

Chapter 2 – Diodes Circuits

Prob 2.1

$$t_{\text{rr}} := 5 \cdot 10^{-6} \quad di_{\text{dt}} := 80 \cdot 10^6$$

(a) Eq. (2.10)

$$Q_{\text{RR}} := 0.5 \cdot di_{\text{dt}} \cdot t_{\text{rr}}^2 \quad Q_{\text{RR}} \cdot 10^6 = 1 \times 10^3 \quad \mu\text{C}$$

(b) Eq. (2-11)

$$I_{\text{RR}} := \sqrt{2 \cdot Q_{\text{RR}} \cdot di_{\text{dt}}} \quad I_{\text{RR}} = 400 \quad \text{A}$$

Prob 2.2

$$t_{\text{rr}} := 5 \cdot 10^{-6} \quad \text{s} \quad I_{\text{fall_rate}} := 800 \cdot 10^6 \quad \frac{\text{A}}{\text{s}} \quad \text{SF} := 0.5$$

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

$$t_{\text{b}} := \text{SF} \cdot t_{\text{a}} \quad t_{\text{b}} = 1.667 \times 10^{-6}$$

$$I_{\text{RR}} := I_{\text{fall_rate}} \cdot t_{\text{a}} \quad I_{\text{RR}} = 2.667 \times 10^3$$

Using Eq. (2-7),

$$(a) \quad Q_{\text{RR}} := \frac{1}{2} \cdot (I_{\text{fall_rate}} \cdot t_{\text{a}}) \cdot (t_{\text{a}} + t_{\text{b}}) \quad Q_{\text{RR}} \cdot 10^6 = 6.667 \times 10^3 \quad \mu\text{C}$$

$$Q_{\text{RR}} := \frac{1}{2} \cdot I_{\text{RR}} \cdot (t_{\text{a}} + t_{\text{b}}) \quad Q_{\text{RR}} \cdot 10^6 = 6.667 \times 10^3$$

Using Eq. (2-6), μC

$$(b) \quad I_{\text{RR}} := I_{\text{fall_rate}} \cdot t_{\text{a}} \quad I_{\text{RR}} = 2.667 \times 10^3$$

Prob 2.3

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

$$SF := 0.5$$

$$t_a := \frac{t_{rr}}{1 + SF}$$

$$t_a = 3.333 \times 10^{-6}$$

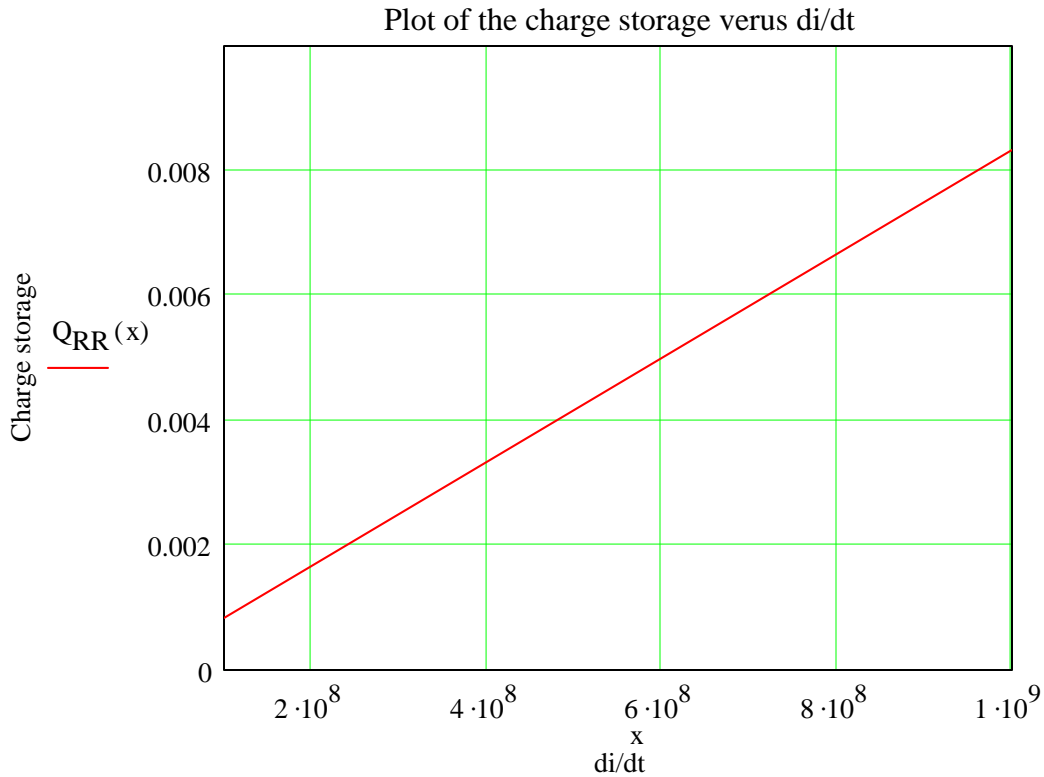
$$t_b := SF \cdot t_a$$

$$t_b = 1.667 \times 10^{-6}$$

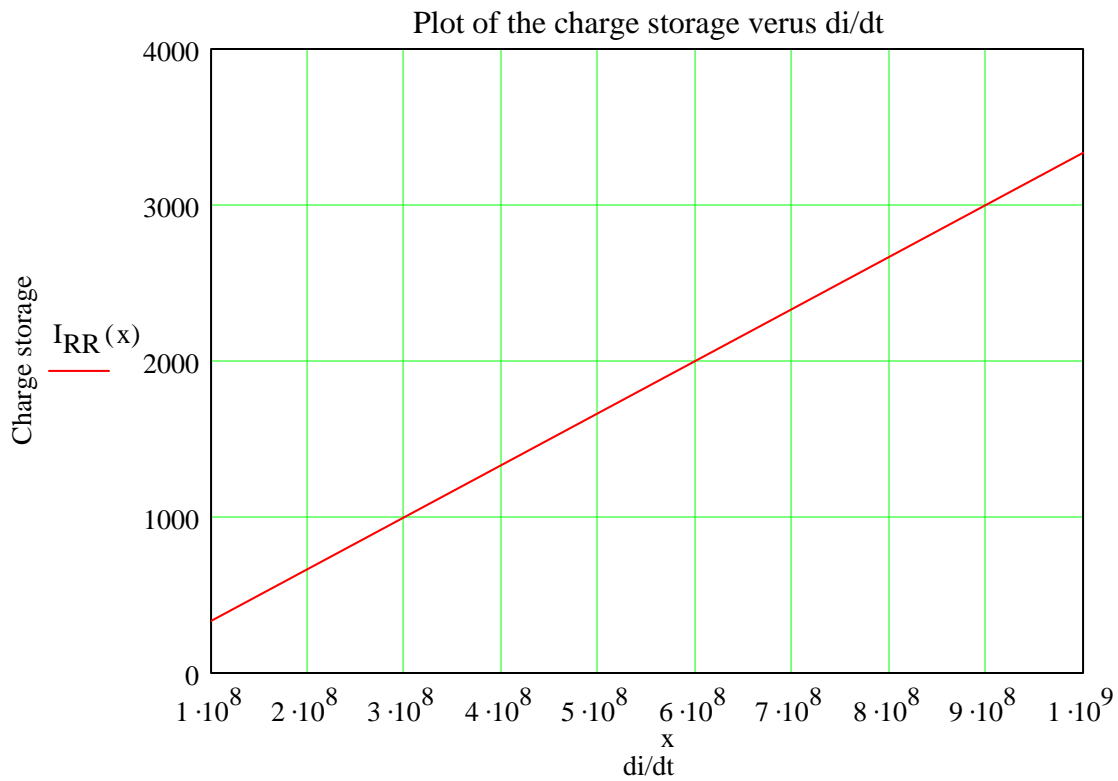
$$m := \frac{1}{2} \cdot t_a \cdot t_{rr}$$

$$m = 8.333 \times 10^{-12}$$

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



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



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

(b) $x := \frac{V_{D1}}{\eta \cdot V_T}$ $x = 8.124$

Using Eq. (2-3),

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

$$I_S := \frac{I_{D1}}{e^x} \quad I_S = 0.03$$

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)

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

$$I_{R1} = 0.022$$

Using Eq. (2-13),

(b)
$$I_{R2} := I_{S1} + I_{R1} - I_{S2}$$

$$I_{R2} = 7 \times 10^{-3}$$

$$R_2 := \frac{V_{D2}}{I_{R2}}$$

$$R_2 = 3.143 \times 10^5$$

Prob 2.11

$$I_T := 300$$

$$V_D := 2.8$$

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

$$I_1 = 150$$

$$I_2 := I_1$$

$$I_2 = 150$$

$$V_{D1} := 1.4$$

$$V_{D2} := 2.3$$

$$R_1 := \frac{V_D - V_{D1}}{I_1}$$

$$R_1 = 9.333 \times 10^{-3}$$

$$R_2 := \frac{V_D - V_{D2}}{I_2}$$

$$R_2 = 3.333 \times 10^{-3}$$

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

Prob 2-13

$$R_1 := 50 \cdot 10^3 \quad R_2 := 50 \cdot 10^3 \quad V_S := 10 \cdot 10^3$$

$$I_{S1} := 20 \cdot 10^{-3} \quad I_{S2} := 30 \cdot 10^{-3}$$

Using Eq. (2-14),

$$V_{D2} := \frac{I_{S1} - I_{S2} + \frac{V_S}{R_1}}{\frac{1}{R_1} + \frac{1}{R_2}} \quad V_{D2} = 4.625 \times 10^3$$

$$V_{D1} := V_S - V_{D2} \quad V_{D1} = 5.375 \times 10^3$$

Prob 2-15

$$I_p := 500 \quad f := 500 \quad t_1 := 100 \cdot 10^{-6}$$

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

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

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

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

Prob 2-16

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

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

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

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

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

Prob 2-17

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

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

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

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

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

Prob 2-18

$$t_1 := 100 \cdot 10^{-6} \quad t_2 := 200 \cdot 10^{-6} \quad t_3 := 400 \cdot 10^{-6} \quad t_4 := 800 \cdot 10^{-6}$$

$$t_5 := 1 \cdot 10^{-3} \quad f := 250 \quad I_a := 150 \quad I_b := 100 \quad I_p := 300$$

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

$$I_{AVG} = 22.387$$

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

$$I_{r1} = 16.771$$

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

$$I_{r2} = 47.434$$

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

$$I_{r3} = 22.361$$

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

$$I_{rms} = 55.057$$

Prob 2-19

$$t_1 := 100 \cdot 10^{-6} \quad t_2 := 200 \cdot 10^{-6} \quad t_3 := 400 \cdot 10^{-6} \quad t_4 := 800 \cdot 10^{-6}$$

$$t_5 := 1 \cdot 10^{-3} \quad f := 250 \quad I_a := 150 \quad I_b := 100 \quad I_p := 150$$

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

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

$$I_{r1} = 0$$

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

$$I_{r2} = 47.434$$

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

$$I_{r3} = 22.361$$

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

$$I_{rms} = 52.44$$

Prob 2-20

$$t_1 := 100 \cdot 10^{-6} \quad t_2 := 200 \cdot 10^{-6} \quad t_3 := 400 \cdot 10^{-6} \quad t_4 := 800 \cdot 10^{-6}$$

$$t_5 := 1 \cdot 10^{-3} \quad f := 250 \quad I_a := 150 \quad I_b := 100 \quad I_p := 150$$

$$I_{\text{rms}} := 180$$

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

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

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

$$(a) \quad I_p := \frac{I_{r1}}{\sqrt{f \cdot \frac{(t_2 - t_1)}{2}}} + I_a \quad I_p = 1.69 \times 10^3$$

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

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

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

$$I_{\text{AVG}} = 44.512$$

Prob 2-21

$$t_1 := 100 \cdot 10^{-6} \quad t_2 := 200 \cdot 10^{-6} \quad t_3 := 400 \cdot 10^{-6} \quad t_4 := 800 \cdot 10^{-6}$$

$$t_5 := 1 \cdot 10^{-3} \quad f := 250 \quad I_a := 150 \quad I_b := 100 \quad I_p := 150$$

$$I_{AVG} := 180$$

$$(a) \quad I_{av1} := I_a \cdot f \cdot t_3 \quad I_{av1} = 15$$

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

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

$$I_p := \frac{I_{av3}}{\left[\frac{2f \cdot (t_2 - t_1)}{\pi} \right]} + I_a \quad I_p = 1.02 \times 10^4$$

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

$$I_{AVG} = 180$$

(b)

$$I_{r1} := (I_p - I_a) \cdot \sqrt{f \cdot \frac{(t_2 - t_1)}{2}} \quad I_{r1} = 1.124 \times 10^3$$

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

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

$$I_{rms} := \sqrt{I_{r1}^2 + I_{r2}^2 + I_{r3}^2} \quad I_{rms} = 1.125 \times 10^3$$

Prob 2-22

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

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

Using Eq. (2-20),

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

$$(b) \quad V_O := V_S$$

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

Using Eq. (2-21),

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

Prob 2-24

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

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

Using Eq. (2-25),

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

$$(b) \quad I_O := I_D$$

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

Using Eq. (2-27),

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

Prob 2-25

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

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

Using Eq. (2-25),

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

$$(b) \quad I_O := I_D$$

$$W := 0.5 \cdot L \cdot I_O^2 \quad W = 7.121$$

Using Eq. (2-27),

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

Prob 2-29

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

Using Eq. (2-32),

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

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

Using Eq. (2-35),

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

Example 2.31

$$L := 4 \cdot 10^{-3} \quad C := 0.05 \cdot 10^{-6} \quad V_s := 220$$

$$(a) \quad R := 160 \quad \alpha := \frac{R}{2 \cdot L} \quad \alpha = 2 \times 10^4$$

Using Eq. (2-41),

$$\omega_o := \frac{1}{\sqrt{L \cdot C}} \quad \omega_o = 7.071 \times 10^4$$

$$\omega_r := \sqrt{\omega_o^2 - \alpha^2} \quad \omega_r = 6.782 \times 10^4$$

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

$$(b) \quad t_1 := \frac{\pi}{\omega_r} \quad t_1 \cdot 10^6 = 46.32 \quad \mu s$$

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

Probl 2-32

$$L := 2 \cdot 10^{-3} \quad C := 0.5 \cdot 10^{-6} \quad V_s := 220$$

$$(a) \quad R := 160 \quad \alpha := \frac{R}{2 \cdot L} \quad \alpha = 4 \times 10^4$$

$$\omega_o := \frac{1}{\sqrt{L \cdot C}} \quad \omega_o = 3.162 \times 10^4 \quad \alpha > \omega_o$$

$$s_1 := -\alpha + \sqrt{\alpha^2 - \omega_o^2} \quad s_1 = -1.551 \times 10^4$$

$$s_2 := -\alpha - \sqrt{\alpha^2 - \omega_o^2} \quad s_2 = -6.449 \times 10^4$$

$$\text{at } t = 0 \quad i := 0 \quad 0 = A_1 + A_2$$

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

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

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

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

Probl 2-33

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

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

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

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

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

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

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

Prob 2-34

$$V_S := 110 \quad L := 1 \cdot 10^{-3} \quad t_1 := 100 \cdot 10^{-6}$$

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

$$W := 0.5 \cdot L \cdot I_O^2 \quad W = 7.121$$

Example 2.36

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

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

Using Eq. (2-52),

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

Using Eq. (2-55),

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

$$(c) \quad I_{o_peak} := \frac{I_o}{a} \quad I_{o_peak} = 2.444$$

Using Eq. (2-58),

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

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

Example 2.37

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

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

Using Eq. (2-52),

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

Using Eq. (2-55),

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

$$(c) \quad I_{o_peak} := \frac{I_o}{a} \quad I_{o_peak} = 44$$

Using Eq. (2-58),

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

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

Example 2.38

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

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

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

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

$$(c) \quad I_{o_peak} := \frac{I_o}{a} \quad I_{o_peak} = 0.44$$

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

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