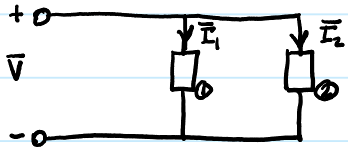
Fall 2017 Exam 1-1

1)



$\bar{V} = 1000\angle 60°$ V

$S_1 = 100$ kVA $\quad PF_1 = 0.866$ lag

$P_2 = 40$ kW $\quad PF_2 = 0.5$ lag

Find: a) $\bar{S}_{tot}$, $\bar{I}_{tot}$, $\bar{I}_1, \bar{I}_2$

b) Q_c for $PF_{TOT} = 0.95$ lag

Solution: $\theta_1 = \cos^{-1}(PF_1) \Rightarrow \theta_1 = 30°$

$\bar{S}_1 = 100\angle 30°$ kVA

$\bar{S}_2 = 80\angle 60°$ kVA

$P_2 = S_2(PF_2) \Rightarrow S_2 = \frac{P_2}{PF_2} \Rightarrow S_2 = 80$ kVA

$\theta_2 = \cos^{-1}(0.5) \Rightarrow \theta_2 = 60°$

$\bar{S}_{TOT} = \bar{S}_1 + \bar{S}_2$

$= (86.603 + j50) + (40 + j69.282)$

$\bar{S}_{TOT} = 126.603 + j119.282$ kVA

$\bar{S}_{TOT} = 173.944\angle 43.295°$ kVA

$\bar{S}_{TOT} = \bar{V}\bar{I}_t^*$

$\bar{I}_t = \left(\frac{\bar{S}_{TOT}}{\bar{V}}\right)^*$

$\bar{I}_{tot} = 173.944\angle 16.705°$

$\bar{S}_1 = \bar{V}\bar{I}_1^* \Rightarrow \bar{I}_1^* = \frac{\bar{S}_1}{\bar{V}_1} \Rightarrow \bar{I}_1 = 100\angle 30°$

$\bar{S}_2 = V\bar{I}_2^* \Rightarrow \bar{I}_2^* = \frac{\bar{S}_2}{\bar{V}_2} \Rightarrow \bar{I}_2 = 80\angle 0°$

b) $PF = 0.95 \quad \theta_n = \cos^{-1}(0.95) \Rightarrow \theta = 18.195°$

$P = 126.603$ kW

$\tan(\theta_n) = \frac{Q_n}{P} \Rightarrow Q_n = P\tan(\theta_n)$

$Q_n = 41.613$ kVAR

$Q_n = Q_1 + Q_c \quad Q_c = Q_n - Q_1$

$Q_c = -77.669$ kVAR

$Q_c = 77.669$ kVAR

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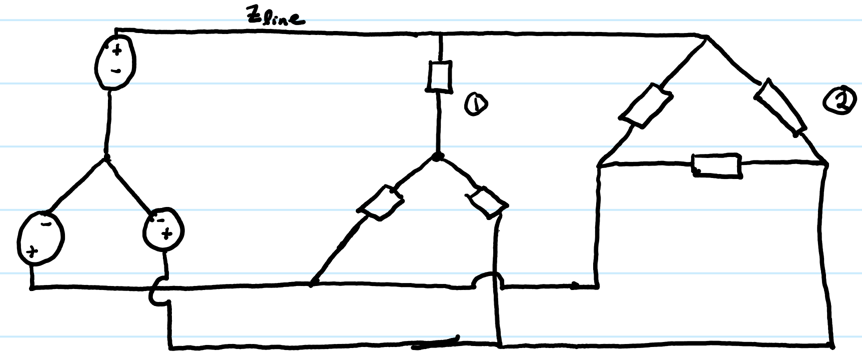
2)



$\bar{Z}_{line} = 0+j1\,\Omega$ $I_{L1} = 10A$ $PF_1 = 0.85$ lag $\bar{S}_2 = 1581.138\angle 18.434°$ VA

$V_{2_{load}} = \frac{300}{\sqrt{3}}$ V (phase to neutral)

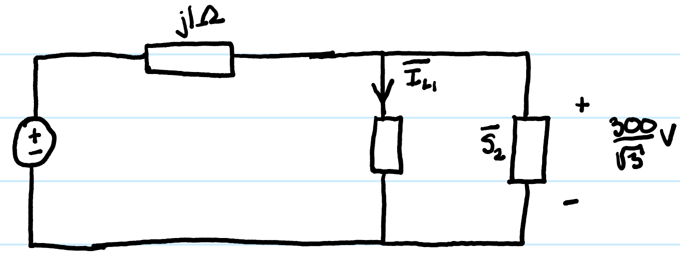
Find: a) Per phase equivalent circuit

b) Voltage at the source

c) $\bar{S}_{3\phi}$ at source

d) $\bar{Z}_{1\phi}$ for load 2

a)



b) $I_1 = I_{L1}\angle -\cos(PF_1) \Rightarrow I_1 = 10\angle -31.788°$

$\bar{S}_{2\,1\phi} = \frac{\bar{S}_2}{3} = 527.046\angle 18.434°$

$\bar{I}_{2\,1\phi} = \left(\frac{\bar{S}_{2\,1\phi}}{\bar{V}}\right)^* \Rightarrow \bar{I}_{2\,1\phi} = 3.043\angle -18.434°$ A

$\bar{I}_{tot} = \bar{I}_1 + \bar{I}_2 \Rightarrow \bar{I}_{tot} = 11.387 - j6.23$ A $\Rightarrow \bar{I}_{tot} = 12.980\angle -28.684°$ A

$\bar{V}_S = \frac{300}{\sqrt{3}}\angle 0 + \bar{Z}_{line}\bar{I}_{tot} \Rightarrow$

$\boxed{\bar{V}_S = 179.435 + j11.387 \text{ V}}$

$\boxed{\bar{V}_S = 179.796\angle 3.631° \text{ V}}$

c) $\bar{S}_{3\phi} = 3\bar{V}_S\bar{I}_{tot}^* \Rightarrow \boxed{\bar{S}_{3\phi} = 7001\angle 32.315° \text{ VA}}$

d) $\bar{S}_{2\,1\phi} = |\bar{I}_2|^2\,\bar{Z}_L \Rightarrow \bar{Z}_L = 56.917\angle 18.434°\,\Omega$ $\bar{Z}_\Delta = 3\bar{Z}_L \Rightarrow \boxed{\bar{Z}_\Delta = 170.751\angle 18.434°\,\Omega}$

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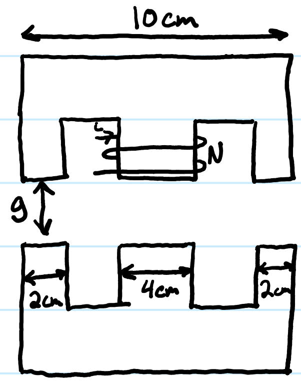
3)



$\mu = \infty$

$N = 200$

$i = 6A$

$g = 0.1cm$

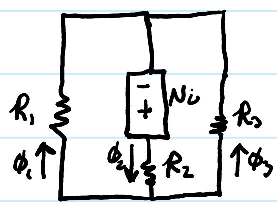
$d = 3 cm$

Find: a) B in each leg

b) L

Solution: a) $\mathcal{R}_1 = \frac{g}{\mu_0 A_1} \Rightarrow \mathcal{R}_1 = 1.326 \times 10^6$ AT/Wb $= \mathcal{R}_3$

$\mathcal{R}_2 = \frac{g}{\mu_0 A_2} \Rightarrow \mathcal{R}_2 = 0.663 \times 10^6$ AT/Wb



$Ni = 1200$ AT

$Ni = \mathcal{R}_2 \phi_2 + \mathcal{R}_1 \phi_1$

$Ni = \mathcal{R}_2 \phi_2 + \mathcal{R}_3 \phi_3$

$\phi_2 = \phi_1 + \phi_3$ $\qquad \phi_1 = \phi_3$

$\phi_2 = 2\phi_1$

$Ni = \mathcal{R}_2 \phi_2 + \mathcal{R}_1 \left(\frac{\phi_2}{2}\right)$

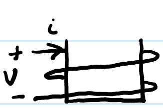
$Ni = \phi_2 \left(\mathcal{R}_2 + \frac{1}{2}\mathcal{R}_1\right) \Rightarrow \phi_2 = \frac{Ni}{\mathcal{R}_2 + \frac{1}{2}\mathcal{R}_1} \Rightarrow \phi_2 = 9.05 \times 10^{-4}$ Wb

$\phi_1 = \phi_3 = 4.525 \times 10^{-4}$ W

$B_2 = 0.754$ T

$B_1 = B_3 = 0.754$ T

b)



$\lambda = N\phi_2 \Rightarrow \lambda = 0.181$ WbT $= L(6A)$

$L = 0.0302$ H

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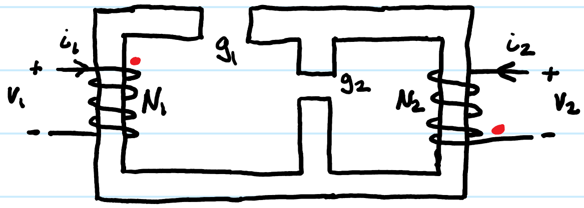


$\mu_c = \infty$

A

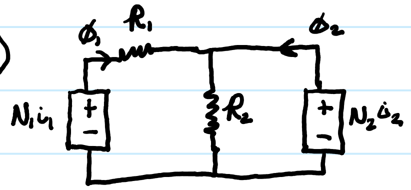
Find: a) dot convention

b) L_1, L_2, M

c) k in terms of g_1 and g_2

d) what happens to k as $g_1 \downarrow$ and $g_2 \uparrow$?

b)



$$R_1 = \frac{g_1}{\mu_0 A} \qquad R_2 = \frac{g_2}{\mu_0 A}$$

$$V_1 = \frac{d\lambda_1}{dt} = N_1 \frac{d\phi_1}{dt}$$

$$V_2 = \frac{d\lambda_2}{dt} = N_2 \frac{d\phi_2}{dt}$$

$$N_1 i_1 = \phi_1 R_1 + R_2(\phi_1 + \phi_2)$$

$$N_2 i_2 = R_2(\phi_1 + \phi_2)$$

$$N_1 i_1 = \phi_1 R_1 + N_2 i_2$$

$$N_1 i_1 - N_2 i_2 = \phi_1 R_1 \Rightarrow \phi_1 = \frac{N_1}{R_1} i_1 - \frac{N_2}{R_1} i_2$$

$$N_2 i_2 = R_2\left(\phi_2 + \frac{N_1}{R_1} i_1 - \frac{N_2}{R_1} i_2\right) \Rightarrow N_2 i_2 = R_2 \phi_2 + \left(\frac{R_2}{R_1}\right) N_1 i_1 - \left(\frac{R_2}{R_1}\right) N_2 i_2 \Rightarrow N_2\left(1 + \frac{R_2}{R_1}\right) i_2 - \left(\frac{R_2}{R_1}\right) N_1 i_1 = R_2 \phi_2$$

$$\left(1 + \frac{R_2}{R_1}\right) N_2 i_2 - \left(\frac{R_2}{R_1}\right) N_1 i_1 = R_2 \phi_2$$

$$\phi_2 = -\frac{N_1}{R_1} i_1 + \left(1 + \frac{R_2}{R_1}\right) \frac{N_2}{R_2} i_2$$

$$\lambda_1 = N_1 \phi_1 \Rightarrow \lambda_1 = \frac{N_1^2}{R_1} i_1 - \frac{N_1 N_2}{R_1} i_2$$

$$\lambda_2 = N_2 \phi_2 \Rightarrow \lambda_2 = -\frac{N_1 N_2}{R_1} i_1 + \left(1 + \frac{R_2}{R_1}\right) \frac{N_2^2}{R_2} i_2$$

$$L_1 = \frac{N_1^2}{R_1} = \frac{\mu_0 A N_1^2}{g_1}$$

$$L_2 = \left(1 + \frac{R_2}{R_1}\right) \frac{N_2^2}{R_2} = \left(1 + \frac{g_2}{g_1}\right) \frac{\mu_0 A N_2^2}{g_2}$$

$$M = \frac{N_1 N_2}{R_1} = \frac{\mu_0 A N_1 N_2}{g_1}$$

c) $k = \dfrac{M}{\sqrt{L_1 L_2}}$

$$k = \frac{\frac{\mu_0 A N_1 N_2}{g_1}}{\sqrt{\frac{\mu_0 A N_1^2}{g_1}\left(1 + \frac{g_2}{g_1}\right)\frac{\mu_0 A N_2^2}{g_2}}} \Rightarrow k = \frac{\frac{1}{g_1}}{\sqrt{\frac{1}{g_1 g_2}\left(1 + \frac{g_2}{g_1}\right)}} \Rightarrow k = \frac{\frac{1}{g_1}}{\sqrt{\frac{1}{g_1^2}\left(\frac{g_1}{g_2}\right)\left(1 + \frac{g_2}{g_1}\right)}}$$

$$k = \frac{1}{\sqrt{\frac{g_1}{g_2} + 1}}$$

d) as $g_1 \downarrow$ and $g_2 \uparrow$, $k \rightarrow 1$