PP1

TECHNICAL UNIVERSITY OF MOMBASA

Faculty of Engineering and Technology

DEPARTMENT OF ELECTRICAL & ELECTRONIC ENGINEERING

UNIVERSITY EXAMINATIONS FOR THE DEGREE OF BACHELOR OF SCIENCE IN ELECTRICAL & ELECTRONIC ENGINEERING

EEE 4405: ELECTRICAL MACHINE III

TIME: 2 HOURS SERIES AUGUST, 2024

INSTRUCTIONS TO CANDIDATES

1. You are required to have the following for this examination;
   - Answer Booklet
   - A Non- Programmable Scientific Calculator

2. This paper consists of **FIVE** Questions.
3. Answer Question **ONE** is **COMPULSORY** and any other **TWO** Questions
4. This paper consists of **FIVE** printed pages.

Question 1 (30 marks) (Compulsory)

(a) Explain the following with regard to Synchronous Machines;
   (i) Why is the knowledge of Voltage regulator important in a synchronous generator.
   (ii) The function of damper winding
   (iii) Why are generator is rated in kVA.

(7 marks)

(b) A 450-Volt, 50 Hz, Δ connected, 4 pole, 3-phase synchronous generator has direct axis reactance of 0.15Ω and quadrature axis reactance of 0.07Ω. Its armature resistance may be neglected. At full load the generator supplies 150A at a power factor of 0.8 lagging. Determine:

(i) The internal generated voltage E_A of this generator at full load, assuming that it has cylindrical rotor reactance is X_d.

(ii) the generated internal voltage E_A of this generator at full load assuming that it has a salient pole rotor.

(7 marks)

(c) (i)With the aid of diagram(s) and graph(s) describe how you can determine the voltage regualation of synchronous machine using the OCC and SCC Characteristics.

(ii)

A 20 kVA, 11000V, 3 phase, star-connected synchronous generator running on constant voltage, constant frequency busbars has a resistance of 0.06 Ω/phase and a synchronous reactance of 1.8 Ω/phase. If excited to give a terminal voltage of 13000V on open circuit Determine its maximum possible output power.

(10 marks)

(d) A 3-phase, 10kVA, 400V, 50Hz, Y-connected alternator supplies the rated load of 0.8pf lagging. If the armature resistance is 0.5Ω/phase and synchronous reactance is 10 Ω/phase Determine;

(i) Voltage Regulation

(ii) Power angle.

(6 marks)

QUESTION TWO [20 MARKS]

(a) Show that power developed in a Salient Pole Synchronous Generator is given by

$$P_d = \frac{E_0 V}{X_d}\sin\delta + \frac{V^2 (X_d - X_q)}{2 X_d X_q}\sin 2\delta \quad \text{per phase}$$

(12 marks)

(b) A 3-phase, Y-Connected synchronous generator supplies a current of 10A having phase angle of 20^0 lagging at 400V (Phase Voltage). Determine;

(i) The load angle

(ii) Components I_d and I_q of armature current

(iii) Voltage Regulation

Given X_d =10Ω and X_q = 6.5 Ω

(8 marks)

QUESTION THREE [20 MARKS]

(a) State any FOUR advantages of paralleling of Alternators **(4 Marks)**

(b) Figure Q3(b). Two 3-phase, star connected alternators 1 and 2 supply a total of 18MVA at 0.7 lagging p.f. at a line voltage of 6.6kVThe two alternators are rated at 10MVA, 6. 6 kV. The machine 1 is operating on full-load at 0.8 lagging power factor Determine:
(I) The current supplied by machine 2.
(II)Operating pf of Machine 2
(III)Power delivered by each machine. **(7Marks)**

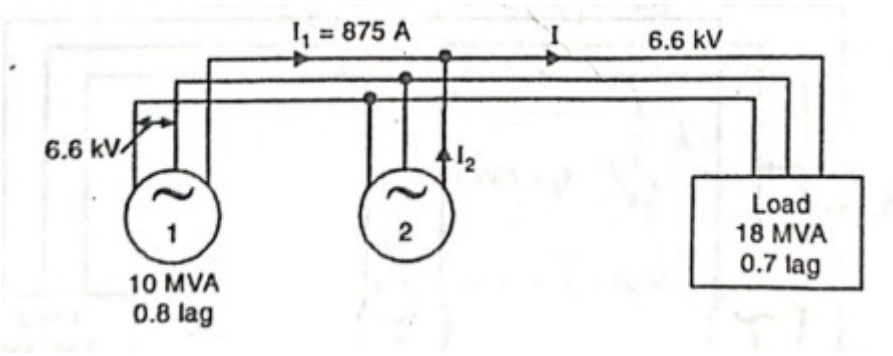

Figure Q3(b).

(c) A 3.5MVA, Y-Connected alternator rated at 4160 Volts at 50Hz has open circuit characteristics given by the following the data in Table Q3(c). A field current of 200A is found necessary to circulate full-load current on short-circuit of the alternator. Calculate by;

(i) By synchronous impedance method and

(ii) Ampere-turn method the full-load voltage regulation at 0.8pf lagging
Neglect armature resistance **(9 marks)**

Table Q3(c)

Field Current (Amps)	**50**	**100**	**150**	**200**	**250**	**300**	**350**	**400**
Line EMF (Volts)	**1620**	**3150**	**4160**	**4750**	**5130**	**5370**	**5550**	**5650**

QUESTION FOUR [20 MARKS]

(a) State the Four Conditions for synchronizing a synchronous generator. **(4 marks)**

(b) Show that the per phase value of Synchronizing Power when two alternators operate in parallel at no-load is given by (**8 marks)**

$$P_{sy} = \frac{\alpha E^2}{2 X_s}$$

(c) A 5.5MVA, 50Hz, 3-phase synchronous generator having a synchronous reactance of 0.3p.u. is running at 1500 r.p.m and is excited to give 11KV. If the rotor deviates slightly from its equilibrium position. Determine the synchronizing torque in N-m per degree mechanical displacement. **(8 marks)**

QUESTION FIVE [20 MARKS]

(a) With the aid of phasor diagram explain the following;
(i) Effect of change of field excitation.
(ii) Effect of change in Mechanical Output

(8marks)

(b) Explain the function of a damper winding in a synchronous generator.

(4 marks)

(c) Two alternators A and B operate in parallel and supply a load of 8MW at 0.8 p.f. lagging. The power output of A is adjusted to 5000KW by changing its steam supply and its p.f. is adjusted to 0.9 lagging by changing its excitation. Determine the p.f. of alternator B. **(8 marks)**