Name: Uwangbe Rita Chidum.
Department: Electronics Electrical Engineering
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Electrical Machines Assignment.
ENG 326

A 25KVA, 415V, three phase, 4 pole, 60Hz, wye connected synchronous generator has a synchronous reactances of 1.5Ω/phase and negligible stator resistance. The generator is connected to an infinite bus (of constant voltage magnitude and constant frequency) at 415V and 60Hz.

a) Determine the excitation voltage, EA when the machine is delivering rated KVA at 0.8 pf lagging.

b) The field excitation ~~voltage~~ current I_f increased by 20% without changing the power input from the prime mover. Find the stator current Ia, power factor and reactive power Q supplied by the machine.

c) With the field excitation current If as in part (a), the input power from the prime mover is increased very slowly. What is the steady state limit? Determine stator current IA, Power factor, and reactive power Q.

Solution

P = 25KVA

P = 4 pole.

f = 60Hz

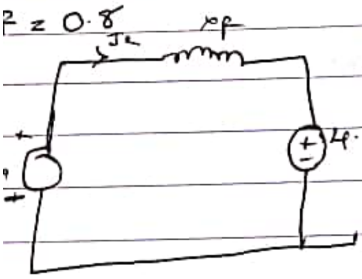
V = 415V

X_s = 1·5Ω.

R_a = 0.

E_a = ?

PF = 0.8



$E_a =$

$V_L = V_p \times \sqrt{3}$

$V_L = 415 \times \sqrt{3}$

$V_L = 718.8V.$

Recall

$I_a = \frac{S_{rated}}{V_L}$

$= \frac{25000}{718.8}$

$= 34.78A.$

$P.f = 0.8$ lagging

$P.f = \cos\theta$

$0.8 = \cos\theta.$

$\theta = \cos^{-1} 0.8$

$\theta = 36.9$ (lagging. $\therefore I_a = 34.780 \angle -36.9^\circ.$

Recall $E_a = V_p + j X_s I_a$

$E_a = 239.6 \angle 0 + (1.5 \angle 90^\circ \times 34.780 \angle -36.87)$

$E_a = 274.0981 \angle 8.758^\circ A.$

$E_a = 270.902 + 41.735j\ A.$

2. Real power of a synchronous motor is given as

$P_{out} = \frac{3 \times V_p \times E_a \sin\delta}{X_s}$

$P_{out} = \frac{3 \times 239.6 \times 274.12 \times \sin(8.75)}{1.5}$

$= 19982.67003$

$\simeq 20KVA.$

The ratio of rated power to real power.

$\frac{25}{20} = 1.25$

$P_{rated} = 1.25 P_{out}.$

$E_{a2} = 1.25 * E_{a1}$

$= 1.25 * 274.12$

$E_a = 342.65 V.$

To Calculate Torque Angle (δ)

$$\frac{3 V_\phi E_{a1} \sin\delta_1}{X_s} = \frac{3 V_\phi E_{a2} \sin\delta_2}{X_s}.$$

$E_{a1}\sin\delta_1 = E_{a2}\sin\delta_2$

$$\sin\delta_2 = \frac{274.12 \sin(8.75)}{342.65}$$

$\sin\delta_2 = 0.12$

$\delta_2 = \sin^{-1}(0.12)$

$\delta_2 = 6.987°.$

Recall

$$I_{Astator} = \frac{E_{a2} - V_s}{X_s}$$

$$= \frac{342.65\angle 6.987 - 239.6\angle 0}{1.5\angle 90°}$$

$I_{Astator} = 72.5368\angle -67.4 A$

Power factor $= \cos\theta$

where ; $\theta = 67.4$

$P.f = \cos(67.4)$

$= 0.384$ lagging.

For reactive power Q.

$Q = \sqrt{3} * V_L * I_L * \sin\theta$

$Q = \sqrt{3} \times 415 \times 72.5368 \times \sin(67.4)$

$Q = 48135.75$

$Q = 48 KVA.$

Steady state limit is the maximum power transmitted without loss in transmission.

$P_{max} = \frac{E_a \times V_\phi \times 3}{X_s}$

$= \frac{3 \times 239 \times 274.1}{1.5}$

$P_{max} = 131029$ KVA

$= 131$ KVA at $90°$.

- Stator current at SSL

$I_{A\,stator} = \frac{E_a - V_\phi}{X_s}$

$\Rightarrow \frac{274.12\angle 90 - 239\angle 0}{1.5\angle 90}$

$= 242.66\angle 41.17°$

- Power factor;

$P.f = \cos\theta$

$P.f = \cos(41.17)$

$= 0.752$ leading.

Reactive Power

$Q = \sqrt{3} \times V_L \times I_L \times \sin\theta$.

$Q = \sqrt{3} \times 415 \times 242.66 \times \sin(41.17)$

$Q = 114822$

$= 115$ KVA //.