Solution Assignment - 2 (Additional) ①

<u>Q1</u> $N_s = 1000$ rpm. $\therefore$ $S_{rated} = \frac{1000-945}{1000} = 0.055$

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

3 marks.

M/c is running at 800 rpm.

$$\therefore \quad S = \frac{1000-800}{800} = 0.25.$$

2 marks.

Let the applied stator voltage / phase = V

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

4 marks.

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

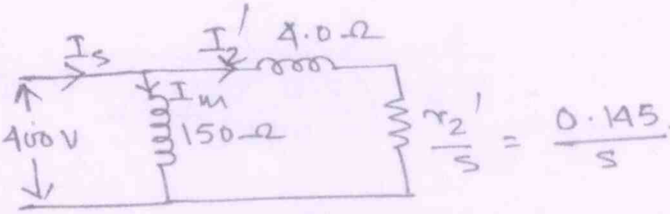
$$\therefore \quad V = 85.149$$

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

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.]

Q2.



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

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

1 marks

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

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

2 marks

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

or, $8.8s^2 + s + 0.011 = 0$

Solving, $s = -0.101, \; -0.012$

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

$$-0.012 = \frac{N_s - N_m}{N_s} = \frac{1500 - N_m}{1500}$$

$$\therefore N_m = 1680 \text{ rpm.}$$ ← 2 marks

The rotor speed is more than the synchronous

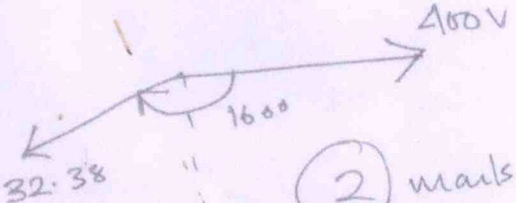
Q2 contd.
speed and hence operating in generating mode.

Considering the stator voltage as the reference phasor,

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

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

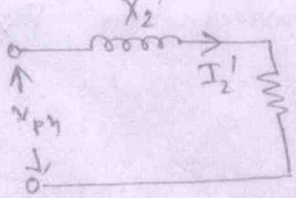
$$= 32.38\angle -157^\circ$$



2 marks.

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

Q3.



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

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

Max^m torque occurs when $X_2' = \frac{r_2'}{S_{max}}$

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

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

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

3

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

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

$$\therefore V_{ph} = 37.36\,V$$ 4

Torque that will be developed at $S = 0.05$

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

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

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

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

$$= 67.21 \text{ Nm.}$$ 1

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 $R' = 10.89, 0.02$ (2)

Discarding 0.02

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

$\therefore R_x = 10.745.$

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 1) 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 $60°$

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