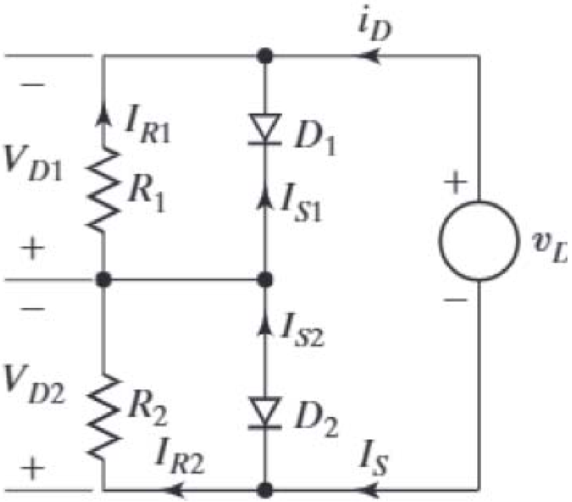
Series-connected diodes

Example 2.3 Finding the Voltage-Sharing Resistors

Two diodes are connected in series, as shown in Figure 2.11a, to share a total dc reverse voltage of $V_D = 5\,\text{kV}$. The reverse leakage currents of the two diodes are $I_{S1} = 30\,\text{mA}$ and $I_{S2} = 35\,\text{mA}$. (a) Find the diode voltages if the voltage-sharing resistances are equal, $R_1 = R_2 = R = 100\,\text{k}\Omega$. (b) Find the voltage-sharing resistances R_1 and R_2 if the diode voltages are equal, $V_{D1} = V_{D2} = V_D/2$.



(a) Circuit diagram

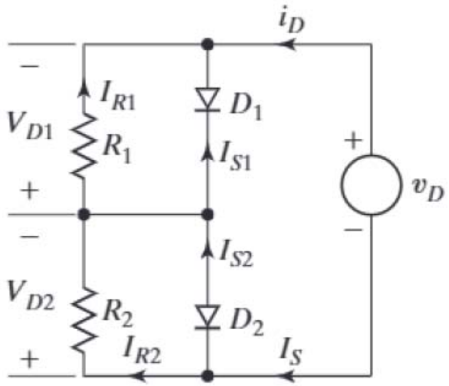
Example 2.3 Finding the Voltage-Sharing Resistors

Two diodes are connected in series, as shown in Figure 2.11a, to share a total dc reverse voltage of $V_D = 5\,\text{kV}$. The reverse leakage currents of the two diodes are $I_{S1} = 30\,\text{mA}$ and $I_{S2} = 35\,\text{mA}$. (a) Find the diode voltages if the voltage-sharing resistances are equal, $R_1 = R_2 = R = 100\,\text{k}\Omega$. (b) Find the voltage-sharing resistances R_1 and R_2 if the diode voltages are equal, $V_{D1} = V_{D2} = V_D/2$.

Solution

a. $I_{S1} = 30\,\text{mA}$, $I_{S2} = 35\,\text{mA}$, and $R_1 = R_2 = R = 100\,\text{k}\Omega$. $-V_D = -V_{D1} - V_{D2}$ or $V_{D2} = V_D - V_{D1}$. From Eq. (2.14),

$$I_{S1} + \frac{V_{D1}}{R} = I_{S2} + \frac{V_{D2}}{R}$$



(a) Circuit diagram

Substituting $V_{D2} = V_D - V_{D1}$ and solving for the diode voltage D_1, we get

$$V_{D1} = \frac{V_D}{2} + \frac{R}{2}\left(I_{S2} - I_{S1}\right)$$
$$= \frac{5\,\text{kV}}{2} + \frac{100\,\text{k}\Omega}{2}\left(35 \times 10^{-3} - 30 \times 10^{-3}\right) = 2750\,\text{V} \tag{2.16}$$

and $V_{D2} = V_D - V_{D1} = 5\,\text{kV} - 2750 = 2250\,\text{V}$.

Series-connected diodes

b. $I_{S1} = 30\,\text{mA}$, $I_{S2} = 35\,\text{mA}$, and $V_{D1} = V_{D2} = V_D/2 = 2.5\,\text{kV}$. From Eq. (2.13),

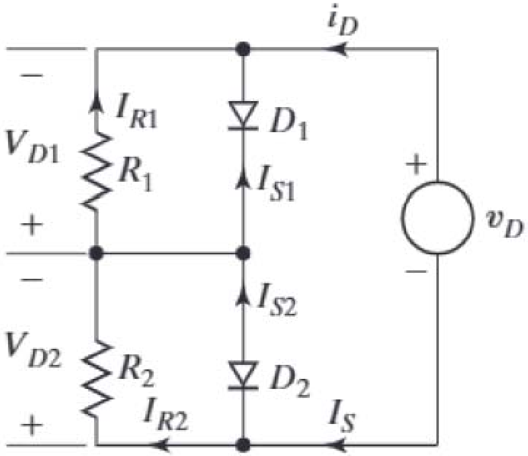
$$I_{S1} + \frac{V_{D1}}{R_1} = I_{S2} + \frac{V_{D2}}{R_2}$$

which gives the resistance R_2 for a known value of R_1 as

$$R_2 = \frac{V_{D2}R_1}{V_{D1} - R_1(I_{S2} - I_{S1})} \tag{2.17}$$

Assuming that $R_1 = 100\,\text{k}\Omega$, we get

$$R_2 = \frac{2.5\,\text{kV} \times 100\,\text{k}\Omega}{2.5\,\text{kV} - 100\,\text{k}\Omega \times (35 \times 10^{-3} - 30 \times 10^{-3})} = 125\,\text{k}\Omega$$

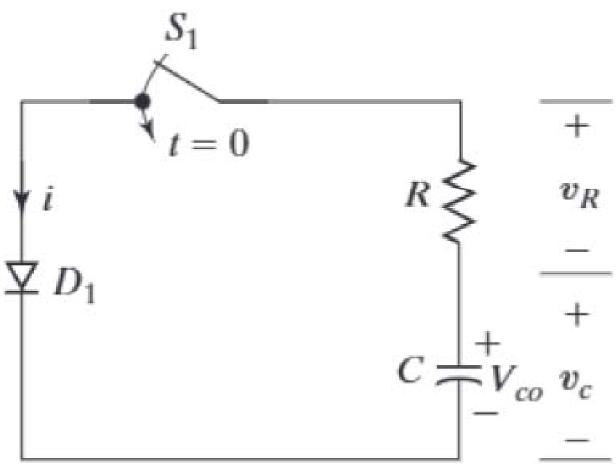


(a) Circuit diagram

Diode switched RL circuit

Example 2.4 Finding the Peak Current and Energy Loss in an *RC* Circuit

A diode circuit is shown in Figure 2.16a with $R = 44\,\Omega$ and $C = 0.1\,\mu F$. The capacitor has an initial voltage, $V_{c0} = V_c(t = 0) = 220\,V$. If switch S_1 is closed at $t = 0$, determine (a) the peak diode current, (b) the energy dissipated in the resistor R, and (c) the capacitor voltage at $t = 2\,\mu s$.



(a) Circuit diagram

FIGURE 2.16

Diode circuit with an *RC* load.

Diode switched RC circuit

Solution

The waveforms are shown in Figure 2.16b.

a. Equation (2.20) can be used with $V_s = V_{c0}$ and the peak diode current I_p is

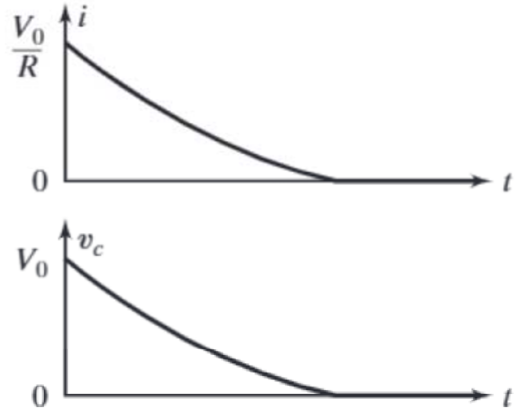
$$I_P = \frac{V_{c0}}{R} = \frac{220}{44} = 5\,\text{A}$$

b. The energy W dissipated is

$$\boxed{W = 0.5CV_{c0}^2} = 0.5 \times 0.1 \times 10^{-6} \times 220^2 = 0.00242\,\text{J} = 2.42\,\text{mJ}$$

c. For $RC = 44 \times 0.1\,\mu = 4.4\,\mu\text{s}$ and $t = t_1 = 2\,\mu\text{s}$, the capacitor voltage is

$$\boxed{v_c(t = 2\,\mu\text{s}) = V_{c0}e^{-t/RC}} = 220 \times e^{-2/4.4} = 139.64\,\text{V}$$



(b) Waveforms

FIGURE 2.16

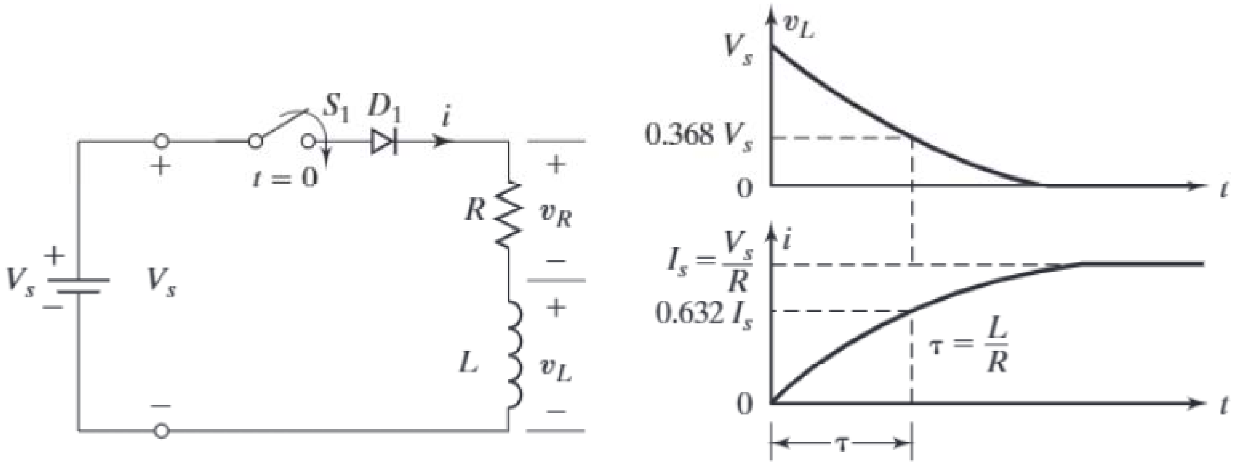
Diode circuit with an *RC* load.

Diode switched RL circuit

Example 2.5 Finding the Steady-State Current and the Energy Stored in an Inductor

A diode RL circuit is shown in Figure 2.17a with $V_S = 220\,\text{V}$, $R = 4\Omega$, and $L = 5\,\text{mH}$. The inductor has no initial current. If switch S_1 is closed at $t = 0$, determine (a) the steady-state diode current, (b) the energy stored in the inductor L, and (c) the initial di/dt.

(d) find the inductor current at t= 1ms



(a) Circuit diagram

(b) Waveforms

FIGURE 2.17

Diode circuit with an RL load.

$$i(t) = \frac{V_s}{R}\left(1 - e^{-tR/L}\right) \qquad (2.25)$$

Solution

The waveforms are shown in Figure 2.17b.

a. Eq. (2.25) can be used with $t = \infty$ and the steady-state peak diode current is

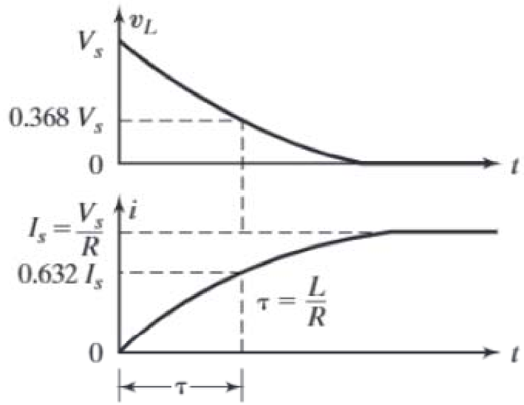
$$I_P = \frac{V_S}{R} = \frac{220}{4} = 55\,\text{A}$$

b. The energy stored in the inductor in the steady state at a time t tending ∞

$$\boxed{W = 0.5\,\mathrm{L}\,\mathrm{I_P^2}} = 0.5 \times 5 \times 10^{-3} 55^2 = 7.563\,\text{mJ}$$

c. Eq. (2.26) can be used to find the initial di/dt as

$$\boxed{\frac{di}{dt} = \frac{V_S}{L}} = \frac{220}{5 \times 10^{-3}} = 44\ \text{A/ms}$$



(b) Waveforms

FIGURE 2.17

Diode circuit with an RL load.

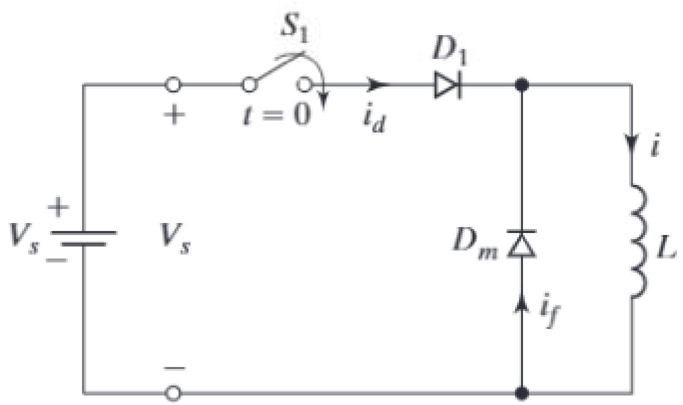
d. For $L/R = 5\,\text{mH}/4 = 1.25\,\text{ms}$, and $t = t_1 = 1\,\text{ms}$, Eq. (2.25) gives the inductor current as

$$\boxed{i(t = 1\,\text{ms}) = \frac{V_S}{R}\left(1 - e^{-tR/L}\right)} = \frac{220}{4} \times \left(1 - e^{-1/1.25}\right) = 30.287\ \text{A}$$

Free-wheeling diode with switched RL circuit

Example 2.8 Finding the Stored Energy in an Inductor with a Freewheeling Diode

In Figure 2.24a, the resistance is negligible ($R = 0$), the source voltage is $V_s = 220\,\text{V}$ (constant time), and the load inductance is $L = 220\,\mu\text{H}$. (a) Draw the waveform for the load current if the switch is closed for a time $t_1 = 100\,\mu\text{s}$ and is then opened. (b) Determine the final energy stored in the load inductor.



(a) Circuit diagram

FIGURE 2.25

Diode circuit with an L load.

(b) Equivalent circuit

Free-wheeling diode with switched RL circuit

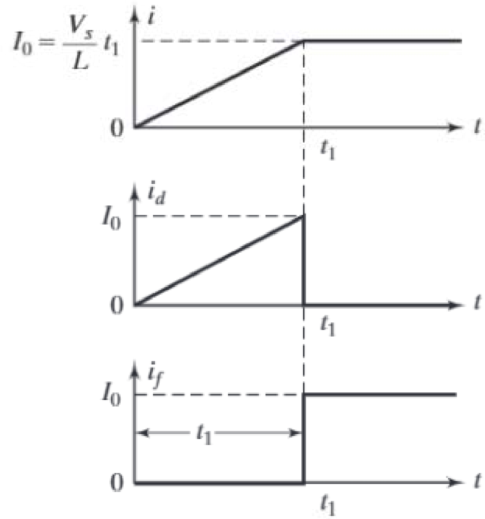
Solution

a. The circuit diagram is shown in Figure 2.25a with a zero initial current. When the switch is closed at $t = 0$, the load current rises linearly and is expressed as

$$i(t) = \frac{V_s}{L} t$$

and at $t = t_1$, $I_0 = V_s t_1 / L = 220 \times 100/220 = 100\,\text{A}$.

b. When switch S_1 is opened at a time $t = t_1$, the load current starts to flow through diode D_m. Because there is no dissipative (resistive) element in the circuit, the load current remains constant at $I_0 = 100\,\text{A}$ and the energy stored in the inductor is $0.5LI_0^2 = 1.1\,\text{J}$. The current waveforms are shown in Figure 2.25b.



(b) Waveforms

(b) Equivalent circuit

Example Problem

2.1 The reverse recovery time of a diode is $t_{rr} = 5\,\mu s$, and the rate of fall of the diode current is $di/dt = 80\,A/\mu s$. If the softness factor is SF = 0.5, determine **(a)** the storage charge Q_{RR}, and **(b)** the peak reverse current I_{RR}.

Do it for two conditions: 1) When trr=ta. 2) When trr=ta+tb

Example Problem

2.1 The reverse recovery time of a diode is $t_{rr} = 5\ \mu s$, and the rate of fall of the diode current is $di/dt = 80\ A/\mu s$. If the softness factor is $SF = 0.5$, determine **(a)** the storage charge Q_{RR}, and **(b)** the peak reverse current I_{RR}.

Do it for two conditions: 1) When trr=ta. 2) When trr=ta+tb

Solution: The ratio t_b/t_a is known as the *softness factor* (SF).

$$Given: t_{rr} = 5us, \frac{di}{dt} = 80\frac{A}{us}, SF = \frac{t_b}{t_a} = 0.5$$

$$For\ Condition - 1: t_{rr} \approx t_{rr}$$

$$From\ I_{rr}\ curve,\ I_{rr} = \frac{di}{dt} \times t_a\ or\ I_{rr} = \frac{di}{dt} \times t_{rr}$$

$$I_{rr} = 80\frac{A}{us} \times 5us = 400\,A$$

$$From\ I_{rr}\ curve, Q_{rr} = \frac{1}{2} \times I_{rr} \times t_{rr} = \frac{1}{2} \times 400A \times 5us$$

$$Q_{rr} = 1000uC$$

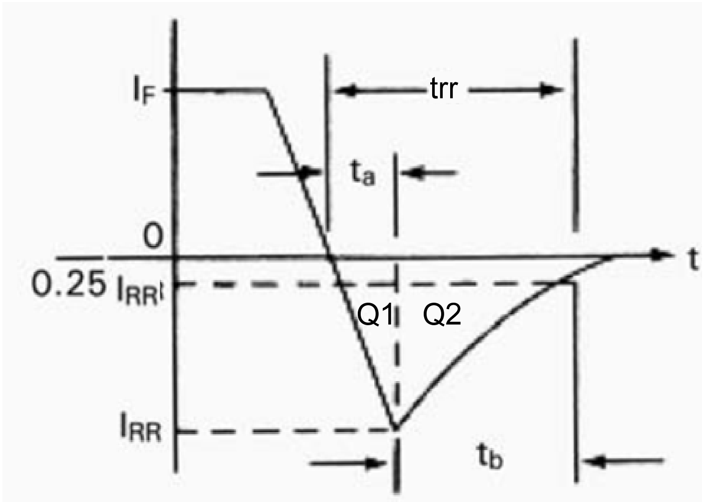


Fig. 1. Diode reverse recovery current

Example Problem

2.1 The reverse recovery time of a diode is $t_{rr} = 5\,\mu s$, and the rate of fall of the diode current is $di/dt = 80\,A/\mu s$. If the softness factor is SF = 0.5, determine **(a)** the storage charge Q_{RR}, and **(b)** the peak reverse current I_{RR}.

Do it for two conditions: 1) When trr=ta. 2) When trr=ta+tb

Solution:

$$Given: t_{rr} = 5us, \frac{di}{dt} = 80\frac{A}{us}, SF = \frac{t_b}{t_a} = 0.5$$

$$For\,Condition-2: t_{rr} = t_a + t_b = t_a + 0.5t_a = 1.5t_a$$

$$t_a = \frac{t_{rr}}{1.5} = \frac{5uS}{1.5} = 3.33uS$$

$$From\, I_{rr}\, curve,\ I_{rr} = \frac{di}{dt}\times t_a$$

$$I_{rr} = 80\frac{A}{us}\times 3.33us = 266.67\,A$$

$$From\, I_{rr}\, curve, Q_{rr} = \frac{1}{2}\times I_{rr}\times t_{rr} = \frac{1}{2}\times 266.67A\times 5us$$

$$Q_{rr} = 666.67uC$$

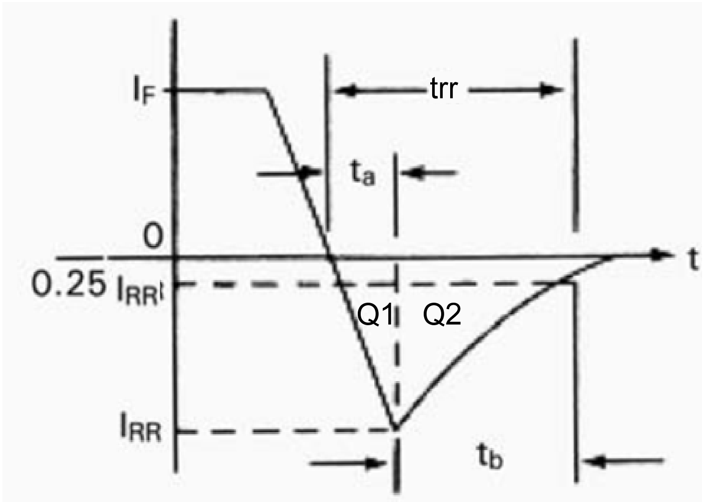


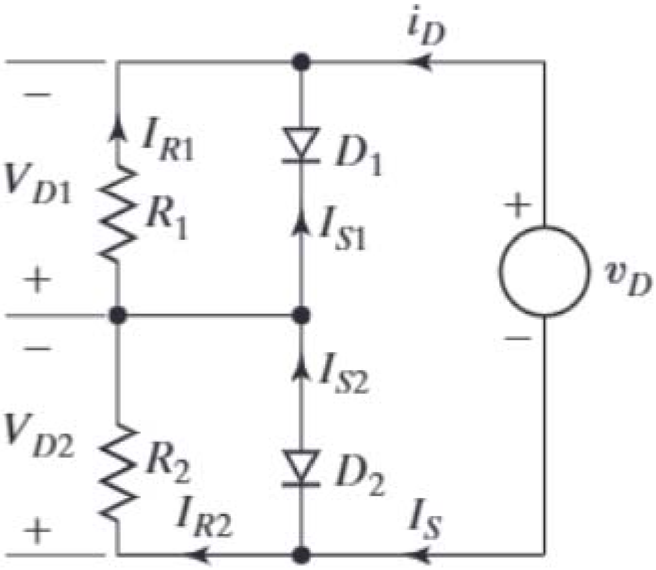
Fig. 1. Diode reverse recovery current

Example Problem

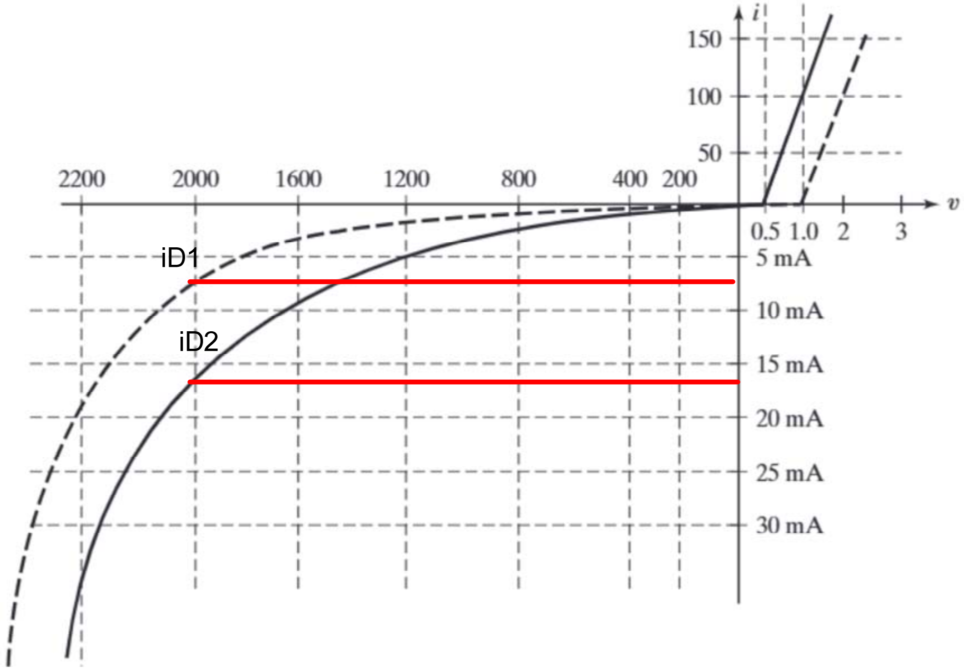
2.2 The storage charge and the peak reverse current of a diode are $Q_{RR} = 10000\,\mu C$ and $I_{RR} = 4000$. If the softness factor is $SF = 0.5$, determine **(a)** the reverse recovery time of the diode t_{rr}, and **(b)** the rate of fall of the diode current di/dt.

Example Problem

2.6 Two diodes are connected in series as shown in Figure 2.11 and the voltage across each diode is maintained the same by connecting a voltage-sharing resistor, such that $V_{D1} = V_{D2} = 2000\,\text{V}$ and $R_1 = 100\,\text{k}\Omega$. The v–i characteristics of the diodes are shown in Figure P2.6. Determine the leakage currents of each diode and the resistance R_2 across diode D_2.



(a) Circuit diagram



Example Problem

2.6 Two diodes are connected in series as shown in Figure 2.11 and the voltage across each diode is maintained the same by connecting a voltage-sharing resistor, such that $V_{D1} = V_{D2} = 2000\text{ V}$ and $R_1 = 100\text{ k}\Omega$. The $v-i$ characteristics of the diodes are shown in Figure P2.6. Determine the leakage currents of each diode and the resistance R_2 across diode D_2.

Solution:

$$Given: V_{D1} = V_{D1} = 2000V, R_1 = 100\,k\Omega$$

$$From\ Figure\ P2.6,$$

$$I_{S1} = 7.5mA, I_{S2} = 17mA$$

$$From\ Circuit:$$

$$I_{S1} + I_{R1} = I_{S2} + I_{R2}$$

$$where, I_{R1} = \frac{V_{D1}}{R_1} = \frac{2000}{100\,k} = 20\,mA$$

$$7.5mA + 20mA = 17mA + I_{R2}$$

$$I_{R2} = 10.5mA$$

$$So, R_2 = \frac{V_{D2}}{I_{R2}} = \frac{2000V}{10.5mA} = 190.4k\Omega$$

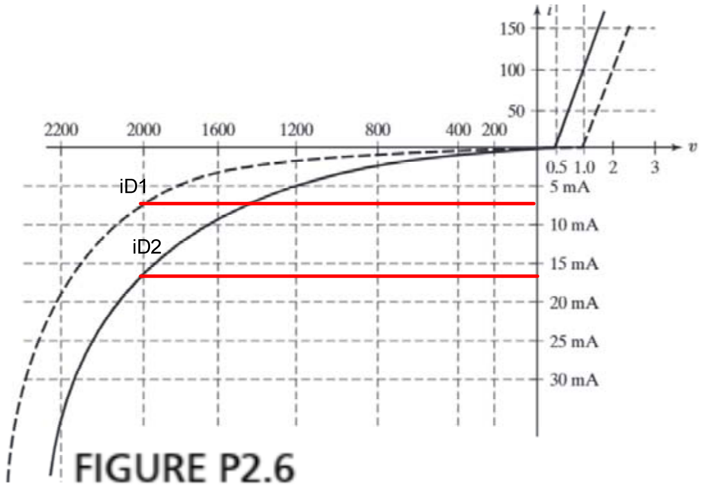
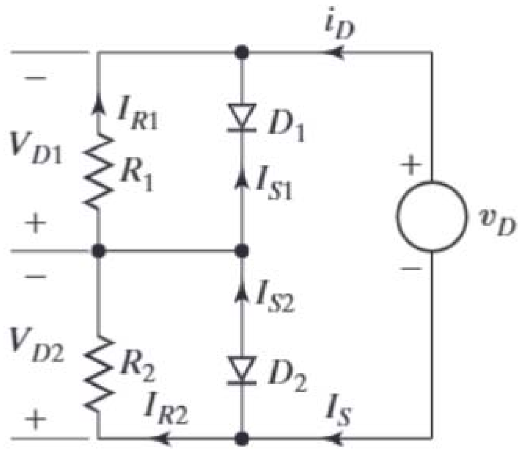


FIGURE P2.6



(a) Circuit diagram

Example Problem

2.12 Two diodes are connected in series as shown in Figure 2.11a. The resistance across the diodes is $R_1 = R_2 = 10\,\mathrm{k}\Omega$. The input dc voltage is 5 kV. The leakage currents are $I_{s1} = 25\,\mathrm{mA}$ and $I_{s2} = 40\,\mathrm{mA}$. Determine the voltage across the diodes.

Example Problem

2.12 Two diodes are connected in series as shown in Figure 2.11a. The resistance across the diodes is $R_1 = R_2 = 10\text{k}\Omega$. The input dc voltage is 5 kV. The leakage currents are $I_{s1} = 25\text{mA}$ and $I_{s2} = 40\text{mA}$. Determine the voltage across the diodes.

Solution:

$$Given:, R_1 = R_2 = 10\,k\Omega, V_D = 5\,kV$$

$$I_{S1} = 25mA, I_{S2} = 40mA$$

$$V_{D2} = V_{D1} - V_{D1} = 5\,kV - V_{D1} \qquad (i)$$

$$I_{S1} + \frac{V_{D1}}{R_1} = I_{S2} + \frac{V_{D2}}{R_2} \qquad (ii)$$

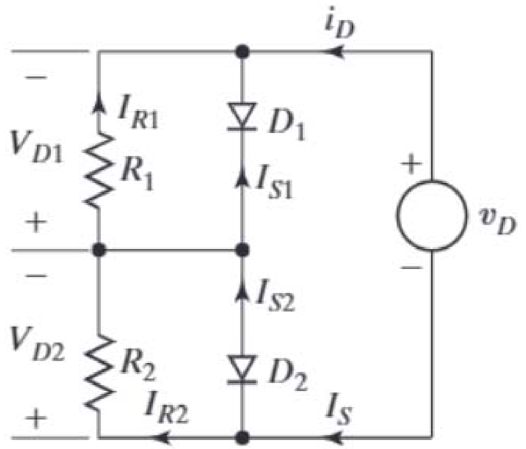
Putting (i) into (ii) and solving, we get

$$V_{D1} = \frac{V_D}{2} + \frac{R}{2}(I_{S2} - I_{S1})$$

$$V_{D1} = \frac{5000}{2} + \frac{10000}{2}(40mA - 25mA)$$

$$V_{D1} = 2575V$$

$$V_{D2} = 5000V - 2575V = 2425V$$



(a) Circuit diagram

Example Problem

2.15 The current waveform of a diode is shown in Figure P2.15. Determine the average, root mean square (rms), and peak current ratings of the diode. Assume $I_P = 500\,\text{A}$ of a half sine-wave.

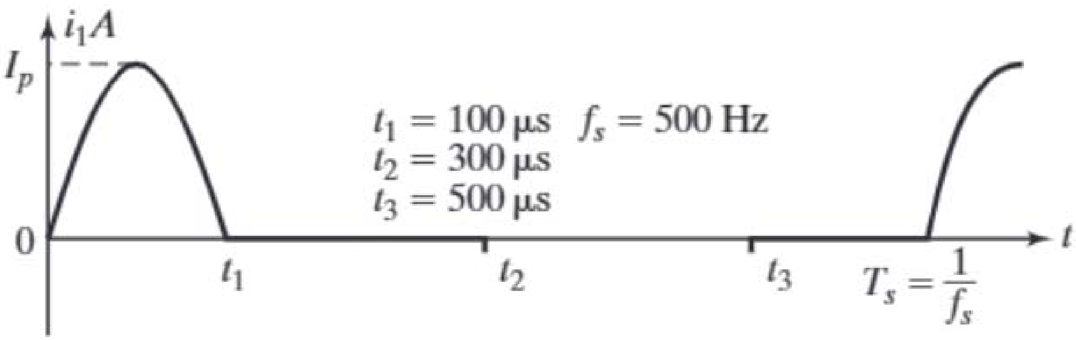


FIGURE P2.15

Example Problem

2.15 The current waveform of a diode is shown in Figure P2.15. Determine the average, root mean square (rms), and peak current ratings of the diode. Assume $I_P = 500$ A of a half sine-wave.

Solution:

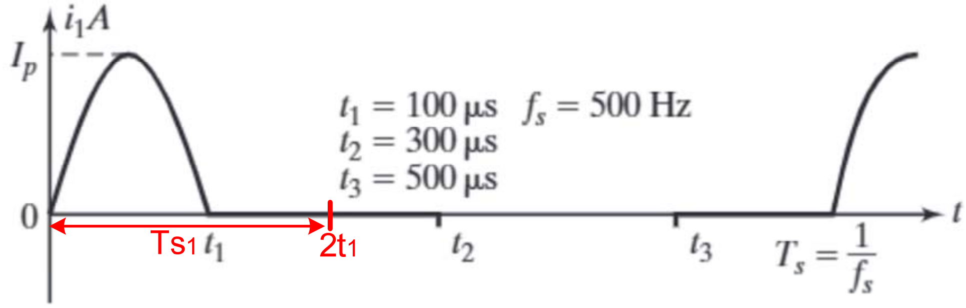


FIGURE P2.15

$Given:, t_1 = 100uS, I_p = 500A, f_s = 500\,Hz$

$T_s = 1/f_s = 20000uS$

1) Average value, $I_{p,avg} = ?$

$$I_{p,avg} = \frac{1}{T_s}\int_0^{t_1} I_p \sin\omega t\,dt \qquad \omega = \frac{2\pi}{2t1}$$

$$I_{p,avg} = \frac{I_p}{T_s}\left.\frac{-\cos\omega t}{\omega}\right|_0^{t_1} = \frac{I_p}{T_s}\left.\frac{-\cos\frac{2\pi}{2t1}t}{\frac{2\pi}{2t_1}}\right|_0^{t_1}$$

$$I_{p,avg} = \frac{I_p t_1}{\pi T_s}\left[-\cos\pi\frac{t_1}{t_1} + \cos 0\right]$$

$$I_{p,avg} = \frac{I_p t_1}{\pi T_s}[-(-1)+1]$$

$$I_{p,avg} = \frac{2I_p t_1}{\pi T} = \frac{2\times 500\times 100uS}{3.14\times 2000uS} = 15.92A$$

Example Problem

2.15 The current waveform of a diode is shown in Figure P2.15. Determine the average, root mean square (rms), and peak current ratings of the diode. Assume $I_P = 500\,\text{A}$ of a half sine-wave.

Solution:

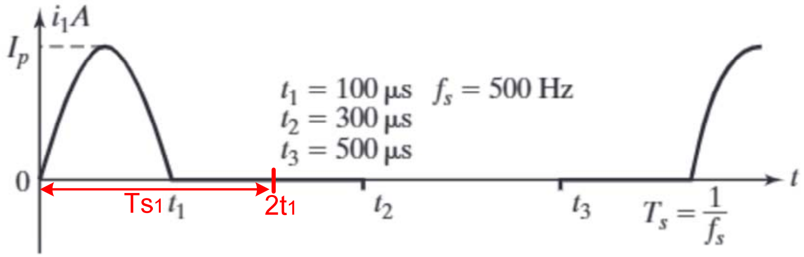


FIGURE P2.15

$2)\ RMS\ value, I_{p,rms} = ?$

$$I_{p,rms}^2 = \frac{1}{T}\int_0^{t_1} I_p^2 \sin^2 \omega t\, dt$$

Since $\sin^2 \omega t = \frac{1}{2}(1 - \cos 2\omega t)$

$$I_{p,rms}^2 = \frac{I_p^2}{2T}\int_0^{t_1}(1 - \cos 2\omega t)\, dt$$

$$\omega = \frac{2\pi}{2t1}$$

$$I_{p,rms}^2 = \frac{I_p^2}{2T}\left[t\Big|_0^{t_1} - \frac{\sin\frac{4\pi}{2t_1}t}{\frac{4\pi}{2t_1}}\Bigg|_0^{t_1} \right]$$

$$I_{p,rms}^2 = \frac{I_p^2}{2T}\left[t_1 - \frac{\sin\frac{2\pi}{t_1}t_1}{\frac{4\pi}{2t_1}} + \sin 0 \right] = \frac{I_p^2}{2T}[t_1 - 0 + 0]$$

$$I_{p,rms}^2 = \frac{I_p^2 t_1}{2T} \Rightarrow I_{p,rms} = I_p\sqrt{\frac{t_1}{2T}}$$

$$I_{p,rms} = 500\sqrt{\frac{100u}{2\times 2000u}} = 79.05A$$

Example Problem

2.15 The current waveform of a diode is shown in Figure P2.15. Determine the average, root mean square (rms), and peak current ratings of the diode. Assume $I_P = 500\,\mathrm{A}$ of a half sine-wave.

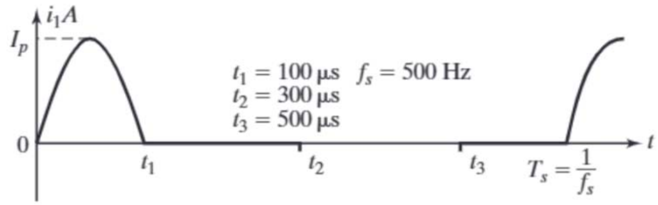


FIGURE P2.15

Solution:

$Given:, t_1 = 100uS, I_p = 500A, f_s = 500\,Hz$

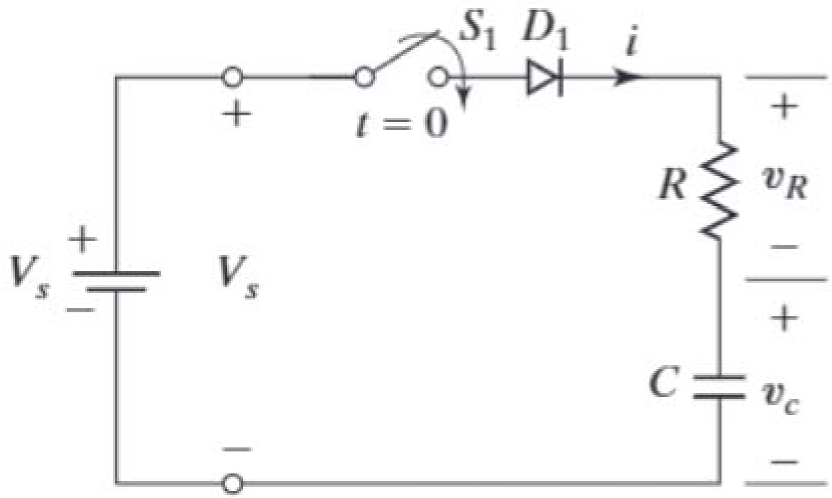
$T = 1/f_s = 20000uS$

1) $Peak\,value, I_{p,peak} = ?$

$I_{p,peak} = I_p = 500A$

Example Problem

2.22 The diode circuit as shown in Figure 2.15a has $V_S = 220\,\text{V}$, $R = 4.7\,\Omega$, and $C = 10\,\mu\text{F}$. The capacitor has an initial voltage of V_{CO} $(t = 0) = 0$. If switch is closed at $t = 0$, determine (a) the peak diode current, (b) the energy dissipated in the resistor R, and (c) the capacitor voltage at $t = 2\,\mu\text{s}$.



(a) Circuit diagram

FIGURE 2.15

Diode circuit with an RC load.

Example Problem

2.22 The diode circuit as shown in Figure 2.15a has $V_S = 220\,\text{V}$, $R = 4.7\,\Omega$, and $C = 10\,\mu\text{F}$. The capacitor has an initial voltage of $V_{CO}\ (t = 0) = 0$. If switch is closed at $t = 0$, determine (a) the peak diode current, (b) the energy dissipated in the resistor R, and (c) the capacitor voltage at $t = 2\,\mu\text{s}$.

Solution:

$$Given: V_s = 220V, R = 4.7\Omega, C = 10uF$$

$$V_{C0}(t=0) = 0$$

$$a)\ Peak\ diode\ current, I_{D,p} = ?$$

$$I_{D,p} = \frac{V_s}{R} = \frac{220}{4.7} = 46.8A$$

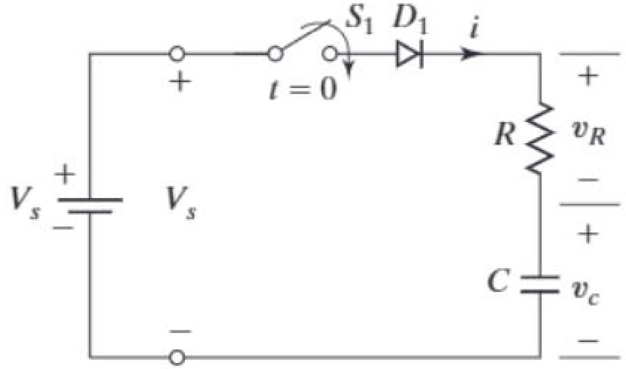
$$b)\ Energy\ dissipated, W = ?$$

$$W = \frac{1}{2}CV_c^2 = \frac{1}{2} \times 10u \times 220^2 = 0.242J$$

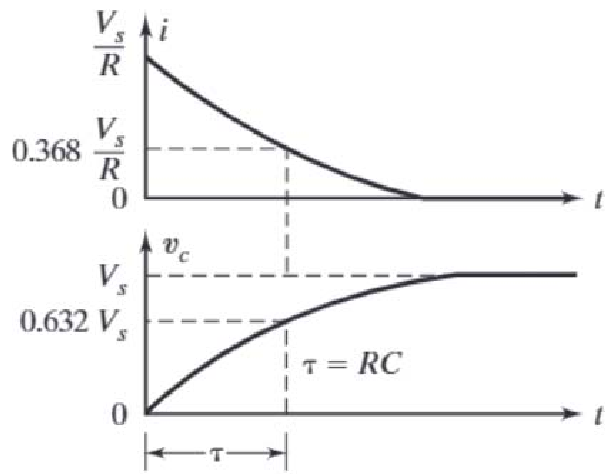
$$c)\ Capacitor\ voltage, Vc(t = 2uS) = ?$$

$$Vc = V_s(1 - e^{\frac{-t}{RC}}) = 220(1 - e^{\frac{-2u}{4.7\times 10u}})$$

$$Vc = 9.165A$$



(a) Circuit diagram

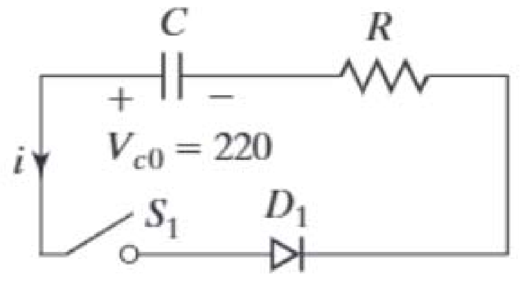


(b) Waveforms

Example Problem

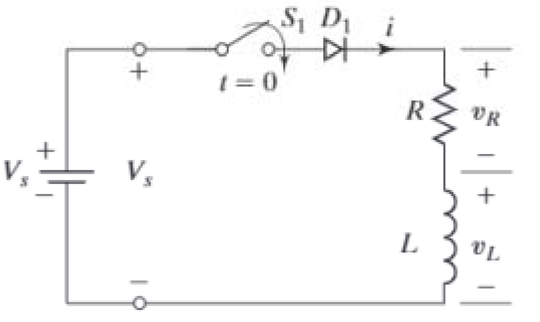
2.23 A diode circuit is shown in Figure P2.23 with $R = 22\,\Omega$ and $C = 10\,\mu\text{F}$. If switch S_1 is closed at $t = 0$, determine the expression for the voltage across the capacitor and the energy lost in the circuit.

FIGURE P2.23



Example Problem

2.24 The diode RL circuit as shown in Figure 2.17a has $V_S = 110\,\text{V}$, $R = 4.7\,\Omega$, and $L = 4.5\,\text{mH}$. The inductor has no initial current. If switch S_1 is closed at $t = 0$, determine (a) the steady-state diode current, (b) the energy stored in the inductor L, and (c) the initial di/dt.



(a) Circuit diagram

FIGURE 2.17

Diode circuit with an RL load.

Example Problem

2.24 The diode RL circuit as shown in Figure 2.17a has $V_S = 110\,\text{V}$, $R = 4.7\,\Omega$, and $L = 4.5\,\text{mH}$. The inductor has no initial current. If switch S_1 is closed at $t = 0$, determine (a) the steady-state diode current, (b) the energy stored in the inductor L, and (c) the initial di/dt.

Solution:

$$Given: V_s = 110V, R = 4.7\Omega, L = 4.5mH$$

$$I_{L0}(t=0) = 0\,A$$

$$a)\ Steady\ state\ diode\ current, I_{D,p} = ?$$

$$I_{D,p} = \frac{V_s}{R} = \frac{110}{4.7} = 23.4A$$

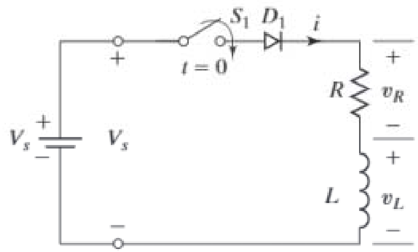
$$b)\ Energy\ dissipated, W = ?$$

$$W = \frac{1}{2}LI_L^2 = \frac{1}{2} \times 4.5m \times 23.4^2 = 1.23J$$

$$c)\ The\ initial\ di/dt = ?$$

$$\frac{di}{dt}(t=0) = \frac{V_s}{L} = \frac{110}{4.5m}$$

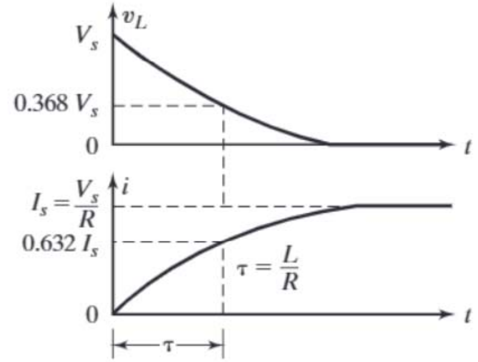
$$\frac{di}{dt} = 2444.4\frac{A}{s}$$



(a) Circuit diagram

FIGURE 2.17

Diode circuit with an RL load.



(b) Waveforms

$$i(t) = \frac{V_s}{R}(1 - e^{-tR/L}) \qquad (2.25)$$

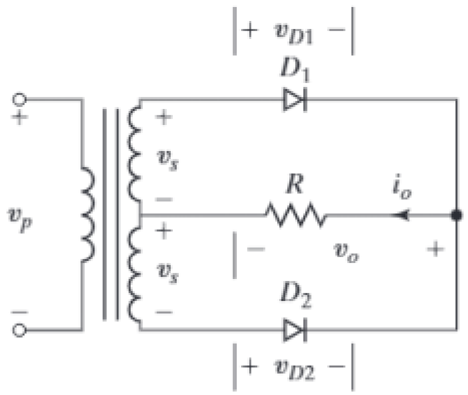
The rate of change of this current can be obtained from Eq. (2.25) as

$$\frac{di}{dt} = \frac{V_s}{L}e^{-tR/L} \qquad (2.26)$$

Example Problem

Example 3.1 Finding the Performance Parameters of a Full-Wave Rectifier with a Center-Tapped Transformer

If the rectifier in Figure 3.2a has a purely resistive load of R, determine (a) the efficiency, (b) the FF, (c) the RF, (d) the TUF, (e) the PIV of diode D_1, (f) the CF of the input current, and (g) the input power factor PF.



(a) Circuit diagram

Example Problem

Example 3.1 Finding the Performance Parameters of a Full-Wave Rectifier with a Center-Tapped Transformer

If the rectifier in Figure 3.2a has a purely resistive load of R, determine (a) the efficiency, (b) the FF, (c) the RF, (d) the TUF, (e) the PIV of diode D_1, (f) the CF of the input current, and (g) the input power factor PF.

Solution

From Eq. (3.11), the average output voltage is

$$V_{dc} = \frac{2}{T}\int_0^{T/2} V_m \sin \omega t \, dt = \frac{2V_m}{\pi} = 0.6366V_m \quad (3.11)$$

$$V_{dc} = \frac{2V_m}{\pi} = 0.6366V_m$$

and the average load current is

$$I_{dc} = \frac{V_{dc}}{R} = \frac{0.6366V_m}{R}$$

The rms values of the output voltage and current are

$$V_{rms} = \left[\frac{2}{T}\int_0^{T/2} (V_m \sin \omega t)^2 \, dt\right]^{1/2} = \frac{V_m}{\sqrt{2}} = 0.707V_m$$

$$I_{rms} = \frac{V_{rms}}{R} = \frac{0.707V_m}{R}$$

Example Problem

Example 3.1 Finding the Performance Parameters of a Full-Wave Rectifier with a Center-Tapped Transformer

If the rectifier in Figure 3.2a has a purely resistive load of R, determine (a) the efficiency, (b) the FF, (c) the RF, (d) the TUF, (e) the PIV of diode D_1, (f) the CF of the input current, and (g) the input power factor PF.

$$P_{dc} = V_{dc} I_{dc} \quad (3.1)$$

From Eq. (3.1) $P_{dc} = (0.6366 V_m)^2/R$

$$P_{ac} = V_{rms} I_{rms} \quad (3.2)$$

from Eq. (3.2) $P_{ac} = (0.707 V_m)^2/R$.

$$\eta = \frac{P_{dc}}{P_{ac}} \quad (3.3)$$

a. From Eq. (3.3), the efficiency $\eta = (0.6366 V_m)^2/(0.707 V_m)^2 = 81\%$.

$$\text{FF} = \frac{V_{rms}}{V_{dc}} \quad (3.5)$$

b. From Eq. (3.5), the form factor FF $= 0.707 V_m / 0.6366 V_m = 1.11$.

c. From Eq. (3.7), the ripple factor RF $= \sqrt{1.11^2 - 1} = 0.482$ or 48.2%.

d.

$$\text{TUF} = \frac{P_{dc}}{V_s I_s}$$

$$V_s = V_m/\sqrt{2} = 0.707 V_m$$

$$I_s = 0.707 V_m / R$$

$$TUF = \frac{(0.6366 V_m)^2 / R}{(0.707 V_m)^2 / R} = 81\%$$

Example Problem

Example 3.1 Finding the Performance Parameters of a Full-Wave Rectifier with a Center-Tapped Transformer

If the rectifier in Figure 3.2a has a purely resistive load of R, determine (a) the efficiency, (b) the FF, (c) the RF, (d) the TUF, (e) the PIV of diode D_1, (f) the CF of the input current, and (g) the input power factor PF.

e. The peak reverse blocking voltage, PIV $= 2V_m$.

f. $I_{s(\text{peak})} = V_m/R$ and $I_s = 0.707V_m/R$. The CF of the input current is CF $= I_{s(\text{peak})}/I_s = 1/0.707 = \sqrt{2}$.

g. The input PF for a resistive load can be found from

$$\text{PF} = \frac{P_{ac}}{V_s I_s}$$

from Eq. (3.2) $P_{ac} = (0.707V_m)^2/R$.

$$V_s = V_m/\sqrt{2} = 0.707V_m$$

$$I_s = 0.707V_m / R$$

$$PF = \frac{(0.707V_m)^2 / R}{(0.707V_m)^2 / R} = 1$$