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17/ENG04/020
Electrical/Electronics
EEE 326

A 25 KVA, 415V, three phase, 4 pole, 60Hz, wye connected synchronous ~~motor~~ generator has a synchronous motor 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 E_A, when the machine is delivering rated KVA at 0.8pf lagging

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

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

Solution

$S_r = 25\,KVA$, $V_L = 415V$, $3-\phi$, 4pole

$f = 60Hz$, $X_s = 1.5$ $R_a = 0$

$\cos\theta$, pf = 0.8 lagging

a.) $E_A = V_t + jX_s I_a + R_a I_a$

$= V_t + jX_s I_a$

$\cos\theta = 0.8$

$\theta = 36.87$

$V_L = 415$; $V_t = \frac{415}{\sqrt{3}} = 239.6\angle 0$

$$I_a = \frac{S_r}{\sqrt{3} \times V_t} = \frac{25 \times 10^3}{\sqrt{3} \times 415}$$

$$= 34.78 \angle -36.87$$

$$E_B = V_p + jX_2 I_a$$

$$= 239.6 \angle 0° + 1.5 \angle 90° \times 34.78 \angle -36.87$$

$$= 270.3 + j41.74$$

$$\therefore 270.3 + j41.7$$

$$\approx 273.51 \angle 8.7 V$$

b.) If I_f is increased by 20%, find I_R, pf and Q

i.) $I_R = \frac{E_{B_2} - V_t}{jX_2}$

$E_{B_2} = 1.2 \times E_B = 1.2 \times 273.5$

$= 328.2$

$I_R = \frac{328.2 \angle 7.47 - 239.6 \angle 0}{1.5 \angle 90°}$

$= 28.44 - j57.20$

$\approx 63.90 \angle -63.6° A$

$E_1 \sin\delta_1 = E_2 \sin\delta_2$

$\sin\delta_2 = \frac{E_1 \sin\delta_1}{E_2}$

$= \frac{273.5 \sin 8.76}{328.2}$

$\sin\delta_2 = 0.127$

$\delta_2 = \sin^{-1}(0.127)$

$\delta_2 = 7.47$

ii.) $pf = \cos\theta$

$\cos(-63.6)$

$= 0.4$ Lagging

iii.) $Q = \sqrt{3} \times V_t \times I_2 \times \sin\theta$

$\sqrt{3} \times 415 \times 63.90 \times \sin 63.6$

$= 41141.29$

$= 41.14$ KVAR

c.) i.) $I_a = \frac{E_{a_2} - V}{jX_2}$

Recall that its using the same condition as in (a)

$= \frac{273.51 \angle 90° - 239.6 \angle 0°}{1.5 \angle 90°}$

$= 182.34 + j159.73$

$I_{a_2} = 242.4 \angle 41.21$ A

ii.) $pf = \cos\theta$

$\cos(41.21)$

$= 0.75$ leading

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

$\sqrt{3} \times 415 \times 242.4 \times \sin 41.21$

114791.21

≈ 115 KVAR