MACHAKOS UNIVERSITY

University Examinations for 2019/2020Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

THIRD YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN ELECTRICAL AND ELECTRONICS ENGINEERING

EEE 315: ELECTRICAL MACHINES III

DATE: 26/11/2020 **TIME: 8.30-10.30 AM**

INSTRUCTIONS

Answer Question One and Any Other Two Questions

QUESTION ONE (30 MARKS) (COMPULSORY)

a) Give three applications of synchronous machines (3 marks)

b) Draw a complete well labelled per phase equivalent circuits with their corresponding phasor diagrams for both the synchronous motor and generator (8 marks)

c) What are the two methods which are normally used to start a synchronous motor? (2 marks)

d) The following tests results were obtained for a 3 phase, 25kV, 750MVA, 60Hz, 3600rpm, star-connected synchronous machine at rated speed.

$I_f(A)$	Open Circuit test (V_{L-L} (kV)	Air gap line (V_{L-L} (kV)	short circuit test I_a (A)
1500	25	30	10,000

Determine the number of poles of the synchronous machine (2 marks)

i. Determine the unsaturated and saturated values of the synchronous reactance in ohms and in per unit (8 marks)

ii. The short circuit test is performed at constant field current(1500A) but at different speeds-1000rpm, 2000rpm, 3000rpm, and 3600rpm, Determine the short-circuit current at these speeds (3 marks)

iii. Determine the field current if the synchronous machine delivers rated MVA to an infinite bus at 0.9 lagging power factor. (4 marks)

QUESTION TWO (20 MARKS)

The synchronous machine was operated as a synchronous motor from 3phase, 208V, 60Hz power supply. The field excitation is adjusted so that the power factor is unity when the machine draws 3kW from the supply. (12 marks)

a) Find the excitation voltage and the power angle. Draw the phasor diagram for this condition.

b) If the field excitation is held constant and the shaft load is slowly increased, determine the maximum torque, (i,e, the pull out torque) that the motor can deliver. (8 marks)

QUESTION THREE (20 MARKS)

a) A 3Ø, 5MVA, 11kV, 60Hz synchronous machine has a synchronous reactance of 10 ohms per phase and a negligible stator resistance. The machine is connected to the 11kV, 60Hz bus and is operated as a synchronous condenser.

Neglect rotational losses.

i. For normal excitation, find the stator current, Draw the phasor diagram (4 marks)

ii. If the excitation is increased by 150 percent if the normal excitation, find the stator current and power factor, Draw the phasor diagram. (4 marks)

iii. If the excitation is decreased to 50 per cent of the normal excitation, find the stator current and power factor, draw the phasor diagram. (4 marks)

b) If the rotational losses are 80kW, find the stator current and excitation voltage for a normal excitation, Draw the phasor diagrams. (8 marks)

QUESTION FOUR (20 MARKS)

A 3Ø, 5kVA, 208V, four pole, 60 Hz, star connected synchronous machine has a negligible stator winding resistance and a synchronous reactance of 8 ohms per phase at the rated terminal voltage.

The machine is first operated as a generator in parallel with a 3Ø,208V, 60Hz supply.

a) Determine the excitation voltage and the power angle when the machine is delivering rated kVA at 0.8pf lagging. Draw the phasor diagram for this condition. (6 marks)

b) If the filed excitation current is now increased by 20 percent (without changing the prime mover power), find the stator current, power factor, and reactive kVA Supplied by the machine. (10 marks)

c) With the field current as in (i) the prime mover is slowly increased. What us the steady-state (or static) stability limit? Power factor, and reactive power at this maximum power transfer condition**?** (4 marks)

QUESTION FIVE (20 MARKS)

A 3phase, 2000kVA, 11kV, 1800rpm synchronous generator has a resistance of 1.5ohms and a synchronous reactance of 15 ohms per phase

a) The field current is adjusted to obtain the rated terminal voltage at open circuit.

i. Determine the excitation voltage (E_f). (2 marks)

ii. If a short circuit is applied across the machine terminals, find the stator current. . (2 marks)

b) The synchronous machine is next to connected to an infinite bus. The generator is made to deliver the rated current at 0.8 power factor lagging.

i) Determine the excitation current (E_f) (2 marks)

ii) Determine the percentage increase in the field current relative to the field current in part (a) (2 marks)

iii) Determine the maximum power the synchronous machine can deliver for the excitation current of part (b). Neglect (R_a) (2 marks)

c) In a factory, a 3phase, 4kV 400kVA synchronous machine is installed along with other induction motors. The following are the loads on the machines:

Induction motor: 500kVA at 0.8 PF lagging

Synchronous motor: 300kVA at 1.0 PF

i. Compute the overall power factor of the factory' (4 marks)

ii. To improve the factory pf, the synchronous machine is over-excited (to draw leading current) without change in its load. Without overloading the motor, to what extent can the factory pf be improved? Find the current and power factor of the synchronous motor for this condition.

(6 marks)