17/ENG07/012: Mece/Elect Engineering · 300 Level

Question a

25 hp

V_{line} = 415V

pole = 6-pole

f = 50Hz

3-phase induction motor

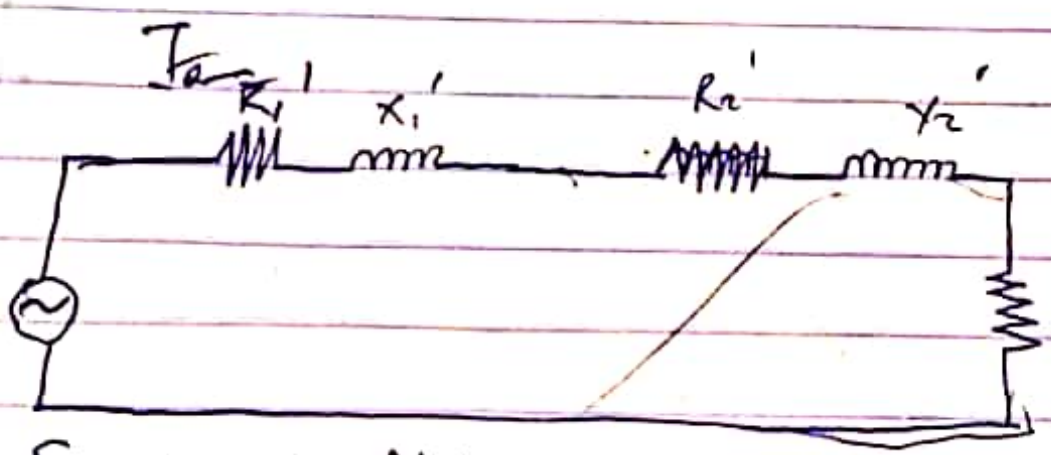
~~V_{ph}~~ K = 5/6

~~Z~~ = (0.25 + j0.75)

~~Z_s~~ = 1.73 + j0.52

Solution:

Equivalent Circuit Diagram refered to the rotor side



Supply ~~per~~ Voltage per phase

$$V_{ph} = \frac{V_{line}}{\sqrt{3}} = \frac{415}{\sqrt{3}} = 239.60V$$

Question 2

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Referring to rotor

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

$= (1.175 + (5/6)^2 \times 0.25)$

$R_{02} = \sout{1.347\Omega}$ ~~1.353~~ $1.347\,\Omega$

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

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

$=$ ~~1.041~~ ~~(j × [1.88)~~

$= 1.041$

~~$X_{02} = (X_2 + k^2 X_1$~~

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

$= 1.347 + j1.041$

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

$= 1.7\Omega$

To find rotor current

$I_2 = \frac{E_2}{Z_{02}}$

Recall that $E_2 = kV_1$

$= 239.6 \times 0.8$

$= 199.67\,V$

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

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Question 1

V = 415V, 3-ϕ, 4-wire, f = 50Hz, P = 74.6kw

pf = 0.7; η → Efficiency = 85% = 0.85

Capacitance per phase of a mesh-connected capacitor necessary to raise the power factor to

Solution

(i) Unity = 1

$V_{ph} = \frac{V_{line}}{\sqrt{3}} = \frac{415}{\sqrt{3}}$

$= 239.6$

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

KVAR = P x (tan actual p.f - tan target p.f)

actual p.f => cosϕ = 0.7

θ = cos⁻¹ 0.7

= 45.57

tan (45.57) = 1.0204

target p.f => cos ϕ = 1

θ = cos⁻¹ 1

= 0

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Question 1

$KVAR = 74.6 \times (1.0201 - 0)$

$= 76.10$

$C = \frac{76.10}{2 \times \pi \times 50 \times (\text{illegible})}$

$= 6.000064422$

$= 42.2 \times 10^{-6} C$

ii) 0.9 lagging

actual P.F = 1.0201

target P.F $\Rightarrow \cos\theta = -0.9$

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

$= 154.16$

$\tan\theta = -0.48$

$KVAR = 74.6 \times (1.0201 - (-0.44))$

$= 111.90$

$\simeq 112$

$C = \frac{KVAR}{2\pi f V^2} = \frac{112}{2\pi \times 50 \times (\text{illegible})}$

$= 0.000 \text{ illegible}$

$\simeq 8.6 \times 10^{-4} F$

8.2

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Question 3

$X_t = 0.25\Omega$

$f = 50Hz$

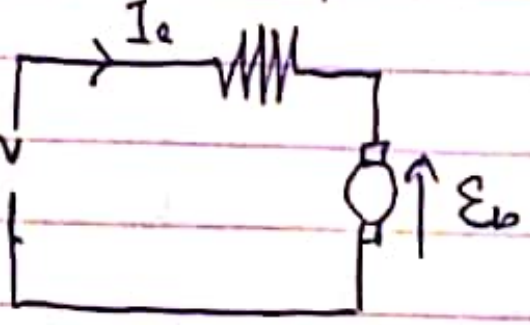
$N_1 = 2000rpm$

$V = 220V_{DC}$

DC Supply

Voltage = 220 V

Current drawn, I = 0.9A



$V - E_b = I_L * R$

$V - [I_a * R] = E_b$

$E_b = 220 - [0.7 * 15]$

$= 209V_{11}$

1) Speed on DC

$N_{dc} = 2000rpm$

Question 3

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Ac supply

Supply Voltage = 220V

Current drawn = $I_L = 0.7$

Resistance Drop = $I_L * R = 0.7 \times 15$

$= 10.5V$

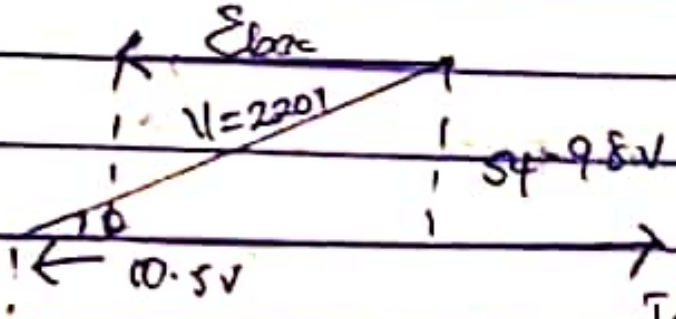
Reactance Voltage drop = $I_L * X_L$

$= 0.7 \times 2\pi fL$

Where $X_L = \omega L = 2\pi fL$

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

$= 54.98V$



$E_{bac} = \sqrt{V^2 - [X_L]^2} - IR$

$= \sqrt{(220)^2 - (54.98)^2} - 10.5V$

$= \sqrt{45397.1996} - 10.5$

$= 213.019 - 10.5$

$= 202.519$

$= 202.52V$

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Question 3

Recall speed that

$$\frac{N_2}{N} = \frac{E_{b2}}{E_{b1}}$$

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

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

$$= 2000 \times \frac{202.52V}{209.5V}$$

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

(i) Power factor, $\cos\phi$

$$\cos\theta = \frac{E_{bac} + I_L}{V}$$

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

$$= 0.968 \text{ Lagging}$$

(ii) Torque developed by the motor

$$T_{ac} = E_{bac} \times I$$

Question 3

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

ω is speed in rad/s

$\omega = 2\pi n$, where n is speed in rev/s

$$T_{ac} = \frac{E_{bac} \times I_c}{\frac{2\pi \times N_{ac}}{60}}$$

$$= \frac{202.52 \times 0.7 \times 0.6}{2\pi \times 1733.37}$$

$$= 0.700 \text{ Nm}$$

ii) What type of motor could be used for this application

Universal motor