

# Solution Assignment - 7 (Additional.)

①

Q1  $N_s = 1000 \text{ rpm}$ .  $\therefore S_{\text{rated}} = \frac{1000 - 945}{1000} = 0.055$

$$T_{\text{rated}} = \frac{3}{\omega_s} \frac{I_2'^2}{S} \frac{r_2'}{S} = \frac{3}{\omega_s} \cdot \frac{(231)^2}{\left(\frac{2.0}{0.055}\right)^2 + 16} \cdot \frac{2.0}{0.055}$$

3 marks.

M/c is running at 800 rpm.

$$\therefore S = \frac{1000 - 800}{800} = 0.25. \leftarrow 2 \text{ marks.}$$

Let the applied stator voltage / phase = V

$$\frac{3}{\omega_s} \cdot \frac{V^2}{\left(\frac{2.0}{0.25}\right)^2 + 16} \cdot \frac{2.0}{0.25} = \frac{3}{2\omega_s} \cdot \frac{(231)^2}{\left(\frac{2.0}{0.055}\right)^2 + 16} \cdot \frac{2.0}{0.055}$$

4 marks.

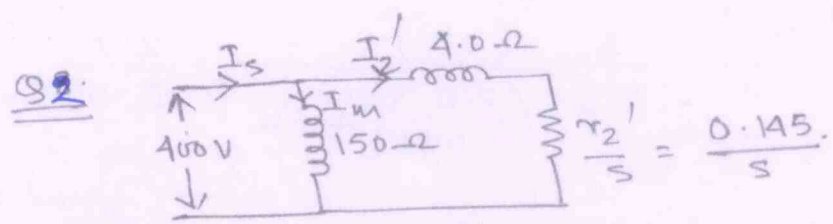
$$\frac{V^2}{64 + 16} \times 8 = \frac{(231)^2}{1322 + 16} \times 18.18$$

$$\therefore V = 85.149$$

$$\therefore V_{LL} = \sqrt{3} \times 85.149 = 147.48 \text{ V}$$

1 mark.

[If 400V is taken as per phase voltage instead of 231V, then 2 marks to be deducted once, if all other procedures are correctly done].



$$S_{rated} = \frac{1500 - 1480}{1500} = 0.013$$

$$\text{Rated torque} = \frac{3}{\omega_s} \cdot \frac{(400)^2}{\left(\frac{0.145}{0.013}\right)^2 + 16} \cdot \frac{0.145}{0.013} \quad \text{1 mark}$$

Let in the given condition, the m/c is running with a slip,  $s$ . and as the developed torque is opposite to the direction of rotation of the rotor, the developed torque is negative to that of the ~~rot~~ normal torque of the m/c.

$$\therefore - \frac{3}{\omega_s} \cdot \frac{(400)^2}{\left(\frac{0.145}{s}\right)^2 + 16} \cdot \frac{0.145}{s} = \frac{3}{\omega_s} \cdot \frac{(400)^2}{\left(\frac{0.145}{0.013}\right)^2 + 16} \cdot \frac{0.145}{0.013} \quad \text{2 marks}$$

$$- \frac{1}{\frac{0.021}{s^2} + 16} \times \frac{1}{s} = - \frac{1}{140.4} \times 76.92$$

$$\text{or, } 8.8s^2 + s + 0.011 = 0$$

$$\text{Solving, } s = -0.101, -0.012$$

of the two value of slip the smaller value is realistic and hence adopted.

$$-0.012 = \frac{N_s - N_m}{N_s} = \frac{1500 - N_m}{1500} \quad \text{2 marks}$$

$$\therefore N_m = 1680 \text{ rpm.}$$

The rotor speed is more than the synchronous

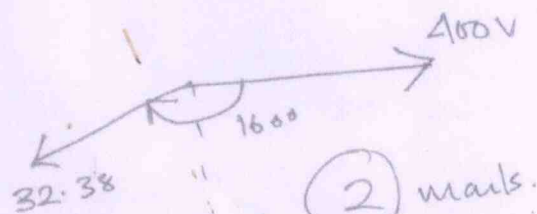
Q2 Contd.  
speed and hence operating in generating mode.

Considering the stator voltage as the reference phasor,

$$\bar{I}_s = \bar{I}_m + \bar{I}'_2 = \frac{400 \angle 0}{150j} + \frac{400 \angle 0}{4j - \frac{0.145}{0.012}} \quad (3 \text{ marks.})$$

$$= 2.66 \angle -90^\circ + \frac{400 \angle 0}{12.72 \angle 161.67}$$

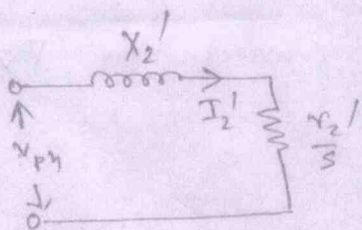
$$= 32.38 \angle -157^\circ$$



(2) marks.

[If 231 V is taken as the per phase stator voltage instead of 400 V, then 2 marks to be deducted once, if all other procedures are correctly done.]

Q3



$$I_2' = \frac{V_{ph}}{\sqrt{(X_2')^2 + \left(\frac{r_2'}{s}\right)^2}}$$

$$T = \frac{3}{\omega_s} \cdot \frac{(V_{ph})^2 \cdot \frac{r_2'}{s}}{\left(\frac{r_2'}{s}\right)^2 + (X_2')^2}$$

Max. Torque occurs when  $X_2' = \frac{r_2'}{s_{max}}$

$$\therefore T_{max} = \frac{3}{\omega_s} \cdot \frac{V_{ph}^2 \cdot X_2'}{2X_2'^2} = \frac{3}{\omega_s} \cdot \frac{V_{ph}^2}{2X_2'}$$

$$s_{max} = \frac{1000 - 875}{1000} = 0.125$$

$$\therefore s_{max} = \frac{r_2'}{X_2'} = 0.125 \Rightarrow 0.125 = \frac{0.25}{X_2'}$$

$$\therefore X_2' = 2 \Omega$$

$$\text{Again, } 10 = \frac{3}{104.72} \cdot \frac{V_{ph}^2}{2 \times 2}$$

$$\therefore V_{ph} = 37.36 \text{ V}$$

Torque that will be developed at  $s = 0.05$

$$T = \frac{3}{104.72} \cdot \frac{(37)^2 \cdot \frac{0.25}{0.05}}{\left(\frac{0.25}{0.05}\right)^2 + (2)^2} = 6.76 \text{ Nm.}$$

Q4  $N_r = 1480 \text{ rpm}$   $\therefore N_s = 1500 \text{ rpm} \Rightarrow P = 4$   
 $= 157.07 \text{ rad/s}$

$$\text{Full load slip} = \frac{1500 - 1480}{1500} = 0.013$$

$$\therefore \text{Full load torque} = \frac{3}{157.07} \cdot \frac{(200)^2 \times \frac{0.145}{0.013}}{\left(0.21 \times 2\right)^2 + \left(\frac{0.145}{0.013} + 0.1\right)^2}$$

$$= 67.21 \text{ Nm.}$$



Let the external resistance connected be  $R_x'$  referred to the stator

$$\therefore R' = R_x' + R_2'$$

$$\therefore \frac{3}{157.07} \cdot \frac{(200)^2 \cdot \frac{R'}{1}}{0.1764 + (0.1 + R')^2} = 67.21$$

Solving  $R' = 10.89, 0.02$

Discarding 0.02

(2)

$$\therefore R_x' = 10.89 - 0.145 = 10.745 = R_x \times (1)^2$$

$$\therefore R_x = 10.745$$

ii) While the m/c is running at 1000 rpm

$$s = 0.33$$

$$\therefore \frac{3}{157.07} \cdot \frac{(200)^2 \cdot \frac{R'}{0.33}}{0.1764 + \left(0.1 + \frac{R'}{0.33}\right)^2} = 67.21$$

Solving  $R' = 3.56, 0.01$

(7)

$$\therefore R_x' = 3.56 - 0.145 = 3.415 \Omega$$

Q5 i) Peak of the resultant mmf =  $2F_m$ .

2) The nature of the resultant mmf is sinusoidally distributed in space. (3)

3) It rotates in space in steps of  $60^\circ$

Need to be shown analytically or ~~graphically~~ graphically.