17/ENG06/067 Mechanical Engineering 300 level

i) Unity = 1

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

KVAR = P x (tan actual pf − tan target pf)

actual pf = $\cos\phi = 0.7$

$\phi = \cos^{-1} 0.7 = 45.57 \Rightarrow \tan(45.57) = 1.0201$

target pf: $\cos\phi = 1 \Rightarrow \phi = \cos^{-1}(1) = 0$

$\tan 0 = 0$

KVAR = 74.6 x (1.0201 − 0)

= 76.0995 ≃ 76.1

$C = \frac{76.10}{2\times\pi\times 50\times\left(\frac{415}{\sqrt{3}}\right)^2} = 4.22\times10^{-6} C$

ii) 0.9 lagging

actual pf = 1.029

target pf = $\cos\phi = -0.9$

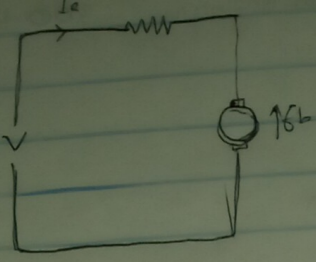
$\phi = \cos^{-1}(-0.9) = 154.16 \Rightarrow \tan\phi = -0.48$

KVAR = 74.6 x (1.0201 + 0.48) = 111.90 ≃ 112

$C = \frac{KVAR}{2\pi f v^2} = \frac{112}{2\times\pi\times 50\times\left(\frac{415}{\sqrt{3}}\right)^2} = 6.21\times10^{-5} C$

drive motor: Three phase induction motor

3)



$V - E_b = I_a \times R$

$V - [I_a \times R] = E_b$

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

$= 209.5V$

Speed on DC, $N_{dc} = 2000$ rpm

recall speed

$$\frac{N_2}{N_1} = \frac{E_{b2}}{E_{b1}} \quad \therefore \quad \frac{E_{bAC}}{E_{bDC}} = \frac{N_{AC}}{N_{DC}}$$

$$N_{AC} = 2000 \times \frac{202.52V}{209.5V} = 1933.37 \text{ rpm}$$

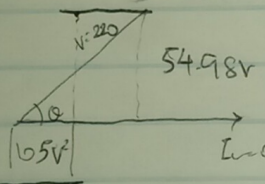
On AC supply

$V = 220V$, $I_a = 0.7A$

Reactance drop $= I_a \times R = 0.7 \times 15 = 10.5V$

Reactance voltage drop $= I_a \times X_L = 0.7 \times 2\pi fL$

$= 0.7 \times 2\pi \times 50 \times 0.25 = 54.98V$



$$E_{bAC} = \sqrt{V^2 - [X_L]^2} - IR = \sqrt{(220)^2 - (54.98)^2} - 10.5V$$

$= 202.52V$

(ii) Power factor, $\cos\phi = \frac{E_{bAC} * I_R}{V} = \frac{202.52 + 10.5}{220} = 0.968$ lagging

(iii) Torque developed;

$$T_{ac} = \frac{E_{bAC} \times I}{\omega}$$

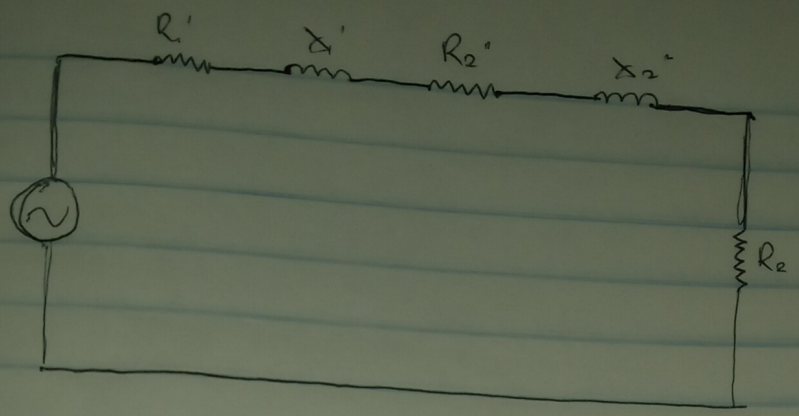
(iv) Universal motor

$\omega = 2\pi n$

$$T_{AC} = \frac{E_{bAC} \times I_a}{2\pi \times \frac{N_{AC}}{60}} = \frac{202.52 \times 0.7 \times 60}{2\pi \times 1933.37}$$

$= 0.700 Nm$

2)



supply voltage per phase, $V = \frac{415}{\sqrt{3}} = 239.50V$

rotor;

$R_{O2} = (R_2 + K^2 R_1) = (1.173 + (5/6)^2 \times 0.25) = 1.347\ \Omega$

$X_{O2} = (X_2 + K^2 X_1) = j(0.52 + (5/6)^2 \times 0.75) = 1.041$

$Z_{O2}\ R_{O2} + X_{O2} = 1.347 + j\,1.041$

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

$= 1.7\ \Omega$

Rotor current;

$I_2 = \frac{E_2}{Z_{O2}}$

$E_2 = KV_1 = 239.6 \times 0.83 = 199.67V$

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