

Chapter 1 - Introduction

Problem 1.1

$\pi := 4 \operatorname{atan}(1)$ $\pi = 3.142$

$I_p := 100$ $T_o := 8.3 \cdot 10^{-3}$ $T := 16.67 \cdot 10^{-3}$

$I_{RMS} := \frac{I_p}{\sqrt{2}}$ $I_{RMS} = 70.711$

$I_{AVG} := 2 \cdot \frac{I_p}{\pi}$ $I_{AVG} = 63.662$

Problem 1.2

$I_p := 100$ $k := 0.5$ $T := 16.67 \cdot 10^{-3}$

$I_{RMS} := I_p \cdot \sqrt{\frac{k}{2}}$ $I_{RMS} = 50$

$I_{AVG} := \frac{I_p}{\pi}$ $I_{AVG} = 31.831$

$t_1 := 0$ $t_1 = 0$

$t_2 := \frac{T}{2}$ $t_2 = 8.335 \times 10^{-3}$

$T_o := k \cdot T$ $T_o = 8.335 \times 10^{-3}$

$\theta_1 := 2 \cdot \pi \cdot \frac{t_1}{T}$ $\theta_1 = 0$

$\theta_2 := 2 \cdot \pi \cdot \frac{t_2}{T}$ $\theta_2 = 3.142$

$I_{AVG} := \frac{I_p}{2 \cdot \pi} \cdot \int_{\theta_1}^{\theta_2} \sin(x) \, dx$ $I_{AVG} = 31.831$

Problem 1.3

$I_p := 100$	$k := 0.8$	$T := 16.67 \cdot 10^{-3}$
$t_1 := T \cdot (1 - k)$		$t_1 = 3.334 \times 10^{-3}$
$t_2 := \frac{T}{2}$		$t_2 = 8.335 \times 10^{-3}$
$T_o := k \cdot T$		$T_o = 0.013$
$I_{RMS} := I_p \cdot \sqrt{\frac{k}{2} + \frac{\sin[T_o \cdot (1 - k)] \cos[\pi \cdot (1 - k)]}{2 \cdot \pi}}$		$I_{RMS} = 63.273$
$\theta_1 := 2 \cdot \pi \cdot \frac{t_1}{T}$		$\theta_1 = 1.257$
$\theta_2 := 2 \cdot \pi \cdot \frac{t_2}{T}$		$\theta_2 = 3.142$
$I_{AVG} := \frac{I_p}{2 \cdot \pi} \cdot \int_{\theta_1}^{\theta_2} \sin(x) dx$		$I_{AVG} = 20.834$

Problem 1.4

$I_p := 100$	$k := 0.4$	$T := 1 \cdot 10^{-3}$
$T_o := k \cdot T$		$T_o = 4 \times 10^{-4}$
$I_{RMS} := I_p \cdot \sqrt{k}$		$I_{RMS} = 63.246$
$I_{AVG} := I_p \cdot k$		$I_{AVG} = 40$

Problem 1.5

$I_a := 80$	$I_b := 100$	$k := 0.4$	$T := 1 \cdot 10^{-3}$
$T_o := k \cdot T$			$T_o = 4 \times 10^{-4}$

$$I_{\text{RMS}} := \sqrt{k \cdot \frac{(I_b^2 + I_a \cdot I_b + I_a^2)}{3}} \quad I_{\text{RMS}} = 57.038$$

$$I_{\text{AVG}} := k \cdot I_a + \frac{\frac{1}{2} \cdot k \cdot T \cdot (I_b - I_a)}{T} \quad I_{\text{AVG}} = 36$$

Problem 1.6

From Fig. 1.10e,

$$I_{\text{rms}} = I_p \sqrt{\frac{k}{3}}$$

Solving it,

$$k = 0.75 = 75\%$$

$$\frac{T_0}{T} = k$$

$$\frac{1.5}{T} = 0.75$$

$$T = 2\text{ms}$$

Chapter 2 – Diodes Circuits

Prob 2.1

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

(a) Eq. (2.10)

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

(b) Eq. (2.11)

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

Prob 2.2

$$Q_{RR} = 10000 \mu C \text{ and } I_{RR} = 4000 A$$

$$Q_{RR} = 0.5 \left(\frac{di}{dt} \right) t_{rr}^2$$

$$I_{RR} = \sqrt{2 Q_{RR} \left(\frac{di}{dt} \right)}$$

Solving both equations,

$$\text{We get, } t_{rr} = 5 \mu s \text{ and } \frac{di}{dt} = 800 A/\mu s$$

Prob 2.3

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

$$SF := 0.5$$

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

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

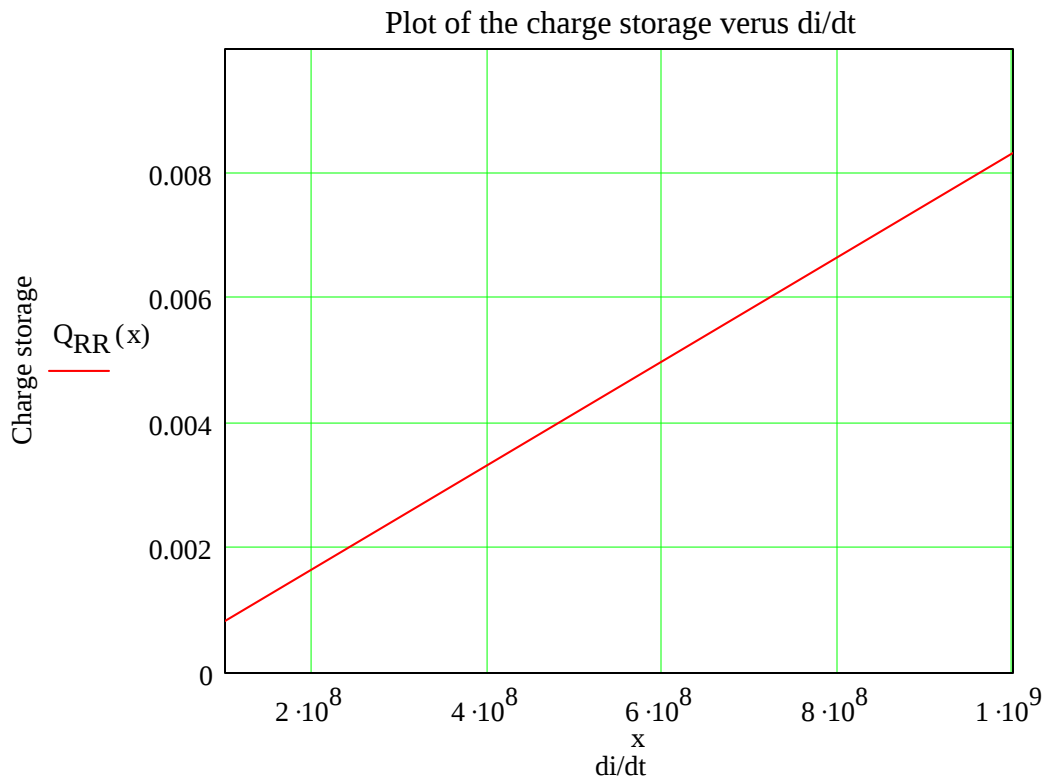
$$t_b := SF \cdot t_a$$

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

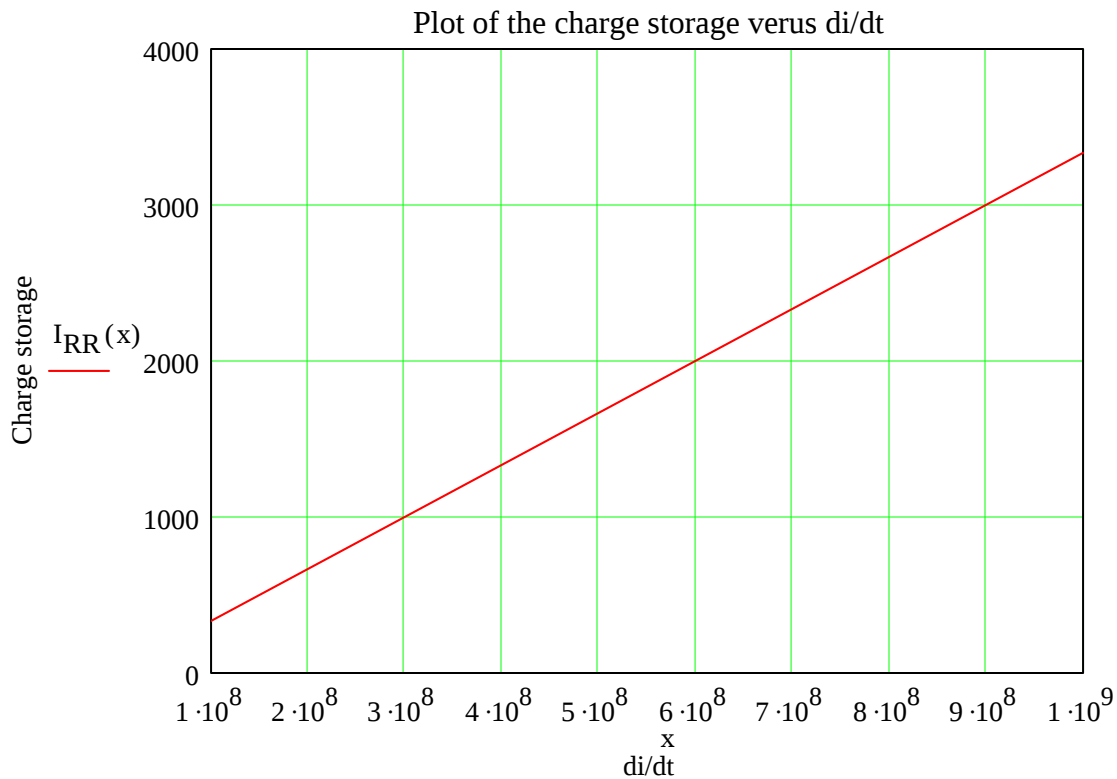
$$m := \frac{1}{2} \cdot t_a \cdot t_{rr}$$

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

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



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



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),

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

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

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

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

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

$$R_1 = R_2 = 50k\Omega, V_s = 10kV, V_{D1} = 5225V, V_{D2} = 4775V$$

$$\text{From Eq. (2-12), } I_{s1} + I_{R1} = I_{s2} + I_{R2}$$

$$\text{or } I_{s1} + \frac{V_{D1}}{R_1} = I_{s2} + \frac{V_{D2}}{R_2}$$

$$I_{s1} + \frac{5225}{50000} = I_{s2} + \frac{4775}{50000}$$

$$V_{D1} + V_{D2} = 10000$$

$$I_{s1}R_1 + I_{s2}R_2 = 10000$$

$$I_{s1}50000 + I_{s2}50000 = 10000$$

Solving for I_{s1} and I_{s2} gives $I_{s1} = 20mA$ and $I_{s2} = 30mA$.

Prob 2-15

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

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

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

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

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

Prob 2-16

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

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

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

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

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

Prob 2-17

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

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

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

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

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

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

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

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

$$I_{rms} := 180$$

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

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

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

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

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

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

$$(b) \quad I_{AVG} := I_a \cdot f \cdot t_3 + I_b \cdot f \cdot (t_5 - t_4) + 2 \cdot (I_p - I_a) \cdot f \cdot \frac{(t_2 - t_1)}{\pi} \\ I_{AVG} = 44.512$$

Prob 2-21

$t_1 = 100\mu\text{s}$, $t_2 = 200\mu\text{s}$, $t_3 = 400\mu\text{s}$, $t_4 = 800\mu\text{s}$, $t_5 = 1\text{ms}$, $f = 250\text{Hz}$, $I_a = 150\text{A}$, $I_b = 100\text{A}$ & $I_{\text{avg}} = 30\text{A}$

(a)

$$I_{\text{avg}} = I_a f t_3 + I_b f (t_5 - t_4) + 2(I_p - I_a) f (t_2 - t_1) / \pi$$

$$30 = 15 + 5 + 2(I_p - 150)250(200 - 100) \times 10^{-6} / \pi$$

Solving for I_p ,

$$I_p = 778\text{A}$$

(b) $I_{r1} = (I_p - I_a) \sqrt{f(t_2 - t_1) / 2}$

$$I_{r1} = (778 - 150) \sqrt{250(200 - 100) \times 10^{-6} / 2} = 70.21$$

$$I_{r2} = I_a \sqrt{f t_3} = 150 \sqrt{250 \times 400 \times 10^{-6}} = 47.43$$

$$I_{r3} = I_b \sqrt{f(t_5 - t_4)} = 100 \sqrt{250(1000 - 800) \times 10^{-6}} = 22.36$$

The rms current is $I_{\text{rms}} = \sqrt{70.21^2 + 47.43^2 + 22.36^2} = 87.36\text{A}$

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

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

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

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

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

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

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

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