UNAM
UNIVERSITY OF NAMIBIA

SCHOOL	ENGINEERING AND THE BUILT ENVIRONMENT
DEPARTMENT	ELECTRICAL AND COMPUTER ENGINEERING
SUBJECT	ELECTRICAL MACHINES II/ELECTRICAL MACHINES ANALYSIS AND DESIGN
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DURATION	3 HRS — **MARKS**: 100

First Opportunity Examination

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This question paper consists of **3** pages excluding this front page.

Instructions

1. Closed book examination.
2. Read the questions carefully
3. Answer **ALL the 5 questions**
4. Marks for each question are indicated
5. Start each question on a fresh paper
6. Additional materials: None

QUESTION 1 [20]

1.1 How do the synchronizing lamps indicate the correctness of phase sequence between existing and incoming Alternators? **[3]**

1.2 A 3-Phase, 5 kVA, 208 V, four-pole, 60 Hz, star-connected synchronous machine has negligible stator winding resistance and a synchronous reactance of 8 ohms per phase at rated terminal voltage. The machine is first operated as a generator in parallel with a 3- Phase, 208 V, 60 Hz power supply.

1.2.1 Determine the excitation voltage and the power angle when the machine is delivering rated kVA at 0.8 PF lagging. Draw the phasor diagram for this condition. **[7]**

1.2.2 If the field 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. **[7]**

1.2.3 With the field current as in (a), the prime mover power is slowly increased. What is the steady-state (or static) stability limit? What are the corresponding values of the stator (or armature) current and power factor at this maximum power transfer condition? **[3]**

QUESTION 2 [20]

2.1 During the preliminary design of a 270 kW, 3600 volts, 3 phase, 8 pole 50 Hz slip ring induction motor the following design data have been obtained: Gross length of the stator core = 0.38 m, Internal diameter of the stator = 0.67 m, Outer diameter of the stator = 0.86 m, No. of stator slots = 96, No. of conductors /slot = 12, Efficiency = 91%, Full load power factor of 0.89, K_W = 0.955. Based on the above information determine flux per pole for the motor. **[4]**

2.2 A generating station for a power system consists of four 120-MVA, 15-kV, 0.85-PFlagging synchronous generators with identical speed droop characteristics operating in parallel. The governors on the generators' prime movers are adjusted to produce a 3-Hz drop from no load to full load. Three of these generators are each supplying a steady 75- MW at a frequency of 60-Hz, while the fourth generator (called the swing generator) handles all incremental load changes on the system while maintaining the system's frequency at 60-Hz.

2.2.1 At a given instant, the total system loads are 260 MW at a frequency of 60 Hz. What are the no-load frequencies of each of the system's generators? **[7]**

2.2.2 If the system load rises to 290 MW and the generator's governor set points do not change, what will the new system frequency be? **[2]**

2.2.3 To what frequency must the no-load frequency of the swing generator be adjusted in order to restore the system frequency to 60 Hz? **[4]**

2.2.4 If the system is operating at the conditions described in **Q. 2.2.3,** what would happen if the swing generator were tripped off the line (disconnected from the power line)? **[3]**

QUESTION 3 [20]

3.1 What is the effect on speed if the load is increased on a 3-phase synchronous motor? **[2]**

3.2 What happens when the field current of a synchronous motor is increased beyond the normal value at constant input? **[3]**

3.3 A three- phase 1MVA, 2300 V, 60 Hz 8-pole synchronous machine has negligible stator resistance and synchronous reactance of 1.25 Ω at rated terminal voltage. The machine is connected to an infinite bus and runs at 95% efficiency at rated speed. Determine

3.3.1 The synchronous reactance X_S in p.u. **[3]**

3.3.2 The excitation voltage and power angle when machine operates as synchronous motor at 0.85 power factor lagging and deliver 373 kW. **[5]**

3.3.3 The field current is now reduced by 40%, keeping the power output the same as in **Q. 3.3.2**. Find the stator current and power factor **[7]**

QUESTION 4 [20]

4.1 Explain why transformers connected in parallel should have:

4.1.1 Same Line Voltages **[2]**

4.1.2 Almost same leakage reactance **[2]**

4.2 A 2 MVA three-phase, 33/6.6 kV, delta/star transformer has a primary resistance of 8 Ω per phase and a secondary resistance of 0.08 ohm per phase. The percentage impedance is 7%. Calculate the secondary terminal voltage, regulation and efficiency at full load and 0.75 power factor lagging when the iron losses are 15 kW **[16]**

QUESTION 5 [20]

5.1 Choice of Power factor and Efficiency plays very important role in design of Induction Motors. State **FOUR (4)** factors you will consider in determining the right Power factor and Efficiency when designing Induction Motors **[4]**

5.2 Explain the importance of adhering to standard specifications in design of electric machines **[4]**

5.3 Determine the main dimensions of the core, the number of turns and cross-sectional area of the conductors in the primary and secondary windings of a 100 kVA, 2200/ 480 V, 1-Phase, 50 Hz, core type transformer, Assume: Volt / turn = 7.5, maximum flux density = 1.2 T. Ratio of effective cross— sectional area-of the core to square of diameter of circumscribing circle, window space factor = 0.28 window proportion = 2 :1, current density = 2.5A/mm^2 **[12]**

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