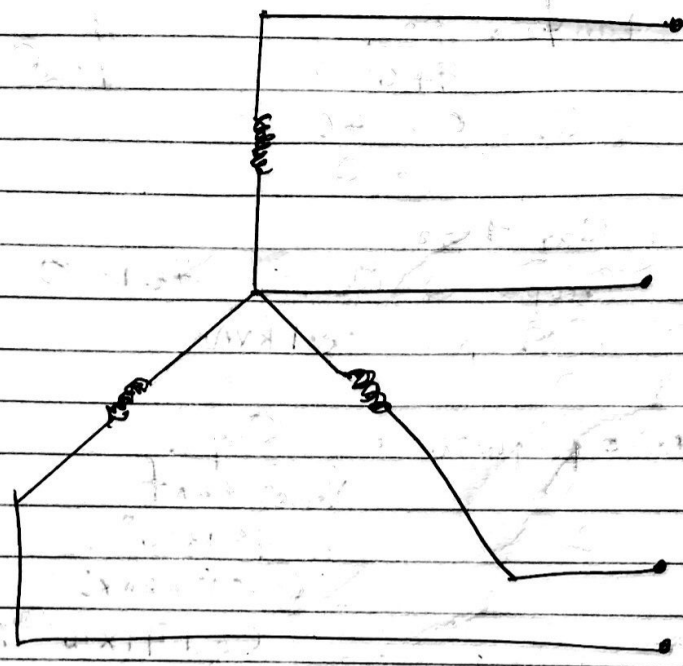
QUESTION 1

The driver motor type is ~~Universal Motor~~ a 3ϕ (phase induction Motor



Determine

1) UNIT 1 p.f = 1

Preamble

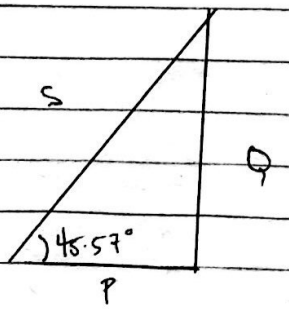
$P_1 = 74.6kW$

Voltage = 415V

p.f = 0.7 lagging

$\cos\phi = 0.7$

$\phi = 45.57°$



$\tan\phi = \frac{Q}{P}$

$\tan(45.57) = \frac{Q}{74.6\times10^3}$

$Q_1 = 76.1kVAR$

$\cos\phi = \frac{74.6\times10^3}{S}$

$S_1 = \frac{74.6\times10^3}{0.7}$

$S_1 = 106.6kVA$

NOTE.

When improving pf

$Q_1 > Q_2$ $P_1 = P_2$ $S_1 > S_2$ $Q_1 > Q_2$

$\tan\phi_2 = \frac{Q_2}{74.6\times10^3}$ $\phi = 0°$

$Q_2 = 0 \times 74.6\times10^3$

$= 0$

$Q_1 = Q_{cap} + Q_2$

$Q_{cap} = Q_1 - Q_2 = 76.1 - 0$

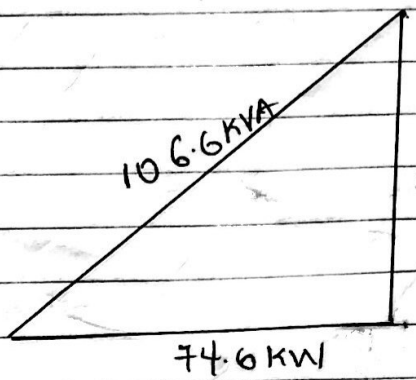
$Q_{cap} = 76.1\ KVAR$

Capacitance per phase $= \frac{Q_{cap}}{V_{rms}^2 \times 2\pi f}$

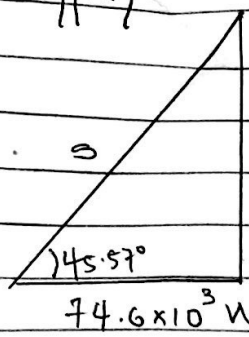
$= \frac{76.1\times10^3}{(415)^2 \times 2\pi \times 50}$

$C = 1.41\times10^{-3}\ F$

The Capacitance per phase required to raise power factor to unity $= 1.41\times10^{-3}\ F$



ii) 0.9 lagging



Preamble

$P = 74.6 \times 10^3$ W

p.f = 0.7 lagging (lagging that means inductive load)

$\cos\phi = 0.7$

$\phi = 45.57°$

$\cos\phi_1 = \frac{74.6 \times 10^3}{S_1}$

$S_1 = 106.6$ KVA

$\tan\phi_1 = \frac{Q}{P}$ $\quad Q_1 = \tan(45.57) \times 74.6 \times 10^3$

$Q_1 = 76.1$ KVAR

NOTE

When improving pf

$\phi_1 > \phi_2$ $\quad P_1 = P_2$ $\quad S_1 > S_2$ $\quad Q_1 > Q_2$

$\phi_2 = 25.84$

$\tan\phi_2 = \frac{Q}{P}$

$\tan(25.84) = \frac{Q}{74.6 \times 10^3}$

$Q = 3.62 \times 10^3$ KVAR

$Q_{cap} = Q_1 - Q_2$ (Recently established)

$Q_{cap} = 76.1$ KVAR $\sim$ 3.62 KVAR

$= 72.48$ KVAR

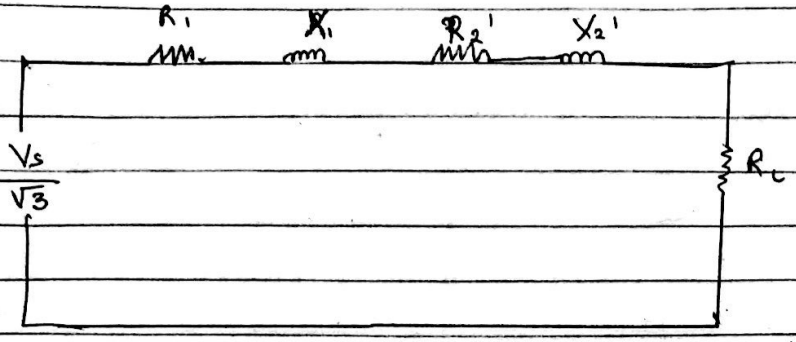
$C = \frac{Q_{cap}}{(V_{rms})^2 \times 2\pi f}$

$= \frac{72.48 \times 10^3}{2\pi \times 50 \times (415)^2}$

$C = 1.34 \times 10^{-3}$ F $= 1.34 \times 10^{3}$ F

The capacitance per phase required is 1.34×10^{-3} F

14,14,15 QUESTION 2



APPROXIMATE CIRCUIT VERSION 2

$R_{o2} = [R_2 + K^2 R_1)$

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

$R_{o1} = 1.347\,\Omega$

$X_{o2} = (X_2 + K^2 X_1)$

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

$= 1.041$

$Z_{o2} = R_{o2} + jX_{o2}$

$1.347 + j1.041$

$Z_{o2} = \sqrt{(1.347)^2 + (1.041)^2}$

$Z_{o2} = 1.7\,\Omega$

~~Rotor current~~

$E_2 = \frac{415}{\sqrt{3}} = 239.6$

$I_2 = \frac{E_2}{Z_{o2}}$

$E_2 = 239.6 \times 0.85$

$= 199.67\,V$

$I_2 = \frac{199.67}{1.7}$

$= 117.45A$

QUESTION 3

Preamble

$f = 50\ Hz$

$N = 2000\ rpm$.

$I = 0.7$

$R_1 = 15$ $X = 0.25$.

i) Speed of motor

$$Slip = \frac{N_s - N}{N_s}$$

$N_s = 2000\ rpm$

$= 2000$

ii) Power factor

$R_1 = 15$ $X_1 = 0.25$.

QUESTION 3

$V - E_b = I_L * R$

$V - [I_L * R] = E_b$

$E_b = 220 - [0.7 \times 15]$

$E_{b\,dc} = 209.5V$

$N_{dc} = 2000\ rpm$

on AC supply

Supply voltage = 220V,

frequency = 50Hz

Current = 0.7A

Resistance voltage $I \times R = 0.7 \times 15$

$= 10.5V$

Reactance voltage $I_L \times X_L$

$= 0.7 \times 2\pi f_1 X_1 = 0.7 \times 2\pi \times 50 \times 0.25$

$= 54.98V$

$E_b = \sqrt{V^2 - [I \times L]^2} - IR$

$= 202.5V$

~~Recall Speed~~

$$\frac{N_{ac}}{N_{dc}} = \frac{E_{bac}}{E_{bdc}}$$

$$N_{ac} = \frac{E_{bac} \times N_{dc}}{E_{bdc}} \qquad E_{bac} = \frac{220}{\sqrt{3}}$$

$$= \frac{2000 \times 209.5}{209.5}$$

$$N_{ac} = 1933.37 \text{ rpm}$$

Power factor $\cos\phi = \frac{E_{bac} + IR}{V}$

$$\frac{202.52 + 10}{220}$$

$$= 0.966 \text{ lagging}$$

iii) Torque developed

$$T_{ac} = \frac{E_{bac} \times I_a}{\omega} \qquad \omega = 2\pi n_s \qquad N_s = \frac{N_{ac}}{60}$$

$$\frac{202.52 \times 0.7}{2\pi \times \frac{1933.37}{60}}$$

$$T_{ac} = \frac{202.52 \times 0.7 \times 60}{2\pi \times 193337}$$

$$= 0.7 \text{ Nm}$$

iv) Type of motor is UNIVERSAL MOTOR