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TEST

MATRIC NO: 17/ENG06/090
DEPARTMENT: MECHANICAL

QUESTION 1

Solution

$V_{line} = 415V \quad f = 50Hz \quad P = 74.6kW \quad P.f = \cos\theta = 0.7$ lagging

$Eff = 85\%$

(a) $V_{phase} = \frac{V_{line}}{\sqrt{3}} = \frac{415}{\sqrt{3}} = 239.6V$

$$C = \frac{kVar\,(Q)}{2\pi f V^2}$$

$$Q = P \times [\tan\theta_1 - \tan\theta_2]$$

where $\theta_1 = \cos^{-1}[0.7] = 45.57°$

∴ target $P.F = \cos\theta = 1$

$\theta = \cos^{-1}[1]$

$\theta_2 = 0°$

∴ $Q = 74.6 \times [\tan(45.57) - \tan(0)]$

$= 74.6 \times 1.02$

$Q = 76.092kVar$

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QUESTION 1

Solution

$$\therefore C = \frac{76.092}{2\pi \times 50 \times 239.6^2} = 4.21\mu F$$

(a) for power factor of 0.9 lagging,

actual P.f angle $= \cos^{-1}[0.7] = 45.57°$

target P.f angle $= \cos^{-1}[0.9] = ~~25.84°~~\ 154.16°$

$$\therefore Q = P[\tan\theta_1 - \tan\theta_2)$$

$$= 74.6 \times [\tan(45.57) - \tan(154.16)]$$

$$Q = 74.6 \times (1.02 + 0.48)$$

$$\therefore Q = 111.9 kVar$$

$$\therefore C = \frac{111.9}{2\pi \times 50 \times 239.6^2} = 6.204\mu F$$

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QUESTION 3

Solution

$f = 50Hz$ $P = \frac{1}{4}h_p =$ $V = 220V$ $I = 0.7A$

$N_r = 2000_{rpm}$

$R = 15\Omega$

$X = 0.25H$

(i) Speed of motor $= \frac{120f}{P} = \frac{120 \times 50}{P} = \frac{6000}{P}$

$V - E_{b_1} = I(R + jX)$

$220 - E_{b_1} = 0.7(15 + 0.25_f)$

$E_{b_1} =$

$V - E_{b_1} = IR$

$220 - E_{b_1} = 0.7(15)$

$E_{b_1} = 209.5V$

for E_{b_2},

$E_{b_2} = \sqrt{V^2 - [IX_L]^2} - IR$

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~~$E_{b_2} = 220^2 - 0.7 \times 0.25$~~

$X_L = 2\pi fL = 2 \times \pi \times 50 \times 0.25 = 78.547\,\Omega$

$\therefore E_{b_2} = [220^2 - [0.7 \times 78.547^2]]^{1/2} - [0.7 \times 15]$

$E_{b_2} = 202.52\,V$

but,

$\frac{N_2}{N_1} = \frac{E_{b_2}}{E_{b_1}}$

and $N_1 = 2000\,rpm$

$\therefore N_2 = N_1 \times \frac{E_{b_2}}{E_{b_1}} = 2000 \times \frac{202.52}{209.5} = 1933.37\,rpm$

(ii) $P.f = \cos\theta = \frac{IR + E_{b_2}}{V} = \frac{(0.7 \times 15) + 202.52}{220}$

$P.f = 0.97$

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QUESTION 3

~~$T = P \times \omega$~~ $P = T \times \omega$

or ~~$T = 9.55$~~

(iii) $\omega = \frac{2\pi N_2}{60} = \frac{2 \times \pi \times 1933.37}{60} = 202.5 \text{ rad/s}$

where $P = \frac{1}{4} h_p = \frac{1}{4} \times 745.7 = 186.43 \text{ watts}$

$\therefore T = \frac{P}{\omega} = \frac{186.43}{202.5} = 0.92 \text{ Nm}$

(iv) Universal Motor

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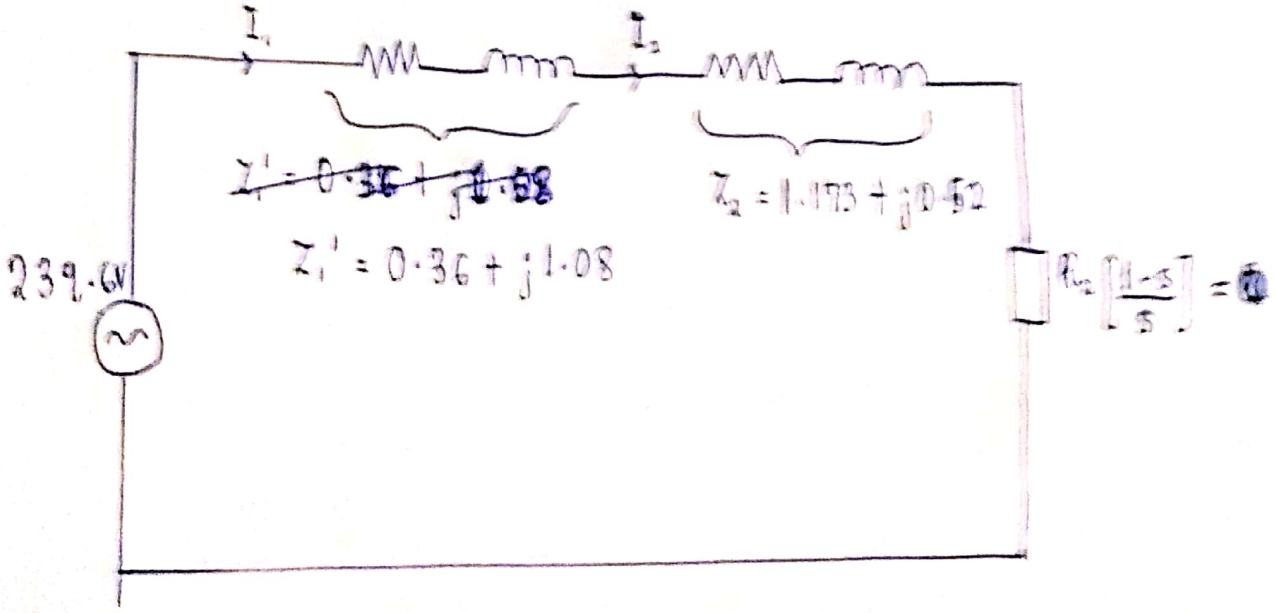
QUESTION 2
Solution

$P = 25 hp = 25 \times 746 = 18650$ watts $P = 5$ poles

$V_{line} = 415V$ $f = 50Hz$ $\frac{V_1}{V_2} = \frac{6}{5}$ $V_{phase} = \frac{415}{\sqrt{3}} = 239.6V$

(i) $Z_1 = 0.25 + j0.75\Omega$ $s = 1$
$Z_2 = 1.173 + j0.52\Omega$



$\therefore \frac{V_2}{V_1} = \frac{5}{6}$ $\therefore Z_1' = \frac{Z_1}{k^2} = \frac{0.25 + j0.75}{0.833^2} = 0.36 + j1.08\Omega$

where $k = \frac{V_2}{V_1} = \frac{5}{6} = 0.833$

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QUESTION 2
Solution

(a) $Z_T = Z_1' + Z_2 = 0.36 + j1.08 + 1.173 + 0.52j$

$= 1.533 + j1.6$

$\therefore I_1 = \frac{V}{Z_T} = \frac{239.6}{1.533 + j1.6} = 108.13 \angle -46.23^\circ A$

$V_{drop} = I_1 \times Z_1' = (108.13 \angle -46.23^\circ)(0.36 + j1.08)$

$= 123.10 \angle 25.34^\circ V$

$\therefore I_2 = \frac{V - V_{drop}}{Z_2} = \frac{239.6 - (123.10 \angle 25.34)}{1.173 + j0.52} =$

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QUESTION 1

Continuation

The drive motor is a star-connected 3 phase induction motor.