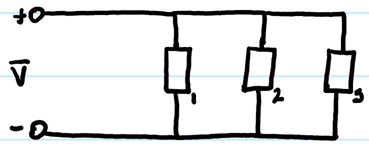
Spring 2018-1-1

1) 

$V = 120\,V$ $f = 60\,Hz$

* $S_1 = 3\,kVA$ $PF_1 = 0.5$ lag
* $\bar{Z}_2 = 3 + j3\,\Omega$
* $I_3 = 10\,A$ $P_3 = 1\,kW$ leading PF

Find: a) $\bar{S}_{tot}$

b) $i_s(t)$

c) Q_c for PF=1 and C

Solution: a) $\theta_1 = \cos^{-1}(0.5) \Rightarrow \theta_1 = 60°$ $\bar{S}_1 = 3000\angle 60°$ VA

$\bar{S}_2 = \frac{V^2}{\bar{Z}^*}$ $\bar{Z} = 3\sqrt{2}\angle 45°$ $\bar{S}_2 = \frac{120^2}{3\sqrt{2}\angle -45°} \Rightarrow \bar{S}_2 = 3394.11\angle 45°$

$P_3 = VI_3\,PF \Rightarrow P_3 = VI_3\cos(-\theta_3) \Rightarrow \cos(-\theta_3) = \frac{P_3}{VI_3} \Rightarrow \theta_3 = -\cos^{-1}\left(\frac{P_3}{VI_3}\right) \Rightarrow \theta_3 = -33.56°$

$\bar{S}_3 = 1200\angle -33.56°$

$\bar{S}_{tot} = \bar{S}_1 + \bar{S}_2 + \bar{S}_3 \Rightarrow$ $\boxed{\begin{aligned}\bar{S}_{tot} &= 4899.97 + j4334.70 \text{ VA} \\ &= 6542.12\angle 41.50° \text{ VA}\end{aligned}}$

b) $\bar{S}_{tot} = \bar{V}\bar{I}_s^* \Rightarrow \bar{I}_s = \left(\frac{\bar{S}_{tot}}{\bar{V}}\right)^* \Rightarrow \bar{I}_s = 54.52\angle -41.50°$ A

$\boxed{i_s(t) = \sqrt{2}(54.52)\cos(2\pi(60)t - 41.50°) \text{ A}}$

c) for PF=1, $Q_c = -4334.70$ VAR $\Rightarrow$ $\boxed{Q_c = 4334.70 \text{ of capacitance}}$

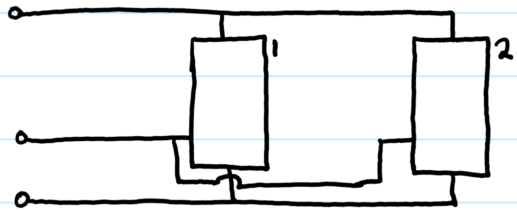
$Q_c = \frac{V^2}{-X} \Rightarrow X = \frac{V^2}{-Q_c} \Rightarrow X = 3.32\,\Omega = \frac{1}{\omega C}$

$C = \frac{1}{\omega(3.32\Omega)}$

$\boxed{C = 7.99 \times 10^{-4}\ F}$

Spring 2018-1-2

2)



* Load 1: wye connected $\bar{Z}_{1\phi} = 60\angle 25^\circ\ \Omega$
* Load 2: delta connected $\bar{Z}_{1\phi} = 90\angle 10^\circ\ \Omega$

$V_L = 4.16\ kV$

Find: a) Draw per phase equivalent circuit

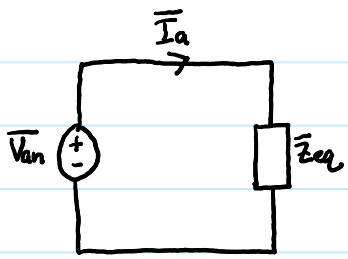
b) $\bar{I}_a, \bar{I}_b, \bar{I}_c$, $\bar{V}_{an}, \bar{V}_{bn}, \bar{V}_{cn}$

c) Draw phasor diagram

d) How would diagram in (c) change for a negative phase sequence

e) $\bar{S}_{3\phi}$

Solution: a)



$\bar{Z}_2 = \frac{\bar{Z}_\Delta}{3} \Rightarrow \bar{Z}_2 = 30\angle 10^\circ\ \Omega$

$\bar{Z}_{eq} = \left(\frac{1}{\bar{Z}_1} + \frac{1}{\bar{Z}_2}\right)^{-1} \Rightarrow \bar{Z}_{eq} = \left(\frac{1}{60}\angle -25^\circ + \frac{1}{30}\angle -10^\circ\right)^{-1}$

$\bar{Z}_{eq} = 20.15\angle 15^\circ$

b) $\bar{V}_{an} = \frac{4.16}{\sqrt{3}}\angle 0^\circ \Rightarrow \bar{V}_{an} = 2401.78\angle 0^\circ$ V

$\bar{V}_{bn} = 2401.78\angle -120^\circ$ V

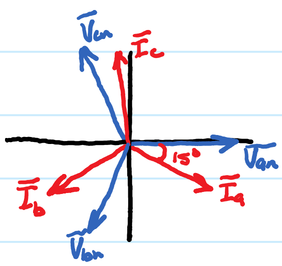
$\bar{V}_{cn} = 2401.78\angle 120^\circ$ V

$\bar{I}_a = \frac{\bar{V}_{an}}{\bar{Z}_{eq}} \Rightarrow \bar{I}_a = 119.19\angle -15^\circ$ A

$\bar{I}_b = 119.19\angle -135^\circ$ A

$\bar{I}_c = 119.19\angle 105^\circ$ A

c)



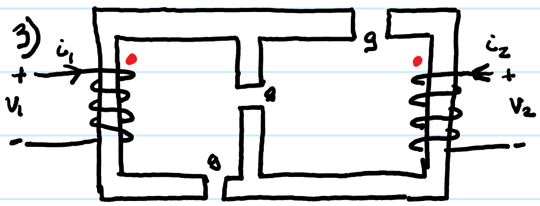
d) $\bar{V}_{bn}$ and $\bar{V}_{cn}$ switch

$\bar{I}_b$ and $\bar{I}_c$ switch

e) $\bar{S}_{3\phi} = 3\bar{V}_{an}\bar{I}_a^* = 3(2401.78\angle 0)(119.19\angle 15^\circ)$

$\boxed{\bar{S}_{3\phi} = 858.8\angle 15^\circ\ kVA}$

3)



* immersed in gas $\mu_r = 2$

$\mu_c = \infty$ $g = 5mm$ $A = 20\,cm^2$

$\mu_0 = 4\pi \times 10^{-7}$ H/m $N_1 = 20$ $N_2 = 40$

Find: a) R_g

b) Draw magnetic circuit

c) λ_1 and λ_2

d) L_1, L_2, M

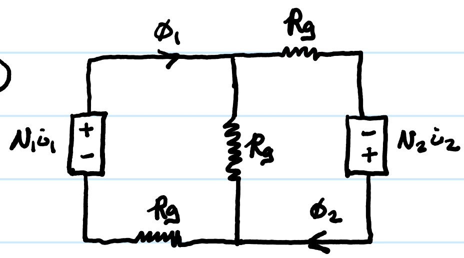
e) k

f) dot marks

g) v_1 in terms of i_1 and i_2

Solution: a) $R_g = \frac{g}{\mu_0 \mu_r A} \Rightarrow R_g = 9.95 \times 10^5$ AT/Wb

b)



c) $N_1 i_1 = R_g \phi_1 + R_g(\phi_1 - \phi_2)$ $\qquad N_2 i_2 = R_g \phi_2 + R_g(\phi_2 - \phi_1)$

$+ \; N_2 i_2 = R_g \phi_2 - R_g(\phi_1 - \phi_2)$

$N_1 i_1 + N_2 i_2 = R_g(\phi_1 + \phi_2) \Rightarrow \phi_1 + \phi_2 = \frac{N_1}{R_g} i_1 + \frac{N_2}{R_g} i_2 \Rightarrow \phi_1 = -\phi_2 + \frac{N_1}{R_g} i_1 + \frac{N_2}{R_g} i_2$

$N_2 i_2 = R_g \phi_2 + R_g\left(2\phi_2 - \frac{N_1}{R_g} i_1 - \frac{N_2}{R_g} i_2\right) \Rightarrow N_2 i_2 = 3R_g \phi_2 - N_1 i_1 - N_2 i_2$

$3R_g \phi_2 = N_1 i_1 + 2N_2 i_2$

$\phi_2 = \frac{N_1}{3R_g} i_1 + \frac{2N_2}{3R_g} i_2$

$\phi_1 = \frac{2N_1}{3R_g} i_1 + \frac{N_2}{3R_g} i_2$

$$\boxed{\begin{aligned} \lambda_1 &= \frac{2N_1^2}{3R_g} i_1 + \frac{N_1 N_2}{3R_g} i_2 \\ \lambda_2 &= \frac{N_1 N_2}{3R_g} i_1 + \frac{2N_2^2}{3R_g} i_2 \end{aligned}}$$

d) $L_1 = 0.268$ mH

$L_2 = 1.07$ mH

$M = 0.268$ mH

e) $k = \frac{M}{\sqrt{L_1 L_2}}$

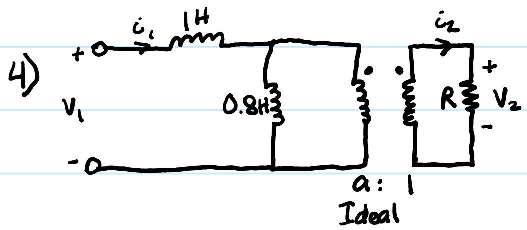
$k = 0.5$

g) $V_1 = \frac{d\lambda_1}{dt}$

$V_1 = 2.68 \times 10^{-4} \frac{di_1}{dt} + 2.68 \times 10^{-4} \frac{di_2}{dt}$

Spring 2018-1-4

4)



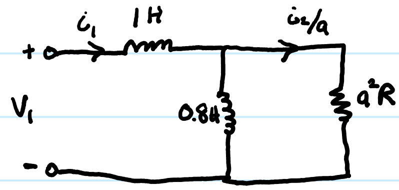
$a = 2$

$R = 5\Omega$

Find: a) Loop equations in time domain

b) If $V_1 = \sqrt{2}(120)\cos(10t)$, $V_2(t)$

Solutions a)



$$V_1 = 1\frac{di_1}{dt} + 0.8\left(\frac{di_1}{dt} - \frac{1}{a}\frac{di_2}{dt}\right) \Rightarrow \boxed{V_1 = \frac{di_1}{dt} + 0.8\left(\frac{di_1}{dt} - \frac{1}{2}\frac{di_2}{dt}\right)}$$

$$0 = \frac{i_2}{a}(a^2R) + 0.8\left(\frac{1}{a}\frac{di_2}{dt} - \frac{di_1}{dt}\right) \Rightarrow \boxed{0 = 10 i_2 + 0.8\left(\frac{1}{2}\frac{di_2}{dt} - \frac{di_1}{dt}\right)}$$

b) $\overline{V}_1 = 120\angle 0^\circ$ V

$$120\angle 0^\circ = j10\overline{I}_1 + j8\left(\overline{I}_1 - \tfrac{1}{2}\overline{I}_2\right)$$

$$0 = 10\overline{I}_2 + j8\left(\tfrac{1}{2}\overline{I}_2 - \overline{I}_1\right)$$

$$10\overline{I}_2 + j4\overline{I}_2 = j8\overline{I}_1$$

$$\overline{I}_2 = \left(\frac{j8}{10+j4}\right)\overline{I}_1 \Rightarrow \overline{I}_2 = (0.2759 + j0.6897)\overline{I}_1$$

$$(120 + j0) = j10\overline{I}_1 + j8\left(\overline{I}_1 - \tfrac{1}{2}\overline{I}_2\right)$$

$$\overline{I}_1 = \frac{120 + j0}{2.7588 + j16.8964}$$

$$\overline{I}_1 = 1.130 - j6.918$$

$$\overline{I}_2 = 5.083 - j1.130$$

$$\overline{V}_2 = \overline{I}_2 R$$

$$\overline{V}_2 = 25.415 - j5.65$$

$$= 26.04\angle -12.53^\circ \text{ V}$$

$$\boxed{V_2(t) = \sqrt{2}(26.04)\cos(10t - 12.53^\circ)}$$