1-

(a) $t_{rr} \cong \sqrt{\dfrac{2Q_{RR}}{di/dt}}$

$Q_{RR} = 0.5\ (di/dt)\ t_{rr}^2 = 0.5 \times 80 \times 5^2 \times 10^{-6} = 1000\ \mu C$

(b) $I_{RR} = \sqrt{2Q_{RR}\dfrac{di}{dt}}$

$$I_{RR} = \sqrt{2Q_{RR}\frac{di}{dt}} = \sqrt{2\times 1000\times 80} = 400\ A$$

2-

$$= \frac{V_m}{\pi}(1 - \cos \omega t_{rr})$$

With zero reverse recovery time, average output voltage, is

$$V_0 = \frac{2\sqrt{2}\times 230}{\pi} = 207.04\ \text{V}$$

(*a*) For $f = 50$ Hz and $t_{rr} = 40\ \mu$s, the reduction in the average output voltage, is

$$V_r = \frac{V_m}{\pi}(1 - \cos 2\pi f t_{rr})$$
$$= \frac{\sqrt{2}\times 230}{\pi}\left(1 - \cos 2\pi \times 50 \times 40 \times 10^{-6} \times \frac{180}{\pi}\right)$$
$$= 8.174\ \text{mV}$$

Percentage reduction in average output voltage

$$= \frac{8.174\times 10^{-3}}{207.04}\times 100 = 3.948\times 10^{-3}\%$$

(*b*) For $f = 2500$ Hz, the reduction in the average output voltage, is

$$V_r = \frac{\sqrt{2}\times 230}{\pi}\left(1 - \cos 2\pi \times 2500 \times 40 \times 10^{-6} \times \frac{180}{\pi}\right)$$
$$= 19.77\ \text{V}$$

Percentage reduction in average output voltage $= \dfrac{19.77}{207.04}\times 100 = 9.594\%.$

It is seen from above that the effect of reverse recovery time is negligible for diode operation at 50 Hz, but for high-frequency operation of diodes, the effect is noticeable.

3-

f = 250 Hz. Use the average output voltage to calculate the load inductance L, which would limit the maximum load ripple current to 10% of I_a.

Solution

$V_s = 550$ V, $R = 0.25\ \Omega$, $E = 0$ V, $f = 250$ Hz, $T = 1/f = 0.004$ s, and $\Delta i = 200 \times 0.1 = 20$ A. The average output voltage $V_a = kV_s = RI_a$. The voltage across the inductor is given by

$$L\frac{di}{dt} = V_s - RI_a = V_s - kV_s = V_s(1 - k)$$

If the load current is assumed to rise linearly, $dt = t_1 = kT$ and $di = \Delta i$:

$$\Delta i = \frac{V_s(1 - k)}{L}kT$$

For the worst-case ripple conditions,

$$\frac{d(\Delta i)}{dk} = 0$$

This gives $k = 0.5$ and

$$\Delta i\, L = 20 \times L = 550(1 - 0.5) \times 0.5 \times 0.004$$

and the required value of inductance is $L = 27.5$ mH.

4-

$V_s = 12$ V, $\Delta V_c = 20$ mV, $\Delta I - 0.8$ A, $f = 25$ kHz, and $V_a = 5$ V.

a. From Eq. (5.48), $V_a = kV_s$ and $k = V_a/V_s = 5/12 = 0.4167 = 41.67\%$.

b. From Eq. (5.51),

$$L = \frac{5(12 - 5)}{0.8 \times 25{,}000 \times 12} = 145.83\ \mu\text{H}$$

c. From Eq. (5.53),

$$C = \frac{0.8}{8 \times 20 \times 10^{-3} \times 25{,}000} = 200\ \mu\text{F}$$

d. From Eq. (5.56), we get $L_c = \dfrac{(1 - k)R}{2f} = \dfrac{(1 - 0.4167) \times 500}{2 \times 25 \times 10^3} = 5.83$ mH

From Eq. (5.57), we get $C_c = \dfrac{1 - k}{16Lf^2} = \dfrac{1 - 0{,}4167}{16 \times 5.83 \times 10^2 \times (25 \times 10^3)^2} = 0.4\ \mu$F

5-

a. From Eq. (6.3), $V_{o1} = 0.45 \times 48 = 21.6$ V.

b. From Eq. (6.1), $V_o = V_s/2 = 48/2 = 24$ V. The output power, $P_o = V_o^2/R = 24^2/2.4 = 240$ W.

c. The peak transistor current $I_p = 24/2.4 = 10$ A. Because each transistor conducts for a 50% duty cycle, the average current of each transistor is $I_Q = 0.5 \times 10 = 5$ A.

d. The peak reverse blocking voltage $V_{BR} = 2 \times 24 = 48$ V.

e. From Eq. (6.3), $V_{o1} = 0.45V_s$ and the rms harmonic voltage V_h

$$V_h = \left(\sum_{n=3,5,7,\ldots}^{\infty} V_{on}^2\right)^{1/2} = (V_o^2 - V_{o1}^2)^{1/2} = 0.2176V_s$$

From Eq. (6.8), THD $= (0.2176V_s)/(0.45V_s) = 48.34\%$.

f. From Eq. (6.2), we can find V_{on} and then find,

$$\left[\sum_{n=3,5,\ldots}^{\infty} \left(\frac{V_{on}}{n^2}\right)^2\right]^{1/2} = \left[\left(\frac{V_{o3}}{3^2}\right)^2 + \left(\frac{V_{o5}}{5^2}\right)^2 + \left(\frac{V_{o7}}{7^2}\right)^2 + \cdots\right]^{1/2} = 0.024V_s$$

From Eq. (6.9), DF $= 0.024V_s/(0.45V_s) = 5.382\%$.

6-

$V_s = 220$ V, $R = 5\ \Omega$, $L = 23$ mH, $f_0 = 60$ Hz, and $\omega = 2\pi \times 60 = 377$ rad/s.

a. Using Eq. (6.16a), the instantaneous line-to-line voltage $v_{ab}(t)$ can be written as

$$v_{ab}(t) = 242.58 \sin(377t + 30°) - 48.52 \sin 5(377t + 30°) - 34.66 \sin 7(377t + 30°) + 22.05 \sin 11(377t + 30°) + 18.66 \sin 13(377t + 30°) - 14.27 \sin 17(377t + 30°) + \cdots$$

$$Z_L = \sqrt{R^2 + (n\omega L)^2} \angle \tan^{-1}(n\omega L/R) = \sqrt{5^2 + (8.67n)^2} \angle \tan^{-1}(8.67n/5)$$

Using Eq. (6.22), the instantaneous line (or phase) current is given by

$$i_{a(t)} = 14 \sin(377t - 60°) - 0.64 \sin(5 \times 377t - 83.4°) - 0.33 \sin(7 \times 377t - 85.3°) + 0.13 \sin(11 \times 377t - 87°) + 0.10 \sin(13 \times 377t - 87.5°) - 0.06 \sin(17 \times 377t - 88°) - \cdots$$

b. From Eq. (6.17), $V_L = 0.8165 \times 220 = 179.63$ V.

c. From Eq. (6.20), $V_p = 0.4714 \times 220 = 103.7$ V.

d. From Eq. (6.19), $V_{L1} = 0.7797 \times 220 = 171.53$ V.

e. $V_{p1} = V_{L1}/\sqrt{3} = 99.03$ V.

f. From Eq. (6.19), $V_{L1} = 0.7797V_S$

$$\left(\sum_{n=5,7,11,\ldots}^{\infty} V_{Ln}^2\right)^{1/2} = (V_L^2 - V_{L1}^2)^{1/2} = 0.24236V_s$$

From Eq. (6.8), THD $= 0.24236V_s/(0.7797V_s) = 31.08\%$. The rms harmonic line voltage is

g. $$V_{Lh} = \left[\sum_{n=5,7,11,\ldots}^{\infty} \left(\frac{V_{Ln}}{n^2}\right)^2\right]^{1/2} = 0.00941V_s$$

From Eq. (6.9), DF $= 0.00941V_s/(0.7797V_s) = 1.211\%$.