Chapter 2 – Diodes Circuits

Prob 2.1

$t_{rr} := 5\cdot10^{-6}$ $\quad$ $di\_dt := 80\cdot10^{6}$

(a) Eq. (2.10)

$Q_{RR} := 0.5\cdot di\_dt\cdot t_{rr}^{2}$ $\quad$ $Q_{RR}\cdot10^{6} = 1\times10^{3}$ $\quad$ μC

(b) Eq. (2-11)

$I_{RR} := \sqrt{2\cdot Q_{RR}\cdot di\_dt}$ $\quad$ $I_{RR} = 400$ $\quad$ A

Prob 2.2

$t_{rr} := 5\cdot10^{-6}$ s $\quad$ $I_{fall\_rate} := 800\cdot10^{6}\ \frac{A}{s}$ $\quad$ $SF := 0.5$

$t_a := \frac{t_{rr}}{1+SF}$ $\quad$ $t_a = 3.333\times10^{-6}$

$t_b := SF\cdot t_a$ $\quad$ $t_b = 1.667\times10^{-6}$

$I_{RR} := I_{fall\_rate}\cdot t_a$ $\quad$ $I_{RR} = 2.667\times10^{3}$

Using Eq. (2-7),

(a) $Q_{RR} := \frac{1}{2}\cdot\left(I_{fall\_rate}\cdot t_a\right)\cdot\left(t_a+t_b\right)$ $\quad$ $Q_{RR}\cdot10^{6} = 6.667\times10^{3}$ $\quad$ μC

$Q_{RR} := \frac{1}{2}\cdot I_{RR}\cdot\left(t_a+t_b\right)$ $\quad$ $Q_{RR}\cdot10^{6} = 6.667\times10^{3}$ $\quad$ μC

Using Eq. (2-6),

(b) $I_{RR} := I_{fall\_rate}\cdot t_a$ $\quad$ $I_{RR} = 2.667\times10^{3}$

Prob 2.3

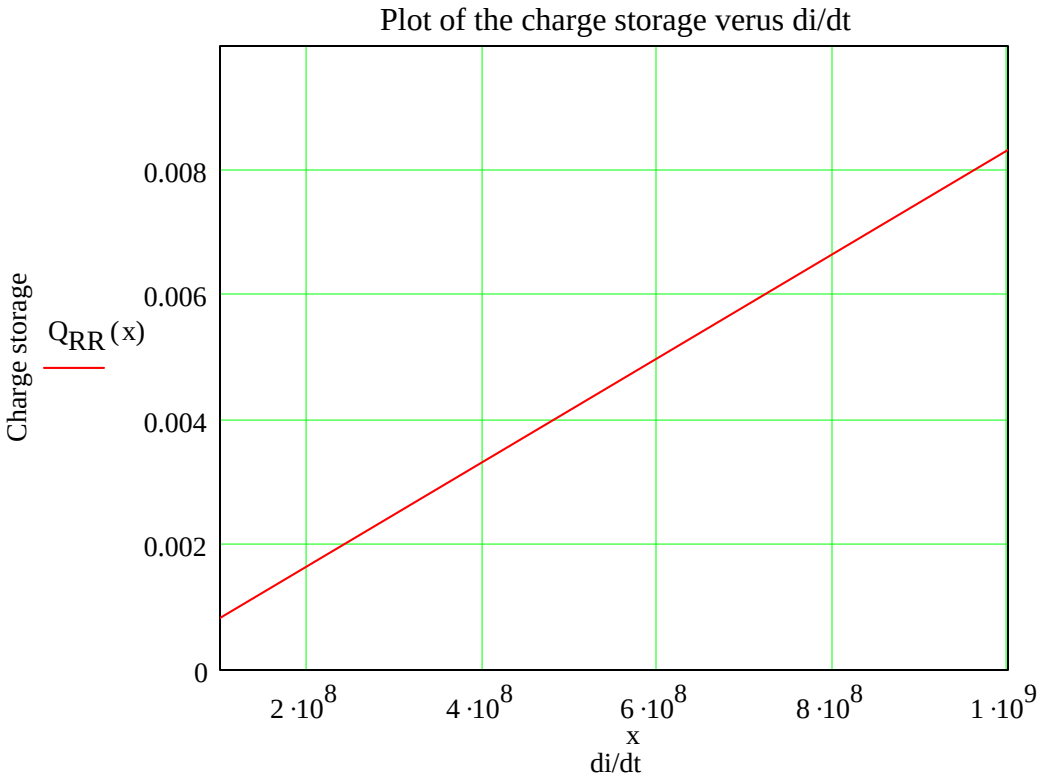
$t_{rr} := 5 \cdot 10^{-6}$ $\quad SF := 0.5$

$t_a := \frac{t_{rr}}{1 + SF}$ $\quad t_a = 3.333 \times 10^{-6}$

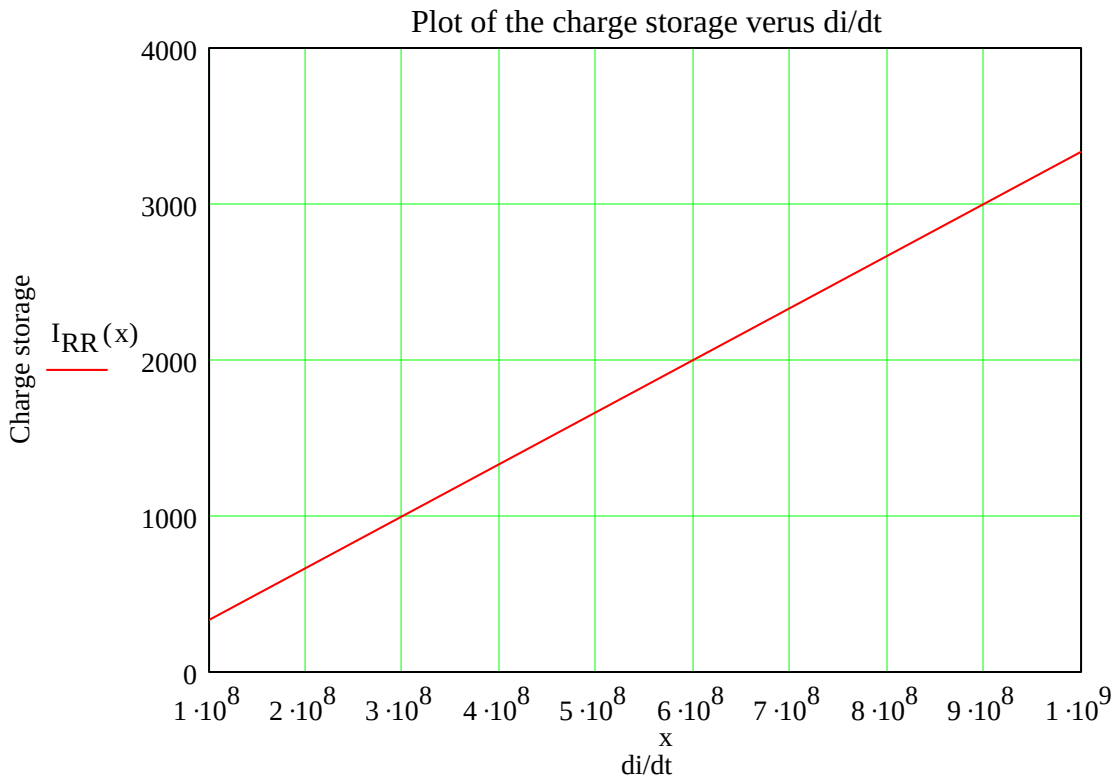
$t_b := SF \cdot t_a$ $\quad t_b = 1.667 \times 10^{-6}$

$m := \frac{1}{2} \cdot t_a \cdot t_{rr}$ $\quad m = 8.333 \times 10^{-12}$

$Q_{RR}(x) := m \cdot x$



$I_{RR}(x) := t_a \cdot x$



Prob 2.5 $V_T := 25.8 \cdot 10^{-3}$

$V_{D2} := 1.6$ $V_{D1} := 1.2$ $I_{D2} := 1500$ $I_{D1} := 100$

Using Eq. (2-3),

(a) $\eta := \dfrac{V_{D2} - V_{D1}}{V_T \cdot \ln\left(\dfrac{I_{D2}}{I_{D1}}\right)}$ $\eta = 5.725$

(b) $x := \dfrac{v_{D1}}{\eta \cdot V_T}$ $x = 8.124$

Using Eq. (2-3), $I_S := \dfrac{I_{D1}}{e^x}$ $I_S = 0.03$

$V_T \cdot \eta \cdot \ln\left(\dfrac{I_{D1}}{I_S}\right) = 1.2$

Prob 2-7

$V_{D1} := 2200$ $V_{D2} := 2200$ $R_1 := 100 \cdot 10^3$

$I_{S1} := 20 \cdot 10^{-3}$ $I_{S2} := 35 \cdot 10^{-3}$

(a)

$$I_{R1} := \frac{V_{D1}}{R_1} \qquad I_{R1} = 0.022$$

Using Eq. (2-13),

(b) $I_{R2} := I_{S1} + I_{R1} - I_{S2}$ $I_{R2} = 7 \times 10^{-3}$

$$R_2 := \frac{V_{D2}}{I_{R2}} \qquad R_2 = 3.143 \times 10^5$$

Prob 2.11

$I_T := 300$ $V_D := 2.8$

$$I_1 := \frac{I_T}{2} \qquad I_1 = 150$$

$I_2 := I_1$ $I_2 = 150$

$V_{D1} := 1.4$ $V_{D2} := 2.3$

$$R_1 := \frac{V_D - V_{D1}}{I_1} \qquad R_1 = 9.333 \times 10^{-3}$$

$$R_2 := \frac{V_D - V_{D2}}{I_2} \qquad R_2 = 3.333 \times 10^{-3}$$

$$I_1 := \frac{I_T}{2}$$

Prob 2-13

$R_1 := 50\cdot10^3$ $R_2 := 50\cdot10^3$ $V_S := 10\cdot10^3$

$I_{s1} := 20\cdot10^{-3}$ $I_{s2} := 30\cdot10^{-3}$

Using Eq. (2-14),

$$V_{D2} := \frac{I_{S1} - I_{S2} + \frac{V_S}{R_1}}{\frac{1}{R_1} + \frac{1}{R_2}} \qquad V_{D2} = 4.625\times10^3$$

$V_{D1} := V_S - V_{D2}$ $V_{D1} = 5.375\times10^3$

Prob 2-15

$I_p := 500$ $f := 500$ $t_1 := 100\cdot10^{-6}$

$T := \frac{1}{f}$ $T\cdot10^3 = 2$

$$I_{AVG} := \frac{I_p}{T}\cdot\int_0^{t_1}\sin(2\cdot\pi\cdot f\cdot t)\,dt \qquad I_{AVG} = 3.895$$

$$I_{RMS} := I_p\sqrt{\frac{1}{T}\cdot\int_0^{t_1}\sin(2\cdot\pi\cdot f\cdot t)^2\,dt} \qquad I_{RMS} = 20.08$$

$I_{peak} := I_p$ $I_{peak} = 500$

Prob 2-16

$I_{RMS} := 120 \qquad f := 500 \qquad t_1 := 100 \cdot 10^{-6}$

$T := \frac{1}{f} \qquad T \cdot 10^3 = 2$

$I_p := \frac{I_{RMS}}{\sqrt{\frac{1}{T} \cdot \int_0^{t_1} \sin(2 \cdot \pi \cdot f \cdot t)^2 \, dt}} \qquad I_p = 2.988 \times 10^3$

$I_{RMS} := I_p \sqrt{\frac{1}{T} \cdot \int_0^{t_1} (\sin(2 \cdot \pi \cdot f \cdot t))^2 \, dt} \qquad I_{RMS} = 120$

$I_{AVG} := \frac{I_p}{T} \cdot \int_0^{t_1} \sin(2 \cdot \pi \cdot f \cdot t) \, dt \qquad I_{AVG} = 23.276$

Prob 2-17

$I_{AVG} := 100 \qquad f := 500 \qquad t_1 := 100 \cdot 10^{-6}$

$T := \frac{1}{f} \qquad T \cdot 10^3 = 2$

$I_p := \frac{I_{AVG}}{\left(\frac{1}{T} \cdot \int_0^{t_1} \sin(2 \cdot \pi \cdot f \cdot t) \, dt \right)} \qquad I_p = 1.284 \times 10^4$

$I_{AVG} := \frac{I_p}{T} \cdot \int_0^{t_1} \sin(2 \cdot \pi \cdot f \cdot t) \, dt \qquad I_{AVG} = 100$

$I_{RMS} := I_p \sqrt{\frac{1}{T} \cdot \int_0^{t_1} (\sin(2 \cdot \pi \cdot f \cdot t))^2 \, dt} \qquad I_{RMS} = 515.55$

Prob 2-18

$t_1 := 100\cdot10^{-6}$ $t_2 := 200\cdot10^{-6}$ $t_3 := 400\cdot10^{-6}$ $t_4 := 800\cdot10^{-6}$

$t_5 := 1\cdot10^{-3}$ $f := 250$ $I_a := 150$ $I_b := 100$ $I_p := 300$

(a) $I_{AVG} := I_a\cdot f\cdot t_3 + I_b\cdot f\cdot\left(t_5 - t_4\right) + 2\cdot\left(I_p - I_a\right)\cdot f\cdot\frac{\left(t_2 - t_1\right)}{\pi}$

$I_{AVG} = 22.387$

(b) $I_{r1} := \left(I_p - I_a\right)\cdot\sqrt{f\cdot\frac{\left(t_2 - t_1\right)}{2}}$ $I_{r1} = 16.771$

$I_{r2} := I_a\cdot\sqrt{f\cdot t_3}$ $I_{r2} = 47.434$

$I_{r3} := I_b\cdot\sqrt{f\cdot\left(t_5 - t_4\right)}$ $I_{r3} = 22.361$

$I_{rms} := \sqrt{I_{r1}^2 + I_{r2}^2 + I_{r3}^2}$ $I_{rms} = 55.057$

Prob 2-19

$t_1 := 100\cdot10^{-6}$ $t_2 := 200\cdot10^{-6}$ $t_3 := 400\cdot10^{-6}$ $t_4 := 800\cdot10^{-6}$

$t_5 := 1\cdot10^{-3}$ $f := 250$ $I_a := 150$ $I_b := 100$ $I_p := 150$

(a) $I_{AVG} := I_a\cdot f\cdot t_3 + I_b\cdot f\cdot\left(t_5 - t_4\right) + 2\cdot\left(I_p - I_a\right)\cdot f\cdot\frac{\left(t_2 - t_1\right)}{\pi}$ $I_{AVG} = 20$

(b) $I_{r1} := \left(I_p - I_a\right)\cdot\sqrt{f\cdot\frac{\left(t_2 - t_1\right)}{2}}$ $I_{r1} = 0$

$I_{r2} := I_a\cdot\sqrt{f\cdot t_3}$ $I_{r2} = 47.434$

$I_{r3} := I_b\cdot\sqrt{f\cdot\left(t_5 - t_4\right)}$ $I_{r3} = 22.361$

$I_{rms} := \sqrt{I_{r1}^2 + I_{r2}^2 + I_{r3}^2}$ $I_{rms} = 52.44$

Prob 2-20

$t_1 := 100\cdot10^{-6}$ $t_2 := 200\cdot10^{-6}$ $t_3 := 400\cdot10^{-6}$ $t_4 := 800\cdot10^{-6}$

$t_5 := 1\cdot10^{-3}$ $f := 250$ $I_a := 150$ $I_b := 100$ $I_p := 150$

$I_{rms} := 180$

$I_{r2} := I_a\cdot\sqrt{f\cdot t_3}$ $I_{r2} = 47.434$

$I_{r3} := I_b\cdot\sqrt{f\cdot(t_5 - t_4)}$ $I_{r3} = 22.361$

$I_{r1} := \sqrt{I_{rms}^2 - I_{r2}^2 - I_{r3}^2}$ $I_{r1} = 172.192$

(a) $I_p := \dfrac{I_{r1}}{\sqrt{f\cdot\dfrac{(t_2 - t_1)}{2}}} + I_a$ $I_p = 1.69\times10^3$

$I_{r1} := (I_p - I_a)\cdot\sqrt{f\cdot\dfrac{(t_2 - t_1)}{2}}$ $I_{r1} = 172.192$

$I_{rms} := \sqrt{I_{r1}^2 + I_{r2}^2 + I_{r3}^2}$ $I_{rms} = 180$

(b) $I_{AVG} := I_a\cdot f\cdot t_3 + I_b\cdot f\cdot(t_5 - t_4) + 2\cdot(I_p - I_a)\cdot f\cdot\dfrac{(t_2 - t_1)}{\pi}$

$I_{AVG} = 44.512$

Prob 2-21

$t_1 := 100\cdot10^{-6}$ $t_2 := 200\cdot10^{-6}$ $t_3 := 400\cdot10^{-6}$ $t_4 := 800\cdot10^{-6}$

$t_5 := 1\cdot10^{-3}$ $f := 250$ $I_a := 150$ $I_b := 100$ $I_p := 150$

$I_{AVG} := 180$

(a)

$I_{av1} := I_a\cdot f\cdot t_3$ $I_{av1} = 15$

$I_{av2} := I_b\cdot f\cdot\left(t_5 - t_4\right)$ $I_{av2} = 5$

$I_{av3} := I_{AVG} - I_{av1} - I_{av2}$ $I_{av3} = 160$

$$I_p := \frac{I_{av3}}{\left[2f\cdot\frac{\left(t_2 - t_1\right)}{\pi}\right]} + I_a \qquad I_p = 1.02\times10^4$$

$$I_{AVG} := I_a\cdot f\cdot t_3 + I_b\cdot f\cdot\left(t_5 - t_4\right) + 2\cdot\left(I_p - I_a\right)\cdot f\cdot\frac{\left(t_2 - t_1\right)}{\pi}$$

$I_{AVG} = 180$

(b)

$$I_{r1} := \left(I_p - I_a\right)\cdot\sqrt{f\cdot\frac{\left(t_2 - t_1\right)}{2}} \qquad I_{r1} = 1.124\times10^3$$

$I_{r2} := I_a\cdot\sqrt{f\cdot t_3}$ $I_{r2} = 47.434$

$I_{r3} := I_b\cdot\sqrt{f\cdot\left(t_5 - t_4\right)}$ $I_{r3} = 22.361$

$I_{rms} := \sqrt{I_{r1}^2 + I_{r2}^2 + I_{r3}^2}$ $I_{rms} = 1.125\times10^3$

Prob 2-22

$V_S := 220$ $R := 4.7$ $C := 10 \cdot 10^{-6}$ $t := 2 \cdot 10^{-6}$

$\tau := R \cdot C$ $\tau = 4.7 \times 10^{-5}$

Using Eq. (2-20),

(a) $I_p := \frac{V_S}{R}$ $I_p = 46.809$

(b) $V_O := V_S$

$W := 0.5 \cdot C \cdot V_O^{2}$ $W = 0.242$

Using Eq. (2-21),

(c) $V_c := V_S \cdot \left(1 - e^{\frac{-t}{\tau}}\right)$ $V_c = 9.165$

Prob 2-24

$V_S := 110$ $R := 4.7$ $L := 6.5 \cdot 10^{-3}$

$\tau := \frac{R}{L}$ $\tau = 723.077$

Using Eq. (2-25),

(a) $I_D := \frac{V_S}{R}$ $I_D = 23.404$

(b) $I_O := I_D$

$W := 0.5 \cdot L \cdot I_O^{2}$ $W = 1.78$

Using Eq. (2-27),

(c) $di := \frac{V_S}{L}$ $di = 1.692 \times 10^{4}$

Prob 2-25

$V_S := 220$ $R := 4.7$ $L := 6.5 \cdot 10^{-3}$

$\tau := \frac{R}{L}$ $\tau = 723.077$

Using Eq. (2-25),

(a) $I_D := \frac{V_S}{R}$ $I_D = 46.809$

(b) $I_O := I_D$

$W := 0.5 \cdot L \cdot I_O^{\,2}$ $W = 7.121$

Using Eq. (2-27),

(c) $di := \frac{V_S}{L}$ $di = 3.385 \times 10^4$

Prob 2-29

$V_S := 110$ $C := 10 \cdot 10^{-6}$ $L := 50 \cdot 10^{-6}$

Using Eq. (2-32),

(a) $I_p := V_S \cdot \sqrt{\frac{C}{L}}$ $I_p = 49.193$

(b) $t_1 := \pi \cdot \sqrt{L \cdot C}$ $t_1 = 7.025 \times 10^{-5}$

Using Eq. (2-35),

(c) $V_C := 2 \cdot V_S$ $V_C = 220$

Example 2.31

$L := 4\cdot10^{-3}$ $C := 0.05\cdot10^{-6}$ $V_s := 220$

(a) $R := 160$ $\alpha := \frac{R}{2\cdot L}$ $\alpha = 2\times10^{4}$

Using Eq. (2-41),

$\omega_o := \frac{1}{\sqrt{L\cdot C}}$ $\omega_o = 7.071\times10^{4}$

$\omega_r := \sqrt{\omega_o^{2} - \alpha^{2}}$ $\omega_r = 6.782\times10^{4}$

$A_2 := \frac{V_s}{\omega_r\cdot L}$ $A_2 = 0.811$

(b) $t_1 := \frac{\pi}{\omega_r}$ $t_1\cdot10^{6} = 46.32$ μs

$v_c(t) := e^{-\alpha\cdot t}\cdot A_2\cdot\sin(\omega_r\cdot t)$

Probl 2-32

$L := 2\cdot10^{-3}$ $C := 0.5\cdot10^{-6}$ $V_s := 220$

(a) $R := 160$ $\alpha := \frac{R}{2\cdot L}$ $\alpha = 4\times10^{4}$

$\omega_o := \frac{1}{\sqrt{L\cdot C}}$ $\omega_o = 3.162\times10^{4}$ $\alpha > \omega_o$

$s_1 := -\alpha + \sqrt{\alpha^{2} - \omega_o^{2}}$ $s_1 = -1.551\times10^{4}$

$s_2 := -\alpha - \sqrt{\alpha^{2} - \omega_o^{2}}$ $s_2 = -6.449\times10^{4}$

at t = 0 $i := 0$ $0 \equiv A_1 + A_2$

at t = 0 $di := 0$ $\frac{V_s}{L} \equiv A_1\cdot s_1 + A_2\cdot s_2$

$$A_1 := \frac{V_s}{L\cdot(s_1 - s_2)} \qquad A_1 = 2.245$$

(b) $A_2 := -A_1 \qquad A_2 = -2.245$

$$v_c(t) := e^{-\alpha\cdot t}\cdot A_1\cdot\left(e^{s_1\cdot t} - e^{s_2\cdot t}\right)$$

Probl 2-33

$L := 2\cdot 10^{-3} \qquad C := 0.05\cdot 10^{-6} \qquad V_s := 220$

(a) $R := 16 \qquad \alpha := \frac{R}{2\cdot L} \qquad \alpha = 4\times 10^3$

$$\omega_o := \frac{1}{\sqrt{L\cdot C}} \qquad \omega_o = 1\times 10^5$$

$$\omega_r := \sqrt{\omega_o^{\,2} - \alpha^2} \qquad \omega_r = 9.992\times 10^4$$

$$A_2 := \frac{V_s}{\omega_r\cdot L} \qquad A_2 = 1.101$$

(b) $t_1 := \frac{\pi}{\omega_r} \qquad t_1\cdot 10^6 = 31.441 \quad \mu s$

$$v_c(t) := e^{-\alpha\cdot t}\cdot A_2\cdot\sin\left(\omega_r\cdot t\right)$$

Prob 2-34 $V_S := 110 \qquad L := 1\cdot 10^{-3} \qquad t_1 := 100\cdot 10^{-6}$

$$I_O := \frac{V_S}{L}\cdot t_1 \qquad I_O = 11$$

$$W := 0.5\cdot L\cdot I_O^{\,2} \qquad W = 7.121$$

Example 2.36

$V_s := 220$ $L_m := 450 \cdot 10^{-6}$ $N_1 := 10$ $N_2 := 100$ $t_1 := 50 \cdot 10^{-6}$

$a := \frac{N_2}{N_1}$ $a = 10$

Using Eq. (2-52),

(a) $v_D := V_s \cdot (1 + a)$ $v_D = 2.42 \times 10^3$

Using Eq. (2-55),

(b) $I_o := \frac{V_s}{L_m} \cdot t_1$ $I_o = 24.444$

(c) $I_{o\_peak} := \frac{I_o}{a}$ $I_{o\_peak} = 2.444$

Using Eq. (2-58),

(d) $t_2 := \frac{a \cdot L_m \cdot I_o}{V_s}$ $t_2 \cdot 10^6 = 500$ μs

(e) $W := \frac{1}{2} \cdot L_m \cdot I_o^2$ $W = 0.134$ J

Example 2.37

$V_s := 220$ $L_m := 250 \cdot 10^{-6}$ $N_1 := 10$ $N_2 := 10$ $t_1 := 50 \cdot 10^{-}$

$a := \frac{N_2}{N_1}$ $a = 1$

Using Eq. (2-52),

(a) $v_D := V_s \cdot (1 + a)$ $v_D = 440$

Using Eq. (2-55),

(b) $I_o := \frac{V_s}{L_m} \cdot t_1$ $I_o = 44$

(c) $I_{o\_peak} := \frac{I_o}{a}$ $I_{o\_peak} = 44$

Using Eq. (2-58),

(d) $t_2 := \frac{a \cdot L_m \cdot I_o}{V_s}$ $t_2 \cdot 10^6 = 50$ μs

(e) $W := \frac{1}{2} \cdot L_m \cdot I_o^{\,2}$ $W = 0.242$ J

Example 2.38

$V_s := 220$ $L_m := 250 \cdot 10^{-6}$ $N_1 := 10$ $N_2 := 1000$ $t_1 := 50 \cdot 10^{-6}$

$a := \frac{N_2}{N_1}$ $a = 100$

(a) $v_D := V_s \cdot (1 + a)$ $v_D = 2.222 \times 10^4$

(b) $I_o := \frac{V_s}{L_m} \cdot t_1$ $I_o = 44$

(c) $I_{o\_peak} := \frac{I_o}{a}$ $I_{o\_peak} = 0.44$

(d) $t_2 := \frac{a \cdot L_m \cdot I_o}{V_s}$ $t_2 \cdot 10^6 = 5 \times 10^3$ μs

(e) $W := \frac{1}{2} \cdot L_m \cdot I_o^{\,2}$ $W = 0.242$ J