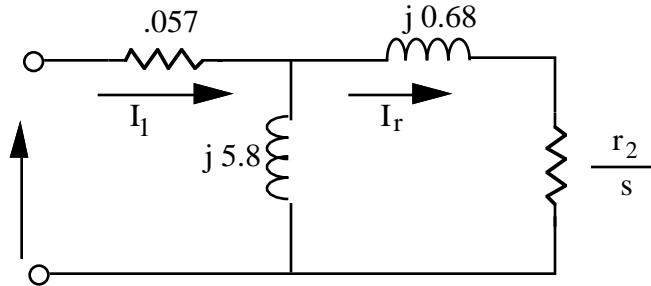


Required Homework 9 Induction Machine Constant Frequency

The equivalent circuit parameters of a 100 Hp, 460 volt (rms line to line), 60 hz, 4-pole three phase induction motor are (in ohms)

$$r_1 = 0.057 \quad x_1 + x_2 = 0.68 \quad r_2 = 0.071 \quad x_m = 5.8$$

and all of the leakage may be placed on the rotor side as shown in the figure



a) Find the power input and torque for rated voltage and frequency and a slip of 0.03.

$$\tilde{Z}_{in} = r_1 + j x_m / \left(\frac{r_2}{0.03} + j(x_1 + x_2) \right) = 1.73 + j 1.22 \text{ ohms}$$

$$\tilde{I}_1 = \frac{265.6 + j 0}{1.73 + j 1.22} = 125.5 \text{ angle } -35.2^\circ \text{ A rms}$$

$$(P_{in} = 3 \times (V_1 I_1 \cos \theta) = 81,718 \text{ W})$$

$$\tilde{I}_r = \tilde{I}_1 \frac{j x_m}{\frac{r_2}{s} + j(x_1 + x_2 + x_m)} = 105.5 \text{ A}$$

$$T_{em} = 3 \times \frac{p}{2} \times \frac{|\tilde{I}_r|^2 r_2}{s \omega_e} \quad \text{or} \quad T_{em} = 3 \times \frac{p}{2} \times \frac{|\tilde{I}_1|^2 r_{eq}}{\omega_e}$$

where $r_{eq} = \text{Re} \tilde{Z}_{in} - r_1 = 1.73 - 0.057 = 1.67 \text{ ohms}$ (this second and computationally simpler method works since there is only one resistor on the rotor side of the circuit)

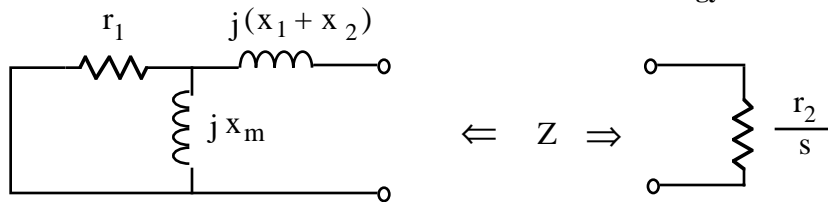
$$T_{em} = 419.4 \text{ Nm}$$

b) Find the peak torque for rated voltage and frequency.

Find slip for max power transfer to $\left(\frac{r_2}{s} \right)$ by using impedance matching

$$\left| \frac{r_2}{s_{mt}} \right| = |j(x_1 + x_2) + r_1 / j x_m| \quad \rightarrow \quad s_{mt} = 0.1$$

ECE 355 - Electromechanical Energy Conversion



use same method as above to calculate T_{pk}

$$\tilde{Z}_{in} = .597 + j 0.666 \text{ ohms}$$

$$\tilde{I}_1 = 198.4 - j 222 \text{ A}$$

$$|\tilde{I}_r| = 264.4 \text{ A}$$

$$T_{em} = 758 \text{ Nm}$$

c) To what value should the rotor resistance be increased to maximize the starting torque at rated frequency?

At starting, $s \triangleq 1$, again, match impedances...

$$\left| \frac{r_2}{s} \right| = |r_2| = |j(x_1 + x_2) + r_1 // j x_m| = 0.683 \text{ ohms}$$