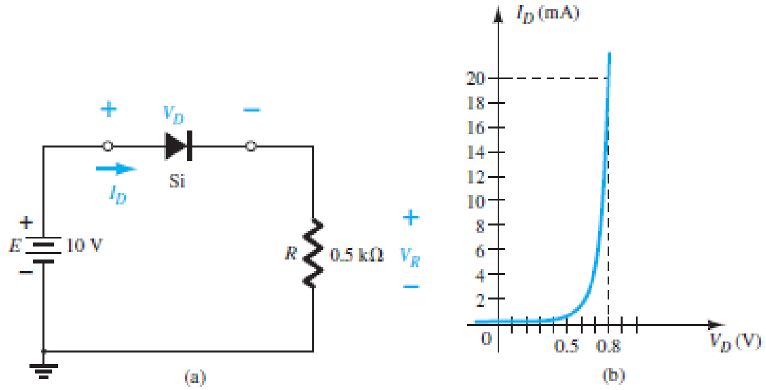
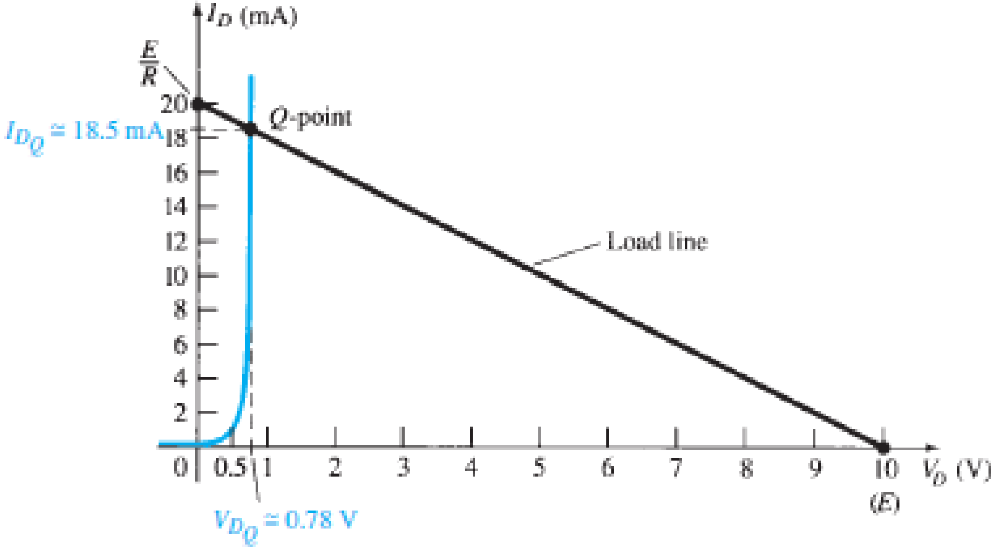


FIG. 2.3
(a) Circuit; (b) characteristics.

a. Eq. (2.2): $I_D = \frac{E}{R}\Big|_{V_D = 0\,V} = \frac{10\text{ V}}{0.5\text{ k}\Omega} = 20\text{ mA}$

Eq. (2.3): $V_D = E\big|_{I_D = 0\,A} = 10\text{ V}$

The resulting load line appears in Fig. 2.4. The intersection between the load line and the characteristic curve defines the *Q*-point as



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

The level of V_D is certainly an estimate, and the accuracy of I_D is limited by the chosen scale. A higher degree of accuracy would require a plot that would be much larger and perhaps unwieldy.

Using the Q-point values, the dc resistance for Example 2.1 is

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

An equivalent network (for these operating conditions only) can then be drawn as shown in Fig. 2.5.

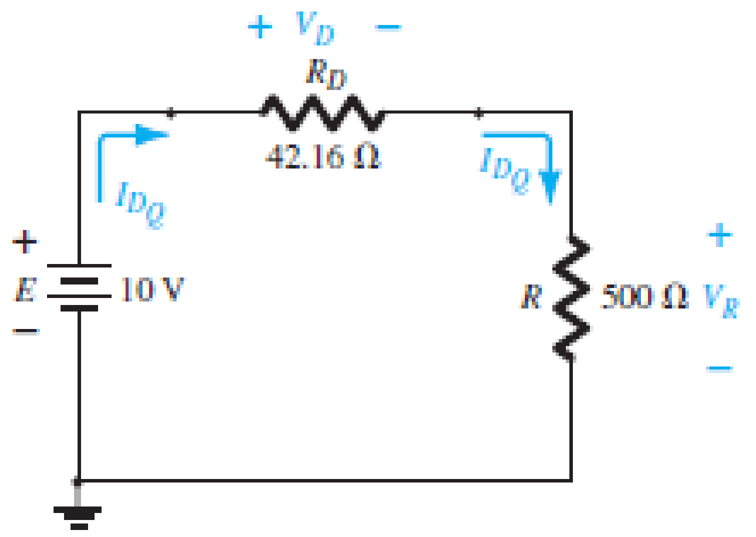


FIG. 2.5
Network quivalent to Fig. 2.4.

The current

$$I_D = \frac{E}{R_D + R} = \frac{10\ \text{V}}{42.16\ \Omega + 500\ \Omega} = \frac{10\ \text{V}}{542.16\ \Omega} \cong \mathbf{18.5\ mA}$$

and $$V_R = \frac{RE}{R_D + R} = \frac{(500\ \Omega)(10\ \text{V})}{42.16\ \Omega + 500\ \Omega} = \mathbf{9.22\ V}$$

EXAMPLE 2.4 For the series diode configuration of Fig. 2.13, determine V_D, V_R, and I_D.

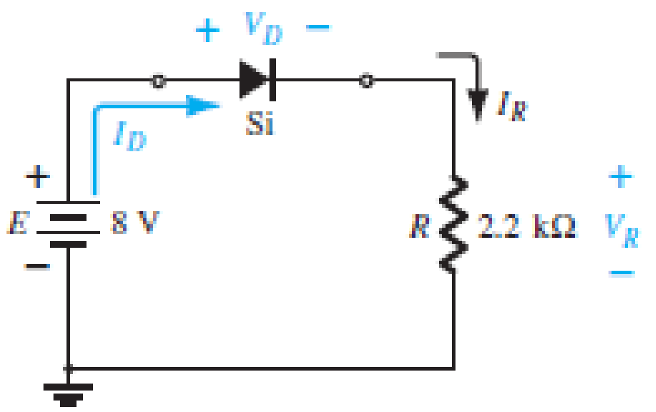


FIG. 2.13
Circuit for Example 2.4.

Solution: Since the applied voltage establishes a current in the clockwise direction to match the arrow of the symbol and the diode is in the "on" state,

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

EXAMPLE 2.5 Repeat Example 2.4 with the diode reversed.

Solution: Removing the diode, we find that the direction of I is opposite to the arrow in the diode symbol and the diode equivalent is the open circuit no matter which model is employed. The result is the network of Fig. 2.14, where $I_D = \mathbf{0\ A}$ due to the open circuit. Since $V_R = I_R R$, we have $V_R = (0)R = \mathbf{0\ V}$. Applying Kirchhoff's voltage law around the closed loop yields

$$E - V_D - V_R = 0$$

and

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

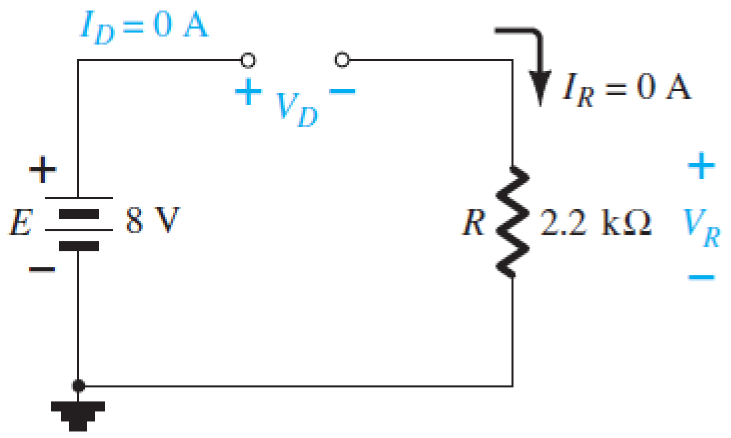


FIG. 2.14
Determining the unknown quantities for Example 2.5.

EXAMPLE 2.6 For the series diode configuration of Fig. 2.16, determine V_D, V_R, and I_D.

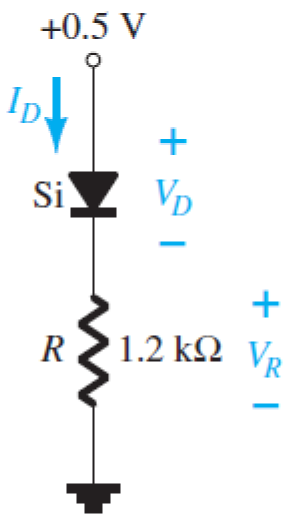


FIG. 2.16
Series diode circuit for Example 2.6.

Solution: Although the "pressure" establishes a current with the same direction as the arrow symbol, the level of applied voltage is insufficient to turn the silicon diode "on." The point of operation on the characteristics is shown in Fig. 2.17, establishing the open-circuit equivalent as the appropriate approximation, as shown in Fig. 2.18. The resulting voltage and current levels are therefore the following:

$$I_D = \mathbf{0\ A}$$

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

and

$$V_D = E = \mathbf{0.5\ V}$$

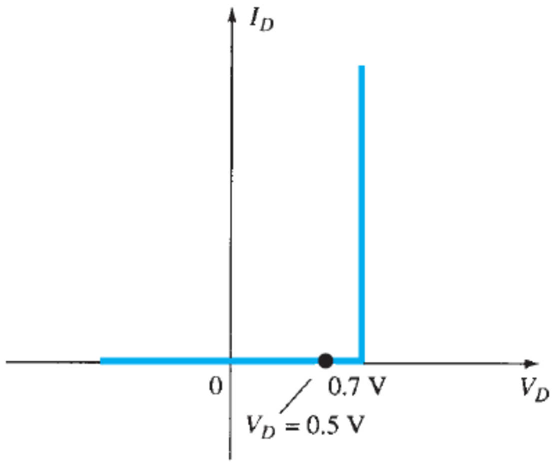


FIG. 2.17
Operating point with E = 0.5 V.

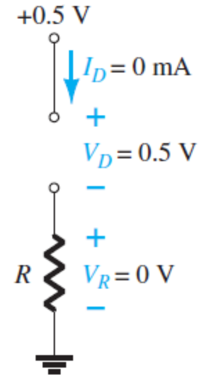


FIG. 2.18
Determining I_D, V_R, and V_D for the circuit of Fig. 2.16.

EXAMPLE 2.7 Determine V_o and I_D for the series circuit of Fig. 2.19. V_{red}=1.8V

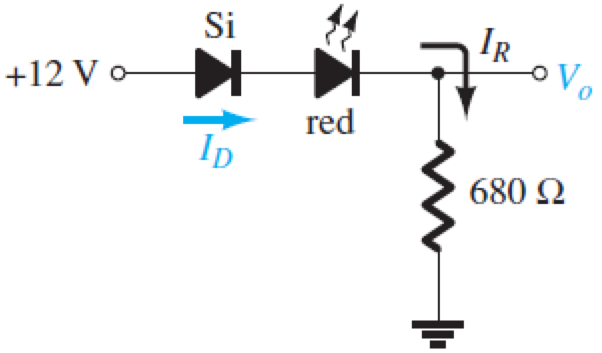


FIG. 2.19
Circuit for Example 2.7.

Solution: An attack similar to that applied in Example 2.4 will reveal that the resulting current has the same direction as the arrowheads of the symbols of both diodes, and the network of Fig. 2.20 results because $E = 12\text{ V} > (0.7\text{ V} + 1.8\text{ V [Table 1.8]}) = 2.5\text{ V}$. Note the redrawn supply of 12 V and the polarity of V_o across the 680-Ω resistor. The resulting voltage is

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

and

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

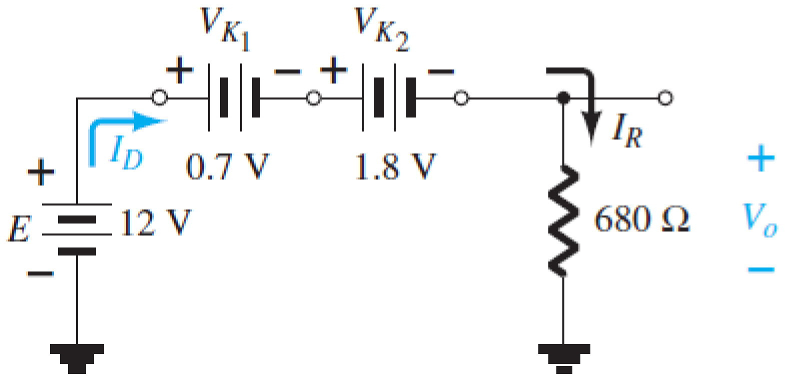


FIG. 2.20
Determining the unknown quantities for Example 2.7.

EXAMPLE 2.8 Determine I_D, V_{D_2}, and V_o for the circuit of Fig. 2.21.

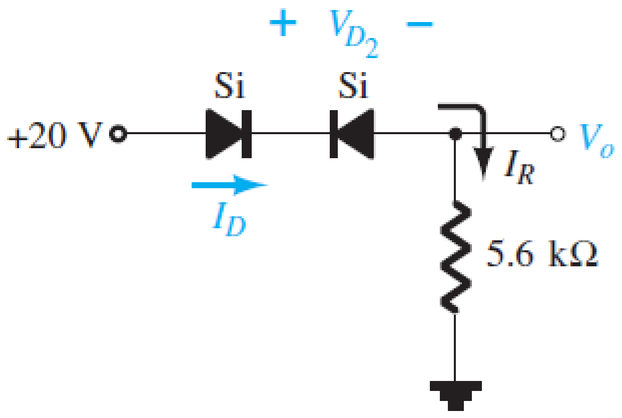


FIG. 2.21
Circuit for Example 2.8.

Solution: Removing the diodes and determining the direction of the resulting current I result in the circuit of Fig. 2.22. There is a match in current direction for one silicon diode but not for the other silicon diode. The combination of a short circuit in series with an open circuit always results in an open circuit and $I_D = \mathbf{0\ A}$, as shown in Fig. 2.23.

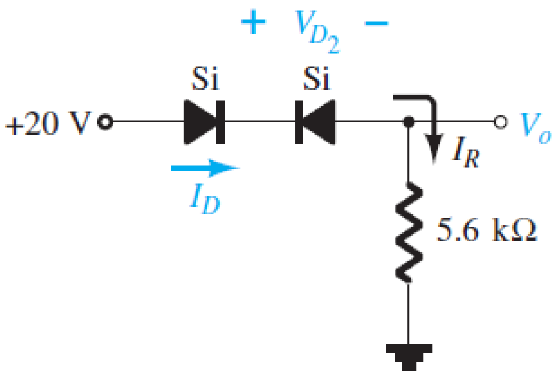


FIG. 2.21
Circuit for Example 2.8.

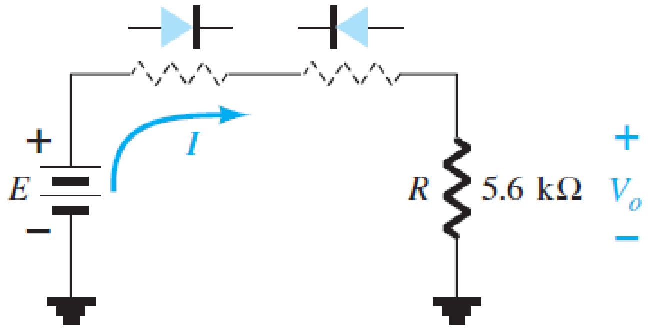


FIG. 2.22
Determining the state of the diodes of Fig. 2.21.

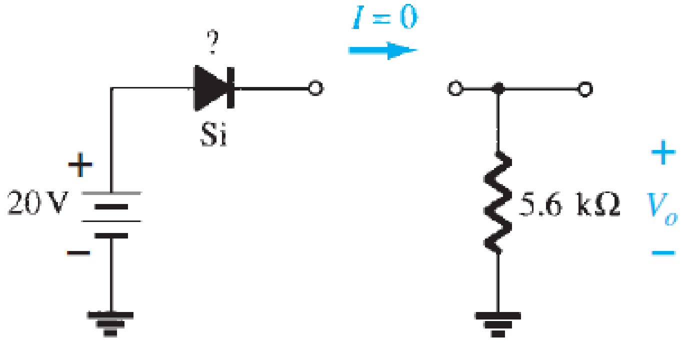


FIG. 2.23
Substituting the equivalent state for the open diode.

$$V_o = I_R R = I_D R = (0\text{ A})R = \mathbf{0\ V}$$
$$V_{D_2} = V_{\text{open circuit}} = E = \mathbf{20\ V}$$

EXAMPLE 2.9 Determine I, V_1, V_2, and V_o for the series dc configuration of Fig. 2.25.

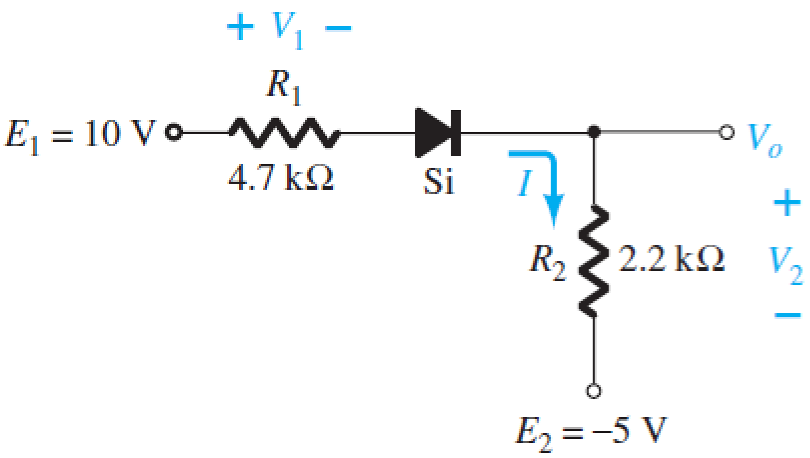


FIG. 2.25
Circuit for Example 2.9.

Solution: The sources are drawn and the current direction indicated as shown in Fig. 2.26. The diode is in the "on" state and the notation appearing in Fig. 2.27 is included to indicate this state. Note that the "on" state is noted simply by the additional $V_D = 0.7$ V on the figure. This eliminates the need to redraw the network and avoids any confusion that may

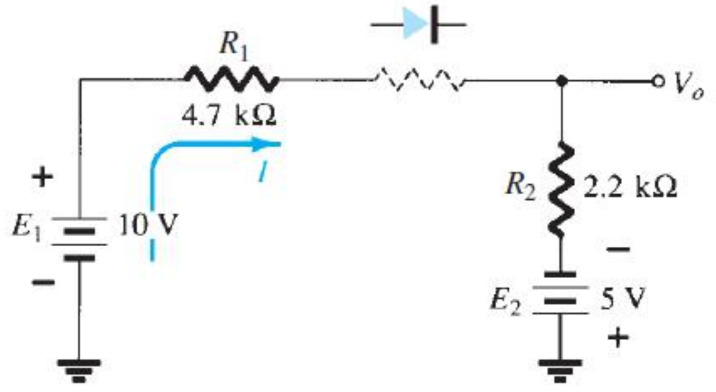


FIG. 2.26
Determining the state of the diode for the network of Fig. 2.25.

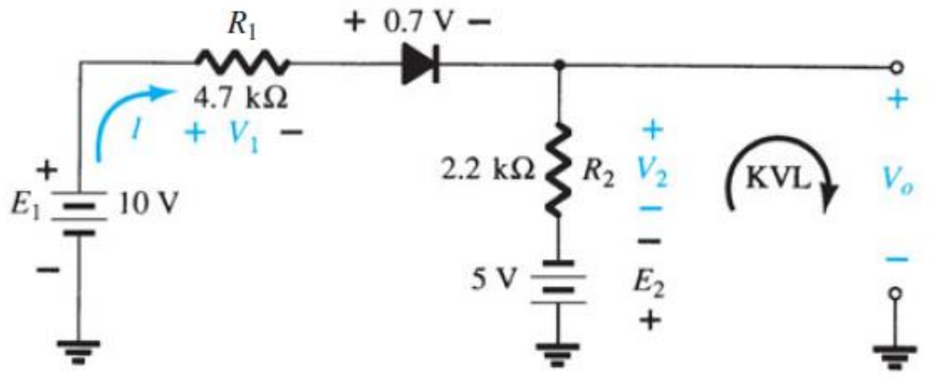


FIG. 2.27
Determining the unknown quantities for the network of Fig. 2.25. KVL, Kirchhoff voltage loop.

result from the appearance of another source. As indicated in the introduction to this section, this is probably the path and notation that one will take when a level of confidence has been established in the analysis of diode configurations. In time the entire analysis will be performed simply by referring to the original network. Recall that a reverse-biased diode can simply be indicated by a line through the device.

The resulting current through the circuit is

$$I = \frac{E_1 + E_2 - V_D}{R_1 + R_2} = \frac{10\text{ V} + 5\text{ V} - 0.7\text{ V}}{4.7\text{ k}\Omega + 2.2\text{ k}\Omega} = \frac{14.3\text{ V}}{6.9\text{ k}\Omega}$$
$$\cong \mathbf{2.07\ mA}$$

and the voltages are

$$V_1 = IR_1 = (2.07\text{ mA})(4.7\text{ k}\Omega) = \mathbf{9.73\ V}$$
$$V_2 = IR_2 = (2.07\text{ mA})(2.2\text{ k}\Omega) = \mathbf{4.55\ V}$$

Applying Kirchhoff's voltage law to the output section in the clockwise direction results in

$$-E_2 + V_2 - V_o = 0$$

and $$V_o = V_2 - E_2 = 4.55\text{ V} - 5\text{ V} = \mathbf{-0.45\ V}$$

The minus sign indicates that V_o has a polarity opposite to that appearing in Fig. 2.25.

PARALLEL AND SERIES–PARALLEL CONFIGURATIONS

EXAMPLE 2.10 Determine V_o, I_1, I_{D_1}, and I_{D_2} for the parallel diode configuration of Fig. 2.28.

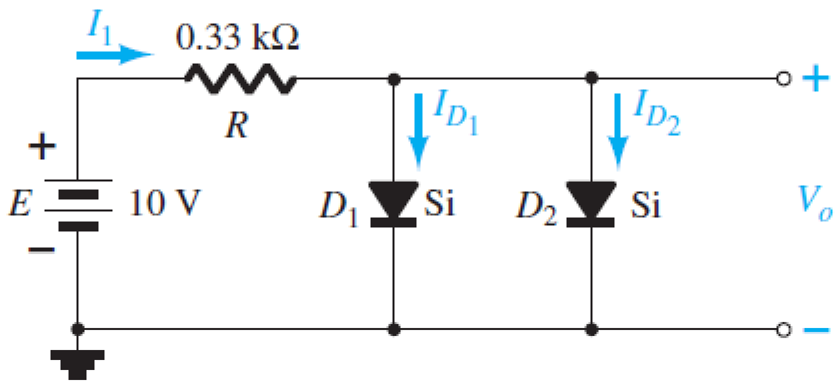


FIG. 2.28
Network for Example 2.10.

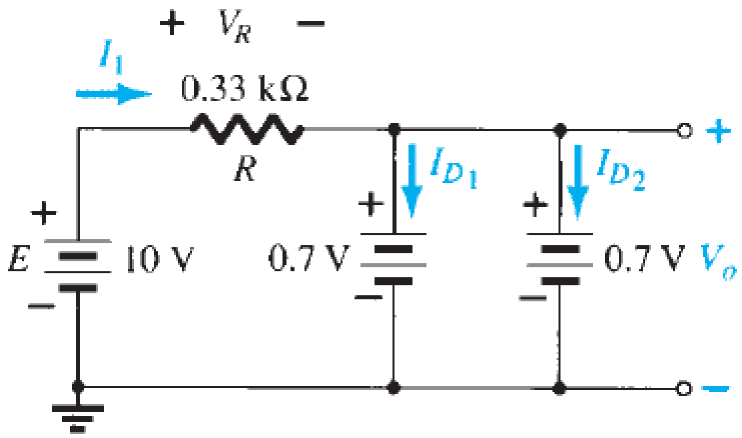


FIG. 2.29
Determining the unknown quantities for the network of Example 2.10.

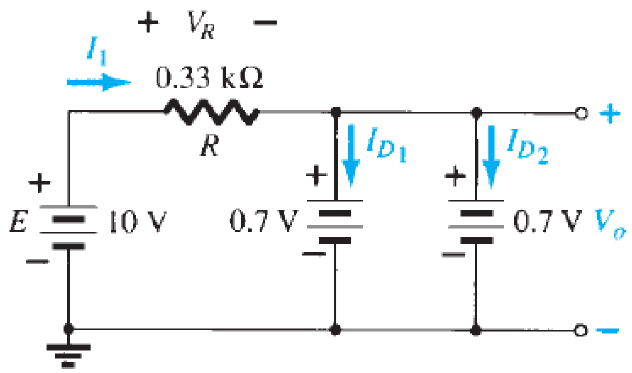


FIG. 2.29
Determining the unknown quantities for the network of Example 2.10.

Solution: For the applied voltage the "pressure" of the source acts to establish a current through each diode in the same direction as shown in Fig. 2.29. Since the resulting current direction matches that of the arrow in each diode symbol and the applied voltage is greater than 0.7 V, both diodes are in the "on" state. The voltage across parallel elements is always the same and

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

The current is

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

Assuming diodes of similar characteristics, we have

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

EXAMPLE 2.13 Determine the currents I_1, I_2, and I_{D_2} for the network of Fig. 2.37.

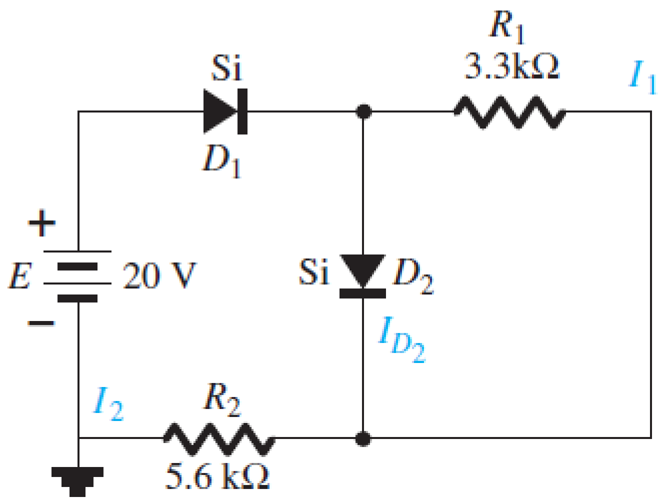


FIG. 2.37
Network for Example 2.13.

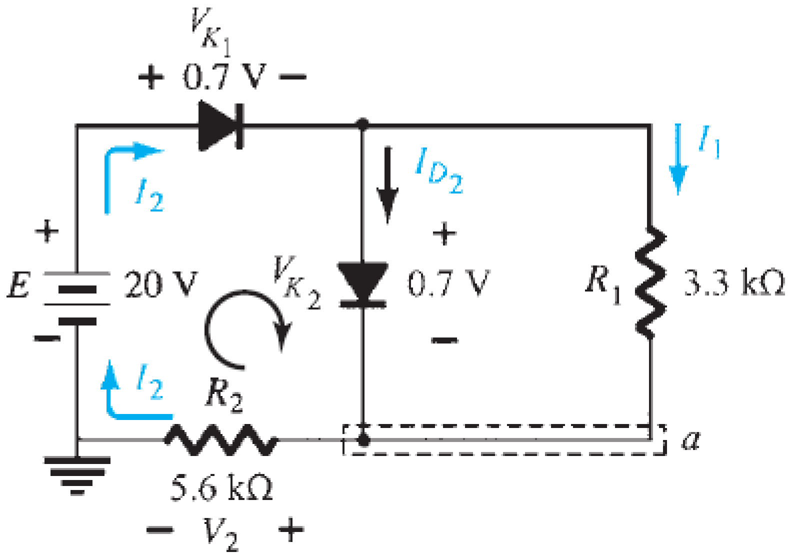


FIG. 2.38
Determining the unknown quantities for Example 2.13.

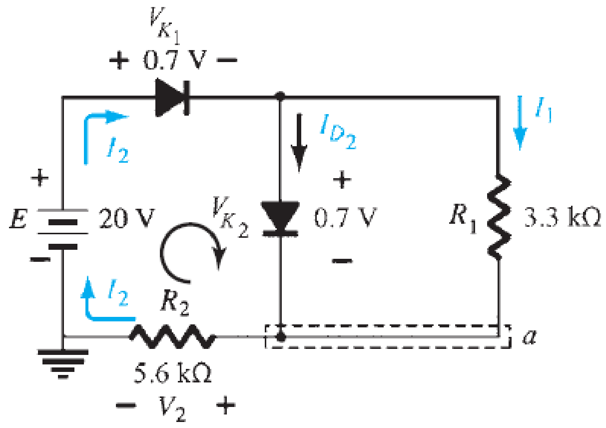


FIG. 2.38
Determining the unknown quantities for Example 2.13.

Solution: The applied voltage (pressure) is such as to turn both diodes on, as indicated by the resulting current directions in the network of Fig. 2.38. Note the use of the abbreviated notation for "on" diodes and that the solution is obtained through an application of techniques applied to dc series–parallel networks. We have

$$I_1 = \frac{V_{K_2}}{R_1} = \frac{0.7\text{ V}}{3.3\text{ k}\Omega} = \mathbf{0.212\text{ mA}}$$

Applying Kirchhoff's voltage law around the indicated loop in the clockwise direction yields

$$-V_2 + E - V_{K_1} - V_{K_2} = 0$$

and
$$V_2 = E - V_{K_1} - V_{K_2} = 20\text{ V} - 0.7\text{ V} - 0.7\text{ V} = \mathbf{18.6\text{ V}}$$

with
$$I_2 = \frac{V_2}{R_2} = \frac{18.6\text{ V}}{5.6\text{ k}\Omega} = \mathbf{3.32\text{ mA}}$$

At the bottom node a,

$$I_{D_2} + I_1 = I_2$$

and
$$I_{D_2} = I_2 - I_1 = 3.32\text{ mA} - 0.212\text{ mA} \cong \mathbf{3.11\text{ mA}}$$