KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

ELECTRICAL ENGINEERING DEPARTMENT

EE 306 – Term 171

HW # 5: Synchronous Machines

Due Date:

UT Classes: December 10, 2017

MW Classes: December 11, 2017

Problem 1

A 9 kVA, 208 V, 1200 rpm, three phase, 60 Hz, Y-connected synchronous generator has a field winding resistance of 4.5 Ω and armature winding impedance of 0.3+j5Ω per phase. When the generator operates at its full load and 0.8 PF lagging, the field winding current is 5 A. The rotational loss is 500 W. Determine:

(a) The voltage regulation

(b) Efficiency

(c) The torque applied by the prime mover

Problem 2

A three phase, 14 kV, 10 MVA, 60 Hz, two pole, 0.85 PF lagging, star connected, synchronous generator has X_s= 20 Ω per phase and R_a= 2 Ω per phase. The generator is connected to an infinite bus.

(a) Determine the excitation voltage at the rated condition. Draw the phasor diagram for this condition.

(b) Determine the torque angle at the rated condition.

(c) If the field current is kept constant, determine the maximum power the generator can supply. Neglect R_a.

(d) For the condition in part (c), determine the generator current and the power factor. Draw the phasor diagram for this condition.

Problem 3

A three phase, 120 MVA, 12 kV, 60 Hz, two pole, 0.85 PF lagging, Y-connected steam turbine driven alternator(synchronous generator) has a stator resistance of R_a= 0.018 Ω and a synchronous reactance of X_s= 1.02 Ω. At full load (rated) condition, the efficiency is 92% (the field winding loss is neglected). At this condition, determine

(a) The synchronous speed
(b) The power loss in the armature resistance
(c) The rotational loss
(d) The torque applied to the shaft by the steam turbine prime mover

Problem 4

A 208-V Y-connected synchronous motor is drawing 40 A at unity power factor from a 208-V power system. The field current flowing under these conditions is 2.7 A. Its synchronous reactance is 0.8 Ω. Assume a linear open-circuit characteristic.
(a) Find the torque angle δ.
(b) How much field current would be required to make the motor operate at 0.8 PF leading?
(c) What is the new torque angle in part *(b)*?

Problem 5

A 480-V, 100-kW, 50-Hz, four-pole, Y-connected synchronous motor has a rated power factor of 0.85 leading. At full load, the efficiency is 91%. The armature resistance is 0.08 Ω, and the synchronous reactance is 1.0 Ω. Find the following quantities for this machine when it is operating at full load:

(a) Output torque
(b) Input power
(c) n_m (Mechanical speed of the machine)
(d) E_A

(e) $|I_A|$

(f) P_{conv}

(g) Rotational loss= $P_{mech} + P_{core} + P_{stray}$