17/ENG04/027

Electrical and Electronics Engineering 300 level

Question 1

Given: $V = 415\,V$, $f = 50Hz$,

$P_o = 74.6\,kW = 74.6 \times 10^3$ watts, $Pf_1 = \cos\theta = 0.7$ (lagging

efficiency $= 85\% = 0.85$

for Unity Pf ie $\cos\theta = 1$

i) using $Q_1 = P_{in}\tan\theta_1$

but P_{in} => efficiency $= \frac{P_{output}}{P_{input}}$

$P_{output} = \text{Efficiency} \times P_{input}$

$\therefore P_{input} = \frac{P_{output}}{\text{efficiency}} = \frac{74.6 \times 10^3}{0.85} =$ ~~90117.64~~ 87764.70 watts

$\theta_1 = \cos^{-1}(0.7) = 45.57°$

$Q_1 = 90117.64 \tan(45.57) = 91928.765$ VAR

$Q_2 = P_{in}\tan\theta_2$

$\theta_2 = \cos^{-1}(1) = 0$

$Q_2 = 90117.64 \tan(0) = 0$ VAR

Question 3:

Given: $F = 50Hz$, $N_{sc} = 2000$ rpm, $I_{sc} = 0.7A$, $V_{sc} = 220V$

$R = 15\Omega$, $X_L = 0.25\,H$

$V_{ac} = 220V$, $f = 50Hz$, $0.7A = I_{ac}$

soln

i) $E_{dc} = V - IR = 220 - (0.7) \times 15 = 209.5$ Volts

$E_{ac} = \sqrt{V^2 - (IX_L)^2} - IR$

but: $X_L = 2\pi f L = 2\pi \times 50 \times 0.25 = 78.539\,H$

$E_{ac} = \sqrt{(220)^2 - (0.7 \times (78.539))^2} - (0.7 \times 15)$

$= 213.01994 - 10.5$

$E_{ac} = 202.61994$ Volts

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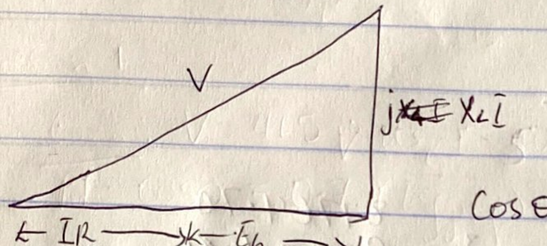
∴ using $\frac{N_{ac}}{N_{dc}} = \frac{E_{ac}}{E_{dc}}$ $N_{ac} = ?$

$N_{ac} \times E_{dc} = N_{dc} \times E_{ac}$

$N_{ac} = \frac{N_{dc} \times E_{ac}}{E_{dc}} = \frac{2000 \times 202.61994}{209.5} = 1934.31 \text{ rpm}$

ii)



SOH CAH TOA

$\cos\theta = \frac{Eb_{ac} + (IR)}{V}$

$\cos\theta = \frac{202.61994 + (0.7 \times 15)}{220} = 0.968$ (lagging)

iii) recall: $T_{orque} = \frac{P_{mech}}{\omega}$

$\omega = 2\pi n_{ac}$

but $n_{ac} = \frac{N_{ac}}{60} = \frac{1934.31}{60} = 32.2385 \text{ rps}$

$P_{mech} = E_{ac} I = 202.61994 \times 0.7 = 141.833 \text{ watts}$

Hence = $T_{orque} = \frac{141.833}{2\pi \times 32.2385} = 0.700 \text{ Nm}$

iv) A universal motor can be used for this application.

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Question 2 : Y-Connection

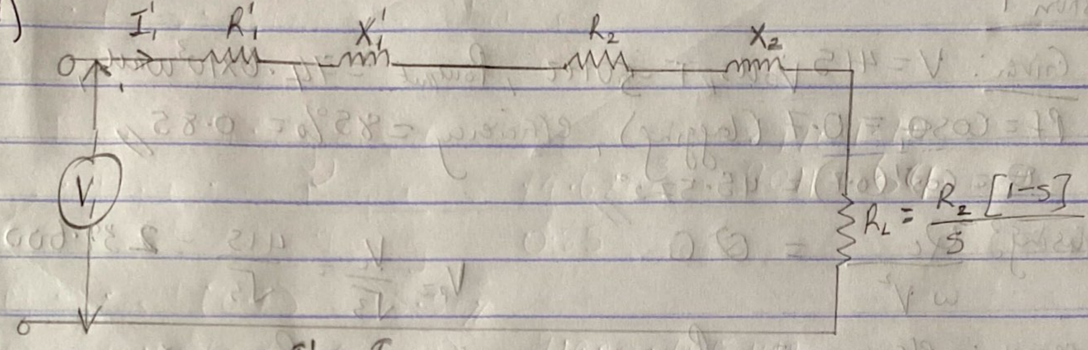
Given: $V_L = 415V$, no of Poles $= 6$, $f = 50Hz$

$k = \frac{E_1}{E_2} = \frac{6}{5}$, $Z_1 = (0.25 + j0.75)$ (R_1, jx_1)

$Z_2 = (1.173 + j0.52)$ (R_2, jx_2), Slip $= 1$

Version 2

i)



$I_1' = I_2$

ii) $I_2 = ?$

$R_1' = K^2 R_1$, $X_1' = K^2 X_1'$, $R_L = \frac{R_2[1-s]}{s}$

$= 1.172\left[\frac{1-1}{1}\right] = 0$

but $\frac{E_1}{E_2} = \frac{6}{5}$

$K = \frac{E_2}{E_1} = \frac{5}{6}$ ~~$= 0.0333$~~

$K = \frac{1}{\frac{6}{5}} = 0.833$

$V_{line} = \sqrt{3} V_{phase}$

$V_{phase} = \frac{V_L}{\sqrt{3}}$

$R_1' = (0.833)^2 \times 0.25 = 0.173\ \Omega$

$X_1' = (0.833)^2 \times 0.75 = j0.520\ \Omega$

$V_{phase} = \frac{V_L}{\sqrt{3}} = \frac{415}{\sqrt{3}} = 239.600$ Volts

$Z_{eq} = Z_1 + Z_2 + R_L$

$= (0.25 + j0.75) + (1.173 + j0.52) + 0$

$Z_{eq} = 1.423 + 1.27j\ \Omega \simeq 1.9073\angle 41.74^\circ\ \Omega$

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NOTE: $I_1 = I_2$

$\therefore I_1 = \frac{V_P}{Z_{eq}} = \frac{239.600}{1.423 + 1.27j} =$

$I_1 = I_2 = 93.723 - 83.64j\ A$

$\simeq 125.621\angle -41.74\ A$

Question 1

Given: $V = 415$ volts, $F = 50Hz$, $P_{output} = 74.6 \times 10^3$ watts,

$Pf = \cos\theta_1 = 0.7$ (lagging), efficiency $= 85\% = 0.85$

$\theta_1 = \cos^{-1}(0.7) = 45.572°$

using: $\frac{Q_c}{\omega V^2} = C$

$V_P = \frac{V_L}{\sqrt{3}} = \frac{415}{\sqrt{3}} = 239.600$ Volts

recall: $\frac{\text{efficiency}}{1} = \frac{P_{output}}{P_{input}}$ ~~→ efficiency = Poutput ×~~

efficiency × Pinput = Poutput

$P_{input} = \frac{P_{output}}{\text{efficiency}} = \frac{74.6 \times 10^3}{0.85} = 87764.7058$ watts

i) Unity Pf ie $\cos\theta = 1$

$\cos\theta_2 = 1 \Rightarrow \theta_2 = \cos^{-1}(1) = 0°$

using $Q_1 = P_{in} \tan\theta_1$

$Q_1 = 87764.7058 \times \tan(45.572)$

$Q_1 = 89534.79576$ VAR

$Q_2 = P_{in} \tan\theta_2$

$Q_2 = 87764 \tan(0) = 0$ VAR

Hence: $Q_c = Q_1 - Q_2 = (\tan\theta_1 - \tan\theta_2)$

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$Q_c = 89534.79576 - 0$

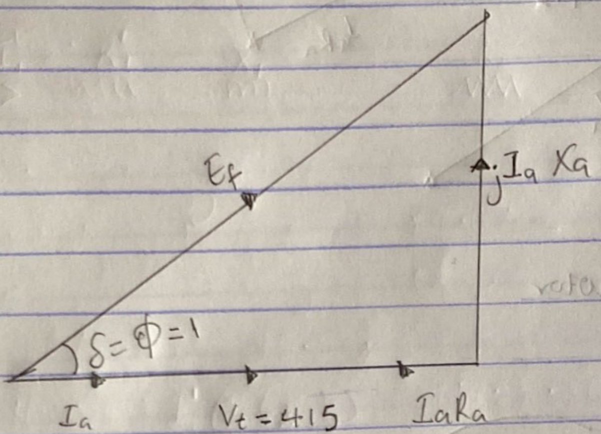
$Q_c = 89534.79576$ VAR

NOTE: $2\pi f = \omega$

$\omega = 2\pi \times 50$

$\omega = 314.159$ rads

$\therefore C = \dfrac{89534.79576}{314.159 \times \left(\frac{415}{\sqrt{3}}\right)^2}$ = ~~1.654×10^{-3} F~~ $= 4.96 \times 10^{-3}$ F



ii) for Pf = 0.9 (lagging).

$\theta_3 = \cos^{-1}(0.9) = 25.841$

$Q_3 = P_{in} \tan \theta_3 = 87764.7058 \times \tan(25.841)$

$Q_3 = 42504.62312$ VAR

$Q_c = Q_1 - Q_3 = 89534.79576 - 42504.62312$

$Q_c = 47030.17264$ VAR

$\therefore C = \dfrac{Q_c}{\omega V^2} = \dfrac{47030.17264}{314.159 \times \left(\frac{415}{\sqrt{3}}\right)^2}$ = ~~8.6922×10^{-4} F~~

$C = 2.6076 \times 10^{-3}$ F

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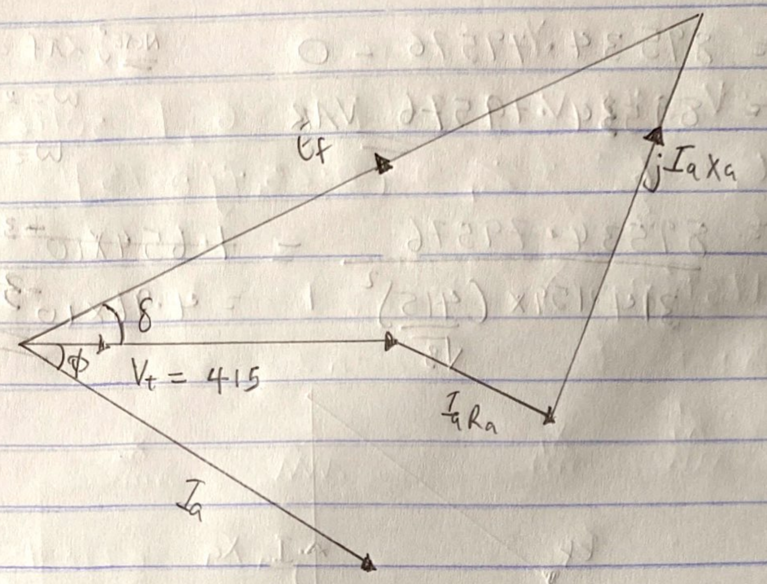

⇒ it is a synchronous motor