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17/ENG04/038

Sheet 1 Sheet

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

a) Determine the excitation voltage E_A, when the machine is developing 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_s, 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 ~~Starth~~ slowly. What is the steady state limit? Determine the stator current, power factor and reactive power Q.

Solution:

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

$f = 60Hz, \quad X_s = 1.5 \quad R_s = 0$

Cosθ, p.f = 0.8 lagging

$$E_a = V_f + jX_s I_a + R_s I_a$$

$$= V_f + jX_s I_a$$

Cosθ = 0.8

$\theta = 36.87$

$V_L = 415 \quad V_f = \frac{415}{\sqrt{3}}$

$= 239.6 \angle 0$

?

$$I_a = \frac{S_r}{\sqrt{3} \times V_L} = \frac{2.5 \times 10^3}{\sqrt{3} \times 4.15}$$

$$= 34.78 \angle -36.87$$

$$E_s = V_p + jX_s I_a$$

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

$$= 270.3 + j41.76$$

$$= 273.51 \angle 8.7 V.$$

b If I_f is increased by 2%, find I_a, P.f. & ϕ

$$I_2 = \frac{E_2 - V}{jX_2}$$

$$I_a = \frac{E_{a_2} - V_L}{jX_a}$$

$$E_{a_2} = 1.2 \times E_a = 1.2 \times 273.5$$

$$= 328.2$$

$$I_a = \frac{328.2 \angle 7.47 - 239.6 \angle 0}{1.5 \angle 90^\circ}$$

$$= 28.44 - j57.20$$

$$= 63.90 \angle -63.6^\circ A$$

$$E_1 \sin s_1 = E_2 \sin s_2$$

$$\sin s_2 = \frac{E_1 \sin s_1}{E_2}$$

$$= \frac{273.5 \sin 8.76}{328.20}$$

$$\sin s_2 = 0.127$$

$$s_2 = \sin^{-1} 0.127$$

$$s_2 = 7.047.$$

ii) P.f = $\cos\phi$

$\cos(63.6)$

= 0.4 lagging

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

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

41141.29

41.4 KVAR

= 4.14 KVAR

c) $I_{A3} = \frac{E_{a3} - V}{j^{\circ} X_2}$

Since its using the same condition as in (a)

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

$= 182.34 + j^{\circ} 159.73$

$I_{a3} = 242.4 \angle 41.21^{\circ} A$

h) $P.f = \cos\phi$

$= \cos(41.21)$

$= 0.75$ leading

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

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

$= 114791.21$

≈ 115 KVAR