B.Sc. in EEE, 4th Semester
DTE. 2nd Semester

May 15, 2024

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ISLAMIC UNIVERSITY OF TECHNOLOGY (IUT)
ORGANISATION OF ISLAMIC COOPERATION (OIC)
**DEPARTMENT OF ELECTRICAL AND ELECTRONIC ENGINEERING**

Semester Final Examination
Course No.: EEE 4405 / EEE 4491
Course Title: Energy Conversion II

Summer Semester, A. Y. 2022-2023
Time: 3 Hours
Full Marks: 150

There are **6 (six)** questions. Answer all **6 (six)** questions. The symbols have their usual meanings. Programmable calculators are not allowed. Marks of each question and corresponding COs and POs are written in the brackets.

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1. Answer the following questions in brief: **25 (CO1, PO1)**
   i. Explain the process by which the rotating magnetic field in a three-phase induction motor leads to the creation of torque in the rotor.
   ii. For a fixed load, if you increase the supply voltage of a three phase induction motor, show the changes in synchronous speed and the rotor speed. Show the effect using a typical torque-speed characteristics curve.
   iii. Discuss various starting methods used for three-phase induction motors and how they mitigate the impact of high starting currents.
   iv. Explain the function of a centrifugal starting switch in a single-phase capacitor start capacitor run induction motor.
   v. For a single phase split-phase motor, the auxiliary winding is designed to have higher resistance/reactance $(R_A / X_A)$ ratio than the main winding $(R_M / X_M)$. State the process of accomplishing this in the motor industries.

2. a) i. Briefly explain the difference between "full-load" and "over-load" of a motor. **14 (CO1, PO1)**
   ii. Explain the possibility of getting load angle (δ) equals to zero for a synchronous motor.
   iii. Describe the available methods of starting a synchronous motor.
   iv. Sketch the equivalent circuit of a synchronous motor. Hence draw the phasor diagram under no-load condition.
   v. Suppose a synchronous motor with damper winding is running without any mechanical load. Under running condition, explain the behavior of the motor if the field supply is disconnected under running condition.
   vi. Clearly show all possible changes in supply current, real power consumption, reactive power consumption using different phasor diagrams if the load of the synchronous motor is increased,

   b) A 200 kVA, 480 V, 50 Hz, Y-connected synchronous generator with a rated field current of 5 A was tested, and the following data were taken: **11 (CO2, PO2)**
   i. $V_{T,OC}$ at the rated $I_F$ was measured to be 540 V.
   ii. $I_{L,SC}$ at the rated $I_F$ was found to be 300 A.
   iii. When a dc voltage of 10 V was applied to two of the terminals, a current of 25 A was measured.

   Find the synchronous reactance that would be used in generator model at the rated condition.

3. a) Answer the following questions in brief: **12 (CO1, PO1)**
   i. Briefly explain the "synchronous condenser" and how it can be used for improving the power factor?
   ii. Show the effect of load in the "V-curve" of a synchronous motor.

iii. A synchronous motor operates at leading power factor. If you increase the field current, show the changes in real power consumption, reactive power consumption and power factor of the motor using phasor diagram.

b) A 208 V, Y-connected synchronous motor is drawing 40 A at unity power factor from a 208 V power system. The field current under these conditions is 2.7 A. Its synchronous reactance is 0.8 Ω. **13 (CO2, PO2)**

i. Find the load angle δ.
ii. Find the value of field current that would be required to make the motor operate at 0.8 pf leading.
iii. Find the value of new torque angle.

4. a) Describe the conditions of parallel operation of alternators. Discuss the advantages of parallel operation of alternators. **10 (CO1, PO1)**

b) Explain the necessity of taking the frequency of the incoming generator a bit higher than the operating frequency while going for the parallel operation of alternators. State if there any problem if you take the frequency a bit lower. Explain using necessary house diagrams. **10 (CO1, PO1)**

c) i. Briefly explain the difference between "full-load" and "over-load" of a synchronous generator. **05 (CO1, PO1)**
ii. Explain the possibility of getting load angle (δ) equals to zero for a synchronous motor.

5. a) Suppose two generators of IUT: generator 1 and generator 2 are operating in parallel under a certain electrical load (both real load and reactive load are present). Initially both the generators were sharing the load equally. Show the effects of the generators using 'house diagram' for the following cases: **15 (CO2, PO2)**

i. only the real power consumption is increased,
ii. only the reactive power consumption is increased,
iii. the mechanical torque of the generator 1 is increased,
iv. the field excitation of the generator 2 is increased and
v. the field excitations of both the generators are increased.

b) A synchronous generator is operating alone. Show the effects of an increase in generator loads at constant power factor upon the terminal voltage change for the following loading cases: **10 (CO2, PO2)**

i. loads with lagging power factor,
ii. loads with unity power factor and
iii. loads with leading power factor.

Sketch the vector diagram, if all loads are removed from the above mentioned generator.

6. a) Suppose that you are an engineer planning a new electric co-generation facility for a plant with excess process steam. You have a choice of either two 10 MW turbine generators or a single 20 MW turbine-generator. Design the new electric co-generation facility for a plant with excess process steam considering the choices mentioned. Explain the advantages and disadvantages of each choice. **12 (CO3, PO3)**

b) For a fixed mechanical input to the rotor shaft of a generator, if the load that takes real power is increased the speed of the rotor is decreased. Explain the reason for this behavior. **13 (CO1, PO1)**