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Question 1

$V = 415\,V$

$f = 50\,Hz$

$P = 74.6$

$pf = 0.7$ lagging

$\eta = 85\%$

i) Unity = 1

$$C = \frac{KVAR}{2\pi f V^2}$$

$$V_{phase} = \frac{V_L}{\sqrt{3}} = \frac{415}{\sqrt{3}} = 239.6$$

actual pf $\Rightarrow \cos\theta = 0.7$

$$\theta = \cos^{-1} 0.7$$

$$= 45.57^\circ$$

$$\tan 45.57 = 1.02$$

Target p.f $\Rightarrow \cos\theta = 1$

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

$$\tan^{-1}(0) = 0$$

$$KVAR = 74.6 \times (1.02 - 0)$$

$$= 76.092$$

$$C = \frac{76.092}{2\pi \times 50 \times 239.6^2} = 4.22 \times 10^{-6}$$

$$= 4.22\,\mu F$$

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ii) 0.9 lagging

Initial pf = 0.7

$\theta = \cos^{-1} 0.7$

$= 45.57$

$\tan\theta = \tan 45.57$

$= 1.02$

Desired pf = 0.9 lagging

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

$= 154.16$

$\tan 154.16 = -0.48$

$KVAR = 74.6(1.02 - (-0.48))$

$= 111.9$

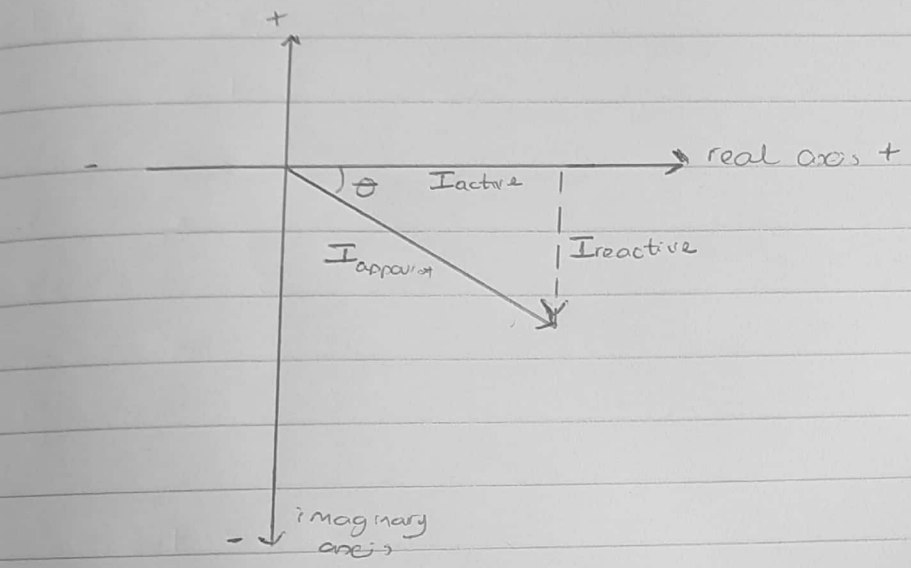
~~$C = \frac{KVAR}{\quad}$~~

$C = \frac{KVAR}{2\pi f V^2}$

$= \frac{111.9}{2 \times \pi \times 50 \times 239.6^2}$

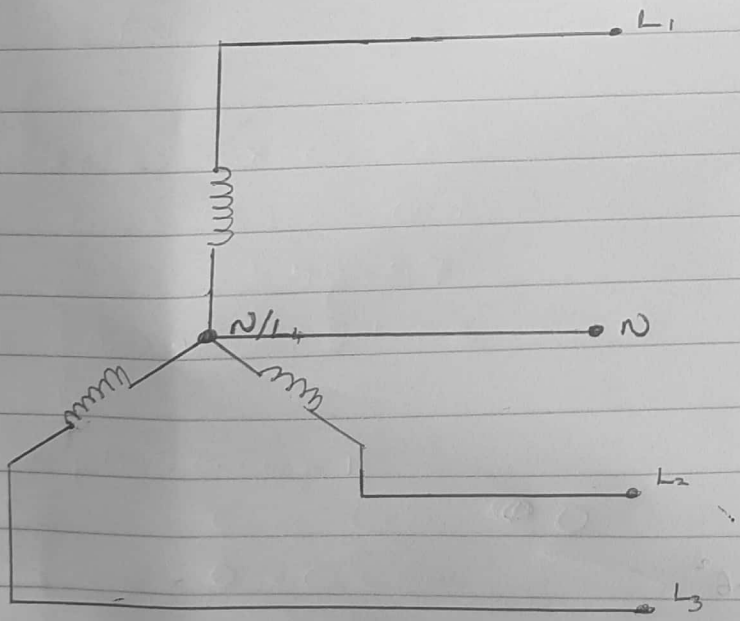
$= 6.2 \times 10^{-6}$

$= 6.2\,\mu F$



$$\cos\theta = \frac{I_{active}}{I_{apparent}}$$

$$\sin\theta = \frac{I_{reactive}}{I_{apparent}}$$



Three phase induction motor.

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Question 2

$V_{line} = 415V$

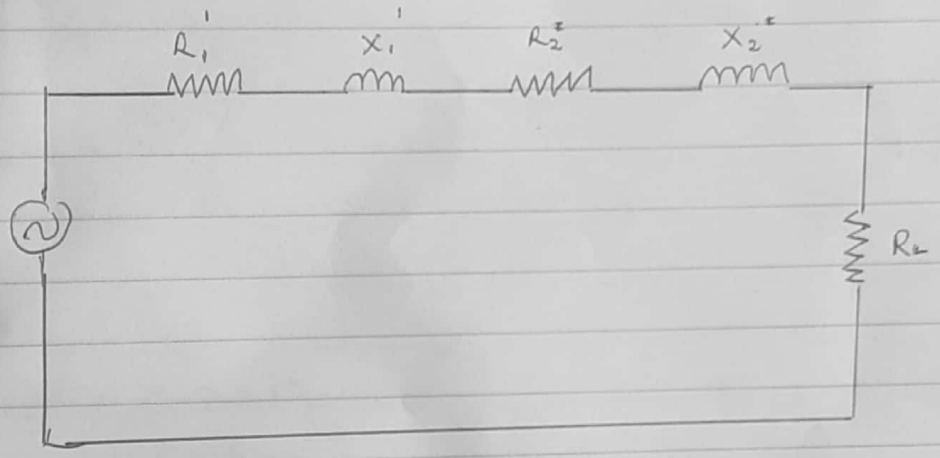
No of poles = 6

$f = 50Hz$

$K = 5/6 = 0.83$

$Z_1 = 0.25 + j0.75$ — stator

$Z_2 = 1.173 + j0.52$ — rotor



Supply voltage per phase, $V = \frac{415}{\sqrt{3}} = 239.60V$

Referring to rotor

$R_{02} = (R_2 + K^2 R_1)$

$= (1.173 + (5/6)^2 \times 0.25)$

$R_{02} = 1.347\Omega$

$X_{02} = (X_2 + K^2 X_1)$

$= j(0.52 + (5/6)^2 \times 0.75)$

$= 1.041$

$Z_{02} = R_{02} + X_{02}$

$= 1.347 + j1.041$

$Z_{02} = \sqrt{1.347^2 + 1.041^2}$

$= \underline{1.7\Omega}$

To find rotor current

$$I_2 = \frac{E_2}{Z_{O_2}}$$

Recall that $E_2 = kV_1$

$= 239.6 \times 0.83$

$E_2 = 199.67 V$

$$\therefore I_2 = \frac{199.67}{1.7} = 117.45 A$$

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Question 3

$f = 50Hz$ $R = 15\Omega$

$N_{dc} = 2000$ rpm (dc) $L = 0.25H$

$I = 0.7A$

$V = 220v$ (dc)

$E_{dc} = V - IR$

$= 220 - (0.7 \times 15)$

$= 209.5V$

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

$IX_L = 0.7 \times 2 \times \pi \times 50 \times 0.25$

$= 54.98V$

$IR = 0.7 \times 15$

$= 10.5V$

$\therefore E_{ac} = \sqrt{220^2 - 54.98^2} - 10.5$

$= 213.02 - 10.5$

$= 202.52V$

a) Speed of motor

Recall $\frac{N_{ac}}{N_{dc}} = \frac{E_{ac}}{E_{dc}}$

$\frac{N_{ac}}{2000} = \frac{202.52}{209.5}$

$N_{ac} = \frac{2000 \times 202.52}{209.5}$

$\therefore N_{ac} = 1933.37$ rpm

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b) power factor

$$pf = \frac{E + IR}{V} = \frac{202.52 + 10.5}{220} = 0.97$$

c) Torque developed.

$$T = \frac{EI}{2\pi N/60} = \frac{202.52 \times 0.7}{2\pi \times 1933.37/60}$$

$$= 0.7 Nm$$

d) Universal Motor