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2020522307



## EE100: Basic Electrical Engineering

## Remote End-Semester Exam

1.(a) Rated voltage and rated current for high voltage side,

$\boxed{\text{rated voltage (HV side)} = 1000\ V}$ (given)

$$\text{rated current (HV side)} = \frac{\text{rated Power}}{\text{rated voltage (HV side)}}$$

$$= \frac{100 \times 10^3\ VA}{10^3\ V}$$

$\boxed{\therefore \text{rated current (HV side)} = 100\ A}$

(b) rated voltage and rated current for low-voltage side,

$\boxed{\text{rated voltage (LV side)} = 100\ V}$ (given)

$$\text{rated current (LV side)} = \frac{\text{rated Power}}{\text{rated Voltage (LV side)}}$$

$$= \frac{100 \times 10^3\ VA}{100\ V}$$

$\boxed{\text{rated current (LV side)} = 1000\ A}$

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(b) OC - test (secondary side)

$$|Y_{ex}| = \frac{I_{oc}}{V_{oc}}$$

$$= \frac{6\ A}{100\ V}$$

$$|Y_{ex}| = 0.06\ S$$

$$\phi = \cos^{-1}\left(\frac{P_{oc}}{I_{oc} \cdot V_{oc}}\right)$$

$$\phi = \cos^{-1}\left(\frac{400}{100 \cdot 6}\right)$$

$$\phi = 48.189^\circ$$

$$\therefore Y_{ex} = 0.06 \angle -48.189^\circ\ S$$

$$Y_{ex} = 0.04 - j(0.0447)\ S$$

$$\because Y_{ex} = \frac{1}{R_c} - \frac{j}{X_m}$$

$$\therefore R_{c,s} = \frac{1}{0.04} = 25\ \Omega$$

$$X_{m,s} = \frac{1}{0.0447} = 22.371\ \Omega$$

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SC - test (primary side)

$$|Z_{eq}| = \frac{V_{sc}}{I_{sc}} = 0.5\,\Omega$$

$$\phi = \cos^{-1}\left(\frac{P_{sc}}{I_x \cdot V_{sc}}\right)$$

$$\phi = \cos^{-1}\left(\frac{1800}{50 \times 100}\right)$$

$$\phi = 68.899^{\circ}$$

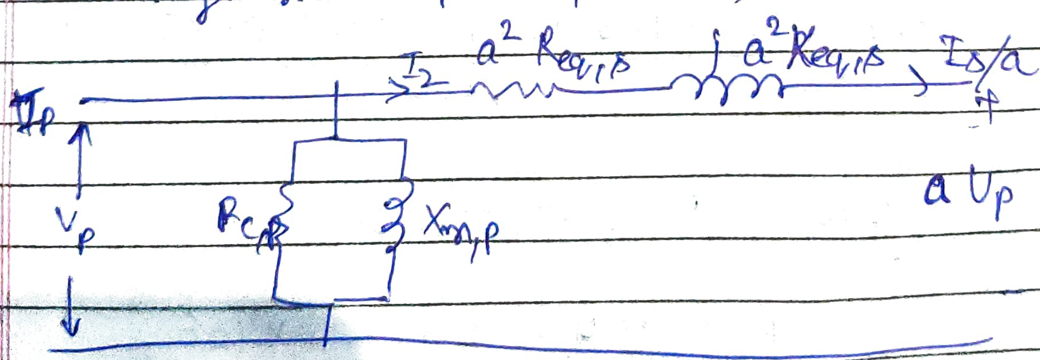
$$Z_{EQ} = 0.5 \angle 68.899^{\circ}\,\Omega$$

$$= 0.18 + j\,0.47\,\Omega$$

$\therefore$ $R_{eq,p} = 0.18\,\Omega$

$X_{eq,p} = \cancel{0.46}\ 0.47\,\Omega$

equivalent circuit referred to high voltage side (primary side)



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Page 4

$R_{c,p} = \left(\frac{1000}{100}\right)^2 R_{c,s}$

$= 2500\,\Omega$

$X_{m,p} = \left(\frac{1000}{100}\right)^2 X_{m,s}$

$X_{m,p} = 2237.1\,\Omega$

$V_p = 1000\,V$

at full load $I_2 = \frac{100 \times 10^3}{1000} = 100\,A$

and power factor $\cos\phi_2 = 0.8$

$\therefore \sin\phi_2 = 0.6$

$\therefore VR = \frac{I_2 R_{eq} \cos\phi_2 + I_2 X_{eq_{11}} \sin\phi_2}{E_2}$

$\% R = \frac{I_2 R_{eq} \cos\phi_2 + I_2 X_{eq} \sin\phi_2}{E_2} \times 100$

$\% R = \frac{100 \times 1.8 \times 0.8 + 100 \times 0.47 \times 0.6}{1000} \times 100$

~~% R = 14.4 + 13.056~~

$\% R = \frac{14.4 + 28.2}{\cancel{1000}\ 10} \times \cancel{100}$

$\% R = 4.26\%$

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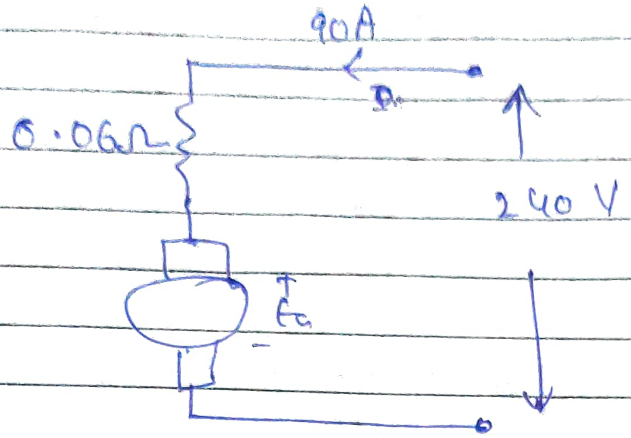
2.




(a) So, $E_a = 240 - 90 \times 0.6$

$E_a = 234.6\ V$

and, $\omega_m = \frac{\cancel{1200}^{20} \times 2\pi}{\cancel{60}} = 40\pi\ rad/s$

$\therefore$ torque $= \frac{E_a I_a}{\omega_m} = \frac{234.6 \times 90}{40\pi}$

$$\boxed{\tau = 168.02\ N\text{-}m}$$

(b) Since, torque $= K\phi I_a$

$\therefore 168.02 = K\phi \times 90$

$\therefore K\phi = \frac{168.02}{90}$

Now, torque $= 280\ N\text{-}m$

$\therefore 280 = K\phi I_{a_2}$

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$$I_{a_2} = \frac{280 \times 90}{168.02} = 149.9\ A$$

$$\boxed{\therefore I_{a_2} = 149.9 A}$$

$$\therefore E_a = 240 - 0.06 \times 149.9$$
$$E_a = 231.006\ V$$

$$\because E_a = K\phi\omega_m$$

$$\omega_m = \frac{231.006}{168.02} \times 90$$

$$= 123.738\ rad/s$$
$$= 123.738 \times \frac{60}{2\pi}\ rpm$$

$$\boxed{\omega_m = 1181\ rpm}$$

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3. (a) at starting, slip $s = 1$.

current $I_2 = \dfrac{E_2}{\sqrt{R_2^2 + X_2^2}}$

$$= \frac{460/\sqrt{3}}{\sqrt{(0.2)^2 + (0.5)^2}}$$

$$= \frac{265.5889}{\sqrt{0.29}}$$

$$I_2 = \frac{265.5889}{0.5385} = 493.201 \text{ A}$$

$\therefore$ starting current is $493.201$ A.

(b) for maximum torque, we know that

$$S_{max} = \frac{R_2}{X_2} = \frac{0.2}{0.5} = 0.4$$

$\therefore$ $S_{max} = 0.4$

torque at $S_{max}$

$$T_{max} = \frac{3 \times 60}{2\pi N_s} \cdot \frac{(S_{max}) E_2^2 R_2}{R_2^2 + (S_{max} X_2)^2}$$

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$$T_{max} = 0.0159 \cdot \frac{(0.4)\left(460/\sqrt{3}\right)^2 \cdot (0.2)}{(0.2)^2 + (0.4\times0.5)^2}$$

$$T_{max} = \frac{89.723}{0.2828} \text{ N-m}$$

$$T_{max} = 317.26 \text{ N-m}$$

(c) at full load

$$\text{slip \% } S = \frac{N_s - N_o}{N_s} \times 100$$

$$N_s = \frac{120 \times f_e}{P} = \frac{120 \times 60}{4} = 1800 \text{rpm}$$

$$\therefore S = \frac{1800-1740}{1800}$$

$$S = 0.033$$

$$\therefore \text{efficiency of motor} = (1-S)\times 100\% = \frac{N_o}{N_s} \times 100\%$$

$$= \frac{1740}{1800} \times 100$$

$$\boxed{\text{efficiency of motor} = 96.67\%}$$