Problem # 1

Load#1

$Z_\Delta = 10\angle 30^\circ \ \Omega/ph = 8.66 + j5 \ \Omega/ph$

$\Delta - Y$ trans. $\quad Z_{Y1} = 2.887 + j1.667 = 3.333\angle 30^\circ \ \Omega/ph$

Load #2 $\quad Z_{Y2} = 5\angle -36.87^\circ = 4 - j3 \ \Omega/ph$

$$Z_t = Z_{Y_1} \parallel Z_{Y_2} = \frac{16.665\angle -6.87}{6.887 - j1.333} = \frac{16.665\angle -6.87}{7.015\angle -10.954}$$

$$= 2.376\angle 4.084 \ \Omega/ph$$

a) the overall power factor $= \cos(4.084) = 0.997$ lagging

b) the total current supplied $= \frac{V_{ph}}{Z_t} = \frac{480/\sqrt{3}}{2.376} = 116.64 \ A$

c) $P_t = \sqrt{3} V_L I_L \cos\phi = \sqrt{3} * 480 * 116.64 * 0.997$

$= 9.668 \ KW$

$Q_t = \sqrt{3} V_L I_L \sin\phi = \sqrt{3} * 480 * 116.64 * \sin(4.084)$ –

$= 6.906 \ KVAR$

$S_t = \sqrt{3} \ V_L I_L = \sqrt{3} * 480 * 116.64$

$= 9.697 \ KVA$

Problem #2

$Z_{ph} = 20 + j15\ \Omega = 25\angle 36.87$

$V_{ph} = \frac{400}{\sqrt{3}}\angle 0 = 231\angle 0$

a) $I_{ph} = I_L = \frac{V_{ph}}{Z_{ph}} = \frac{231\angle 0}{25\angle 36.87} = 9.24\angle -36.87^\circ$

b) $P = \sqrt{3} * V_L I_L \cos 36.87 = \sqrt{3} * 400 * 9.24 * 0.8$

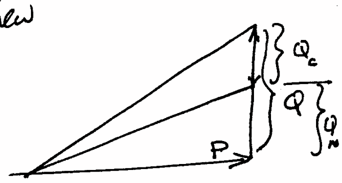
$= 5120\ W$

$Q = \sqrt{3}\, V_L I_L \sin 36.87 = \sqrt{3} * 400 * 9.24 * 0.6$

$= 3840\ VAR$

When the capacitor bank is connected

$pf_{new} = 0.95$; $\phi_{new} = 18.19^\circ$; $\tan\phi_{new} = 0.3286$



real Power remains Constant

$Q_{new} = P \tan\phi_{new} = 1682\ VAR$

$Q_c = Q - Q_{new}$

$Q_c = 3840 - 1682 = 2158\ VAR$

$Q_{cph} = \frac{2158}{3} = 719.3\ VAR$

$Q_{cph} = \frac{V_L^2}{X_c} \longrightarrow X_c = \frac{V_L^2}{Q_{cph}} = \frac{(400)^2}{719.3} = 222.44\ \Omega = \frac{1}{\omega C}$

$C = \frac{1}{2\pi * 50 * 222.44} = 14.31\ \mu F$

Prob. 3

At P.F =0.65 lag

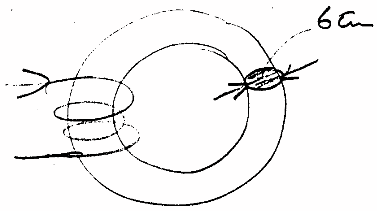
$$I = \frac{40X10^3}{\sqrt{3}X230X0.65} = 154.47A$$

At P.F =0.95 lag

$$I = \frac{40X10^3}{\sqrt{3}X230X0.95} = 105.69A$$

Note: The current is reduced due to the power factor improvement

Problem #4



$l = \pi d_m = \pi * 25 = 78.64$ cm

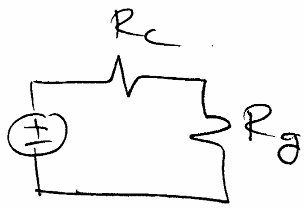
$A = \pi * \frac{(6)^2}{4} = 28.27$ cm^2

a) $B = \frac{1.7 * 10^{-3}}{28.27 * 10^{-4}} = 0.6$ T

From table $H = 600$ AT/m

so $NI = Hl$ $\quad I = \frac{600 * 78.64 * 10^{-2}}{600}$

$I = \underline{0.7864}$ A



(b) Same Φ and B

$H_c = 600$ AT/m

$l_c \simeq 78.64$ cm

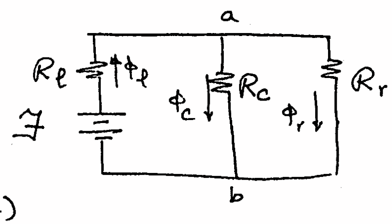
$H_g = \frac{B}{\mu_0} = \frac{0.6}{4\pi * 10^{-7}} = 477.5 * 10^3$ AT/m

$l_g = 2 * 10^{-3}$ m

$NI = H_g l_g + H_c l_c = 1427$ AT

$I = \underline{2.378}$ A

Problem # 5



$\phi_c = 0.36$ m Wb

$B_c = \frac{\phi_c}{A} = \frac{0.36 * 10^{-3}}{4 * 10^{-4}} = \underline{0.9 \text{ Wb/m}^2}$

$H_c = 150$ AT/m (From B-H Curve)

$\therefore AT_{ab} = H_c \ell_c = 150 * 0.06 = 9$ AT $\quad (\ell_c = 4+1+1 = 6$ Cm$)$

$= H_r \ell_r = H_r * (6+6+6) * 10^{-2}$

$\therefore H_r = \frac{9}{18 * 10^{-2}} = 50$ AT/m

$\therefore B_r$ (Corresponding Value from B-H Curve) $= 0.35$ Wb/m^2

$\therefore \phi_r = B_r A_r = 0.35 * 4 * 10^{-4} = \underline{0.14}$ m Wb

$\therefore \phi_\ell = \phi_c + \phi_r = 0.36 + 0.14 = \underline{0.5}$ m Wb

$\therefore B_\ell = \frac{\phi_\ell}{A} = \frac{0.5 * 10^{-3}}{4 * 10^{-4}} = 1.25$ Wb/m^2

$\therefore H_\ell = 500$ AT/m (from B-H Curve).

$\therefore H_\ell \ell_\ell = 500 * (6+6+6) * 10^{-2} = \underline{\underline{90}}$ ATs

$\therefore \mathcal{F} = H_\ell \ell_\ell + H_c \ell_c = 90 + 9 = 99$ ATs

$= N I$

$\therefore I = \frac{99}{300} = \underline{\underline{0.33}}$ Amps

(Contd)

$$V_1 = E_1 + I_1 (R_1 + jX_1)$$

$$= 218.17 + j\,10.02 + 13.49\angle 20.59 \,(0.25 + j\,0.75)$$

$$= (218.17 + (-0.4)) + j\,(10.02 + 10.655)$$

$$= 217.77 + j\,20.67$$

$$V_1 = 218.748 \angle 5.422^\circ \text{ Volt}$$

Hence $\% VR = \dfrac{V_1 - aV_2}{aV_2} \times 100\%$

$$= \frac{218.748 - 220}{220} \times 100\% = -0.57\%$$

the output power $= 3 \times 10^3 (0.9) = 2.7$ kwatt

$$\text{losses} = (I_2/a)^2 a^2 R_2 + I_c^2 R_{c_1} + I_1^2 R_1$$

$$= (13.635)^2 (0.2) + (0.303)^2 (720) + (13.49)^2 (0.25)$$

$$= 148.78 \text{ watt}$$

$$\% \text{ effeciency} = \frac{2700}{2700 + 148.78} \times 100\% = 94.77\%$$