Solution to Final Exam June 2010

Elect. Power Eng. 2nd year Com.

(1) (b) $A = D = 1 + \frac{YZ}{2}$

$= 1 + \frac{1}{2}(35 + j140)(930 \times 10^{-6})$

$= 0.935 + j0.0163 = 0.935 \angle 1^\circ$

$B = Z = 35 + j140 = 144.5 \angle 75.8^\circ \ \Omega$

$C = Y(1 + \frac{ZY}{4}) = 900 \times 10^{-6} \angle 90.5 \ S'$

$= -7.57 \times 10^{-6} + j900 \times 10^{-6} \ S'$

$V_R = \frac{220}{\sqrt{3}} = 127 \ kV$

$P_R = \sqrt{3} V_L I_L \cos\theta$

$40 \times 10^6 = \sqrt{3} \times 220 \times 10^3 \times I_L \times 0.9$

$\therefore I_L = 116.5 \angle -25.8^\circ A = 105 - j50.6 \ A$

$V_S = A V_R + B I_R$

$= 0.935 \angle 1^\circ \times 127 \times 10^3 \angle 0 + 144.5 \angle 75.8^\circ \times 116.5 \angle -25.8^\circ$

$= 129.75 + j15 = 131 \angle 6.6^\circ \ kV$ (phase-to-neutral)

$= 227 \angle 6.6^\circ \ kV$ (Line-to-Line)

$I_S = C V_R + D I_R$

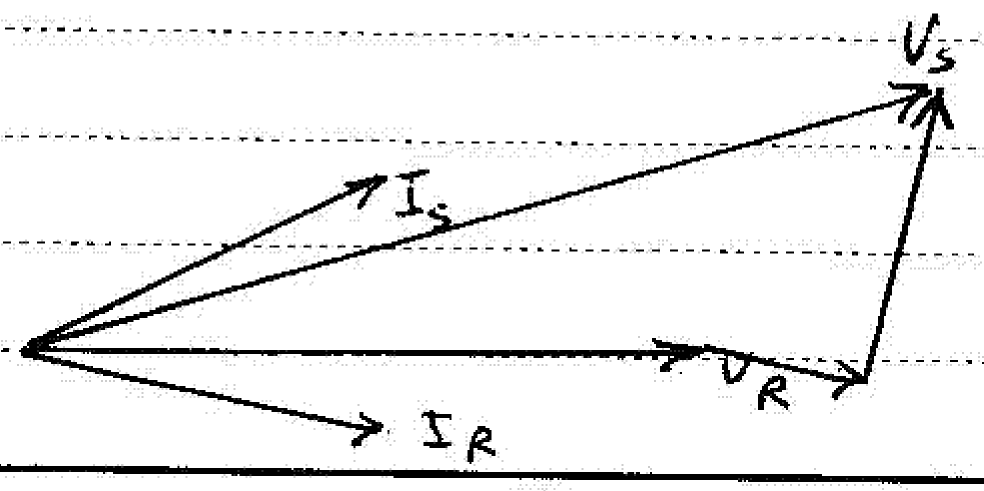
$= 900 \times 10^{-6} \angle 90.5 \times 127 \times 10^3 + 0.935 \angle 1^\circ \times 116.5 \angle -25.8^\circ$

$= 98.065 + j68.31 = 119.8 \angle 35^\circ$

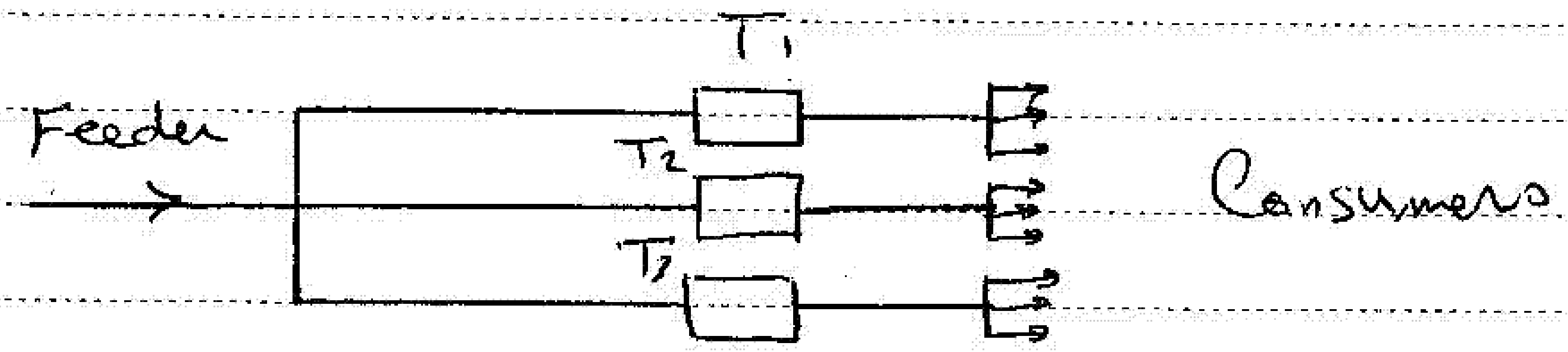
$P_S = \sqrt{3} V_S I_S \cos\theta = \sqrt{3} \times 227 \times 119.8 \times 0.88 = 41.2 \ MW$

$\eta = \frac{P_R}{P_S} \times 100 = \frac{40}{41.2} \times 100 = 97.3\%$

$\% \epsilon = \frac{V_S - V_R}{V_R} \times 100 = \frac{227 - 220}{220} \times 100 = 2.75\%$



(c)



Max Demand on T_1 = Connected load x demand factor

$= 10 \times 0.65 = 6.5$ kW

Max Demand on $T_1 = \dfrac{6.5}{1.5} = 4.33$ kW

Max Demand on $T_2 = \dfrac{12 \times 0.6}{3.5} = 2.057$ kW

Max Demand on $T_3 = \dfrac{15 \times 0.7}{1.5} = 7$ kW

Max Demand on Feeder $= \dfrac{4.33 + 2.057 + 7}{1.3}$

$= 10.3$ kW

(2)(c) Total Lumen Required $= 35 \times 100 \times 20 = 70\,000$ Lumen

Lamp Lumen Required $= \dfrac{70\,000}{0.55 \times 0.85} = 149732.6$ Lumen

Assuming 200 W lamp, the number of lamps required is

$$N = \frac{149732.6}{200 \times 15} = 49.9 \text{ Lamp}$$

The lamps will be assumed as:

4 rows of 12 lamps each

Thus max spacing $= \dfrac{100}{12}$ m

$$\frac{S}{h} = \frac{100}{12 \times 4} = 2.08 > 1.5$$

Let number of lamps $= 4 \times 13 = 52$ lamp

$$\frac{S}{h} = \frac{100}{13 \times 4} = 1.9 > 1.5$$

Let number of lamps $= 4 \times 15 = 60$ lamp

$$\frac{S}{h} = \frac{100}{15 \times 4} = 1.6$$

Let number of lamps $= 4 \times 16 = 64$ lamp

$$\frac{S}{h} = \frac{100}{16 \times 4} = 1.56 \checkmark$$

(3) (b) $d = 2.5$ cm and $D = 6$ cm

$$\frac{D}{d} = \frac{6}{2.5} = 2.4 = \alpha^3$$

$$\therefore \alpha = \sqrt[3]{2.4} = 1.34$$

$$\because \alpha = \frac{d_1}{d} = \frac{d_2}{d_1} = \frac{D}{d_2}$$

$$\therefore 1.34 = \frac{d_1}{2.5}$$

$$d_1 = 2.5 \times 1.34 = 3.35 \text{ cm}$$

$$d_2 = 3.35 \times 1.34 = 4.489 \text{ cm}$$

$$V_{peak} = \frac{66}{\sqrt{3}} \times \sqrt{2} = 53.8 \text{ kV}$$

$$V_2 = \frac{V}{1 + \frac{1}{\alpha} + \frac{1}{\alpha^2}} = \frac{53.8}{1 + \frac{1}{1.34} + \frac{1}{(1.34)^2}} = \frac{53.8}{2.305} = 23.34 \text{ kV}$$

$$V_1 = V_2\left(1 + \frac{1}{\alpha}\right) = 1.7463 \times 23.34 = 40.77 \text{ kV}$$

Without the intersheaths, the maximum stress would be

$$\frac{2V}{d \ln\frac{D}{d}} = \frac{2 \times 53.8}{2.5 \ln\frac{6}{2.5}} = 49.17 \text{ kV per cm}$$

while the minimum stress $= 49.17 \times \frac{2.5}{6}$

$= 20.49$ kV per cm

When the intersheaths are used, the max. stress is

$$g_{max} = \frac{53.8}{\frac{1}{3}(1 + 1.34 + 1.79)} = 39.06 \text{ kV/cm}$$

(c) $C_A = 3\,C_s$

$$\therefore C_s = \frac{1}{3} C_A = \frac{12.6}{3} = 4.2 \quad \mu F$$

$$C_B = 2\,C_c + C_s$$

$$\therefore C_c = \frac{C_B - C_s}{2} = \frac{7.4 - 4.2}{2} = 1.6 \; \mu F$$

$$C_N = 3\,C_c + C_s = 3 \times 1.6 + 4.2 = 9 \quad \mu F$$

$$\begin{aligned} I_{ch} &= \omega\, C_N\, V_{ph} \\ &= 2\pi f\, C_N\, V_{ph} \\ &= 2\pi \times 50 \times 9 \times 10^{-6} \times \frac{66 \times 10^{3}}{\sqrt{3}} \\ &= 107.74 \text{ A} \end{aligned}$$

(4) (a) Assume v_1 and a_1 be the volume and area of a section for 200 V system and v_2 and a_2 for that of 400 V system

$P = V_1 I_1 = 200 I_1$

$P = V_2 I_2 = 400 I_2$

Since P is the same

$\therefore 200 I_1 = 400 I_2 \Rightarrow I_2 = 0.5 I_1$

Power loss $W_1 = 2 I_1^2 R_1$

$W_2 = 2 I_2^2 R_2 = 2 (0.5 I_1)^2 R_2 = 0.5 I_1^2 R_2$

$\therefore W_1 = W_2$

$2 I_1^2 R_1 = 0.5 I_1^2 R_2$

$\frac{R_2}{R_1} = \frac{2}{0.5} = 4$

$\frac{a_1}{a_2} = 4$ and $\frac{v_1}{v_2} = 4$

$\frac{v_2}{v_1} = \frac{1}{4} = 0.25$

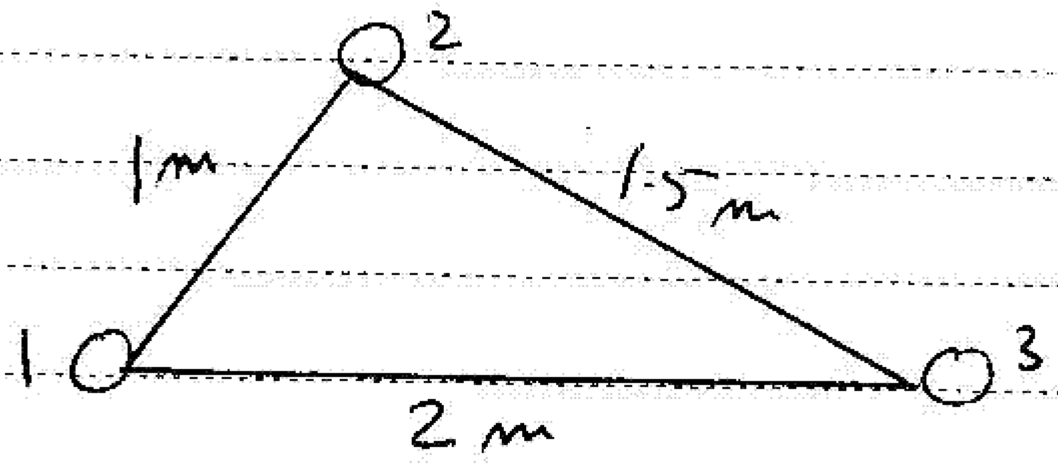
% Saving in feeder copper $= \frac{v_1 - v_2}{v_1} \times 100$

$= (1 - \frac{v_2}{v_1}) \times 100$

$= (1 - 0.25) \times 100$

$= 75\%$

4 (c)



$L = 2\times10^{-7} \ln \frac{GMD}{GMR}$

$GMD = \sqrt[3]{D_1 D_2 D_3} = \sqrt[3]{1\times1.5\times2} = 1.44\ m$

$GMR = 0.7788 \times 0.98 =$

$\therefore L = 2\times10^{-7} \ln\left(\frac{1.44\times10^{2}}{0.7788\times0.98}\right) = 10.48\times10^{-7}\ H/m$

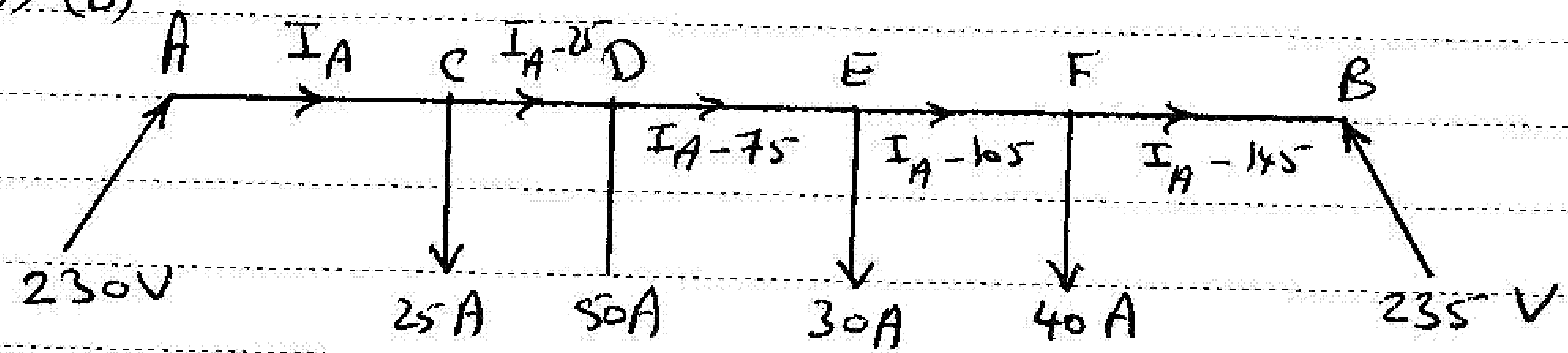
$X_L = 2\pi\times50\times10.48\times10^{-7} = 0.329\ \Omega/km/ph$

$C_n = \frac{2\pi\epsilon}{\ln\frac{GMD}{GMR}}$; $GMD = 1.44\ m$ $GMR = r = 0.98\,cm$

$C_n = \frac{2\pi\times8.85\times10^{-12}}{\ln\frac{1.44\times10^{2}}{0.98}} = 11.13\times10^{-9}\ F/km$

$I_{ch} = 2\pi\times50\times11.13\times10^{-9}\times\frac{132\times10^{3}}{\sqrt{3}}$
$= 0.267\ A/km$

(5) (b)



Resistance of 1000 m length of distributor (both wires)

$= 2 \times 0.3 = 0.6\ \Omega$

Resistance of section AC, $R_{AC} = 0.6 \times \frac{50}{1000} = 0.03\ \Omega$

" " " CD, $R_{CD} = 0.6 \times \frac{25}{1000} = 0.015\ \Omega$

" " " DE, $R_{DE} = 0.6 \times \frac{25}{1000} = 0.015\ \Omega$

" " " EF, $R_{EF} = 0.6 \times \frac{50}{1000} = 0.03\ \Omega$

" " " FB, $R_{FB} = 0.6 \times \frac{50}{1000} = 0.03\ \Omega$

$V_B = V_A - V.D_{AB}$

$= V_A - [I_A R_{AC} + (I_A - 25) R_{CD} + (I_A - 75) R_{DE} + (I_A - 105) R_{EF} + (I_A - 145) R_{FB}]$

$235 = 230 - [0.03 I_A + 0.015 (I_A - 25) + 0.015 (I_A - 75) + 0.03 (I_A - 105) + 0.03 (I_A - 145)]$

$235 = 230 - [0.12 I_A - 9]$

$I_A = \frac{239 - 235}{0.12} = 33.34\ A = I_{AC}$

$I_{CD} = 33.34 - 25 = 8.34\ A$

$I_{DE} = 33.34 - 75 = -41.66\ A$

$I_{EF} = 33.34 - 105 = -71.66\ A$

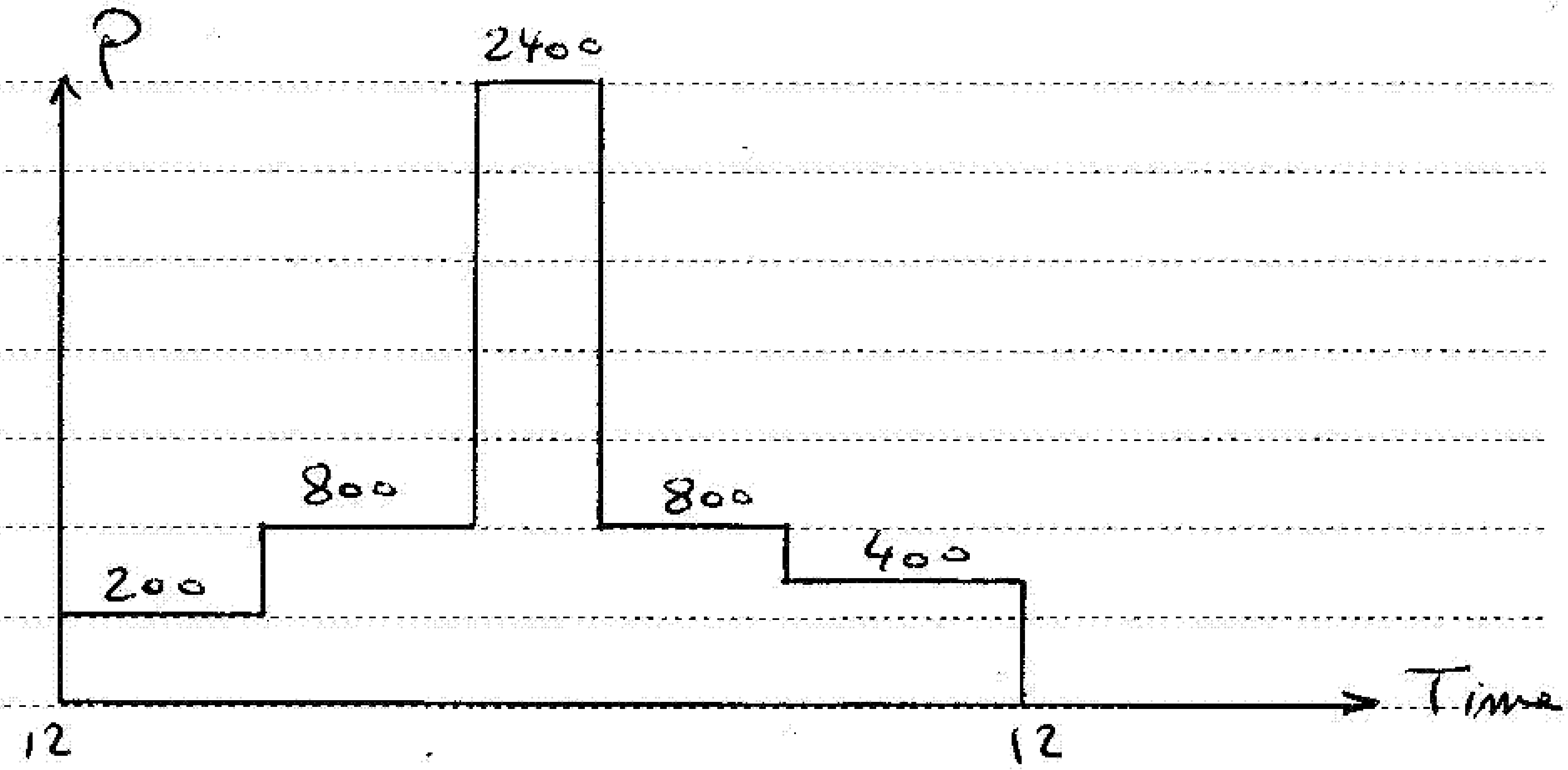
$I_{FB} = 33.34 - 145 = -111.66\ A$

The point of min. potential is point "D"

$V_D = V_A - [I_{AC} R_{AC} + I_{CD} R_{CD}]$

$= 230 - 1.125 = 228.875\ V$

(c)



Max Demand of Consumer 1 = 800 W

" " " " 2 = 1000 W

" " " " 3 = 1200 W

L.F. of Consumer 1 = $\frac{600\times6+200\times2+800\times6}{800\times24}\times100 = 45.8\%$

" " Consumer 2 = $\frac{200\times8+1000\times2+200\times2}{1000\times24}\times100 = 16.7\%$

" " Consumer 3 = $\frac{200\times6+1200\times2+200\times2}{1200\times24}\times100 = 13.8\%$

Simul Max Demand on the Station = 200 + 1000 + 1200 = 2400 MW

Diversity factor = $\frac{800+1000+1200}{2400} = 1.25$

Station Load Factor = $\frac{\text{Total Energy Consumed / day}}{\text{Simul Max Demand} \times 24}$

$= \frac{8800+4000+4000}{2400\times24}\times100$

$= 29.1\%$