Chapter 1 - Introduction

Problem 1.1

$pi := 4\,atan(1)$ $\quad pi = 3.142$

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

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

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

Problem 1.2

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

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

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

$t_1 := 0$ $\quad t_1 = 0$

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

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

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

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

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

Problem 1.3

$I_p := 100$ $k := 0.8$ $T := 16.67 \cdot 10^{-3}$

$t_1 := T \cdot (1 - k)$ $t_1 = 3.334 \times 10^{-3}$

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

$T_o := k \cdot T$ $T_o = 0.013$

$$I_{RMS} := I_p \cdot \sqrt{\frac{k}{2} + \frac{\sin\left[T_o \cdot (1 - k)\right] \cos[pi \cdot (1 - k)]}{2 \cdot pi}} \qquad I_{RMS} = 63.273$$

$\theta_1 := 2 \cdot pi \cdot \frac{t_1}{T}$ $\theta_1 = 1.257$

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

$$I_{AVG} := \frac{I_p}{2 \cdot pi} \cdot \int_{\theta_1}^{\theta_2} \sin(x)\, dx \qquad I_{AVG} = 20.834$$

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

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

$T_o := k \cdot T$ $T_o = 4 \times 10^{-4}$

$$I_{RMS} := \sqrt{k \cdot \frac{\left(I_b^{\,2} + I_a \cdot I_b + I_a^{\,2}\right)}{3}} \qquad I_{RMS} = 57.038$$

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

Problem 1.6

From Fig. 1.10e,

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

Solving it,

k = 0.75 = 75%

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

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

T = 2ms

Chapter 2 – Diodes Circuits

Prob 2.1

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

(a) Eq. (2.10)

$Q_{RR} := 0.5 \cdot di\_dt \cdot t_{rr}^{2}$ $\quad$ $Q_{RR} \cdot 10^{6} = 1 \times 10^{3}$ $\quad$ μC

(b) Eq. (2-11)

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

Prob 2.2

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

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

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

Solving both equations,

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

Prob 2.3

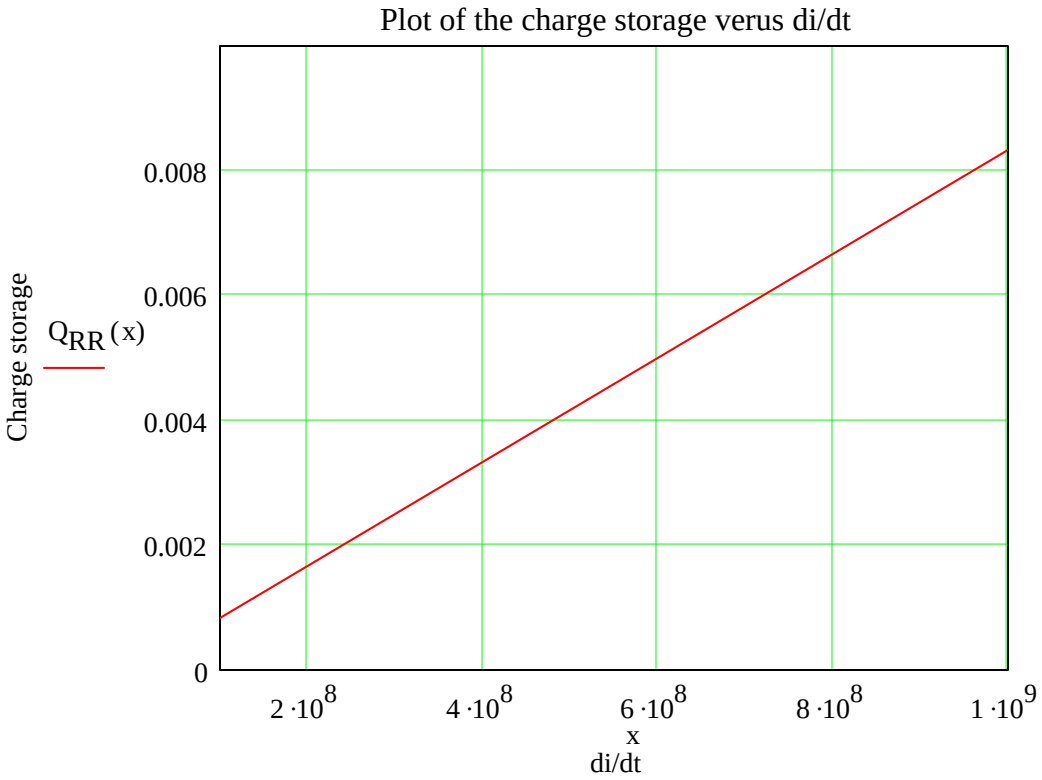
$t_{rr} := 5 \cdot 10^{-6}$ $\quad SF := 0.5$

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

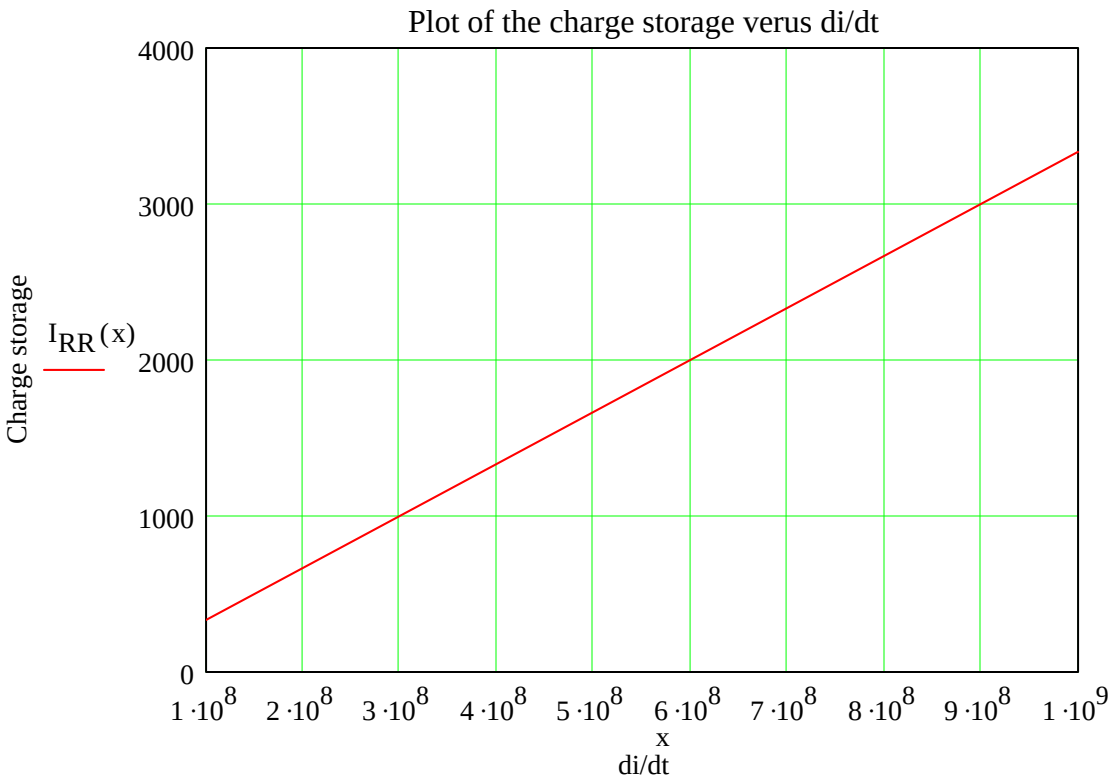
$t_b := SF \cdot t_a$ $\quad t_b = 1.667 \times 10^{-6}$

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

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



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



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

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

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

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

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

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

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

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

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

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

$I_{AVG} = 22.387$

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

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

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

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

Prob 2-19

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

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

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

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

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

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

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

Prob 2-20

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

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

$I_{rms} := 180$

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

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

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

(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

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

(a)

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

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

Solving for I_p,

$$I_p = 778A$$

(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 $I_{rms} = \sqrt{70.21^2 + 47.43^2 + 22.36^2} = 87.36A$

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