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

May 04, 2023

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. 2021-2022
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.

---

1. a) Answer the following questions in brief: **17.5 (CO1, PO1)**
   i. Sketch the single phase induction motor torque-speed characteristic curve.
   ii. Sketch the torque speed curve of shaded pole motor.
   iii. State the type of the single phase induction motor system that has the highest starting torque.
   iv. Explain the function of a centrifugal starting switch in a single-phase capacitor start capacitor run induction motor.
   v. State three ways to control speed of Single Phase induction Motor.
   vi. Compare between capacitor start induction run motor and capacitor start capacitor run motor.
   vii. Explain the behavior of the rotor speed using the "Torque-Speed characteristics curve" if you increase the supply frequency of a capacitor start-induction-run motor.

   b) A single-phase, induction motor has stator windings in space quadrature and is supplied with a single-phase voltage of 200 V at 50 Hz. The standstill impedance of the main winding is (5.2 + j10.1) ohm and of the auxiliary winding is (19.7 + j14.2) ohm. Find the value of capacitance to be inserted in the auxiliary winding for maximum starting torque. **7.5 (CO2, PO2)**

2. a) Answer the following questions in brief: **14 (CO1, PO1)**
   (i) Explain the phenomenon when a large load is connected suddenly to a 3 phase induction motor.
   (ii) How can you reverse the direction of a three-phase induction motor?
   (iii) Give two advantages of a wound-rotor motor over a squirrel-cage motor.
   (iv) Explain "Electrical Braking System" of a 3-phase induction motor.
   (v) Show the behavior of a 3-phase induction motor if the slip-ring connection of wound rotor is kept open and a 3-phase supply is given to the stator. Explain the behavior for both standstill and running conditions.
   (vi) Explain the behavior of a 3-phase induction motor if a 3-phase induction motor is switched on with one phase disconnected. Justify your answer.
   (vii) Show changes in starting current and running current for a 3-phase induction motor, if the rotor resistance (R_2) is increased.

   b) A 208 V, three phase, twelve-pole, 50 Hz induction motor is running at a slip of 0.03. **11 (CO2, PO2)**
   (i) Find the synchronous speed of this motor.
   (ii) Find the rotor speed of this motor at the full-load.
   (iii) Find the rotor current frequency of this motor at the full-load.

(iv) Find the stator current frequency of this motor at the starting of the motor.
(v) Find the stator current frequency of this motor at the full load.
(vi) Calculate the synchronous speed if the supply frequency is changed to 60
(vii) If the direction of the synchronous speed is reversed when the rotor is running at the full load, calculate the value of slip at that instance.

3. a) (i) State any two important characteristic of a 3 phase synchronous motor not found in 3 phase induction motor. **12 (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) Draw 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 behavor 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: **13 (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.

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. Is there any problem if you take the frequency a bit lower? Explain using necessary diagrams. **10 (CO1, PO1)**

5. a) Suppose a Generator is synchronized with an infinite bus system and sharing a certain amount of electrical load (both real load and reactive load are present). The frequency of the infinite bus is 50 Hz. Draw the 'house diagram' to represent this system. Show the effects of the generator and the infinite bus using 'house diagram' for the following cases: **15 (CO2, PO2)**

(i) the mechanical torque of the Generator is increased,
(ii) the field excitation of the Generator is increased,
(iii) only the real power consumption is increased,
(iv) only the reactive power consumption is increased and
(v) the input mechanical torque is stopped.

b) 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). Consider a situation when generator 1 has a no-load frequency of 51.5 Hz and a slope S_{p1} of 1 MW/Hz and generator 2 has a no-load frequency of 51.0 Hz and a slope S_{p2} of 1 MW/Hz. The two generators are supplying a real load totaling 2.5 MW at 0.8 pf lagging. The resulting system house diagram is shown in Fig. 5.b. **15 (CO2, PO2)**

(i) Find the operating frequency of the system and power supplied by each of the two generators.

(ii) Suppose an additional 1-MW load is attached to this power system. Find the new system frequency, and the real power supplied by generator 1 and generator 2.

(iii) With the system in the configuration described in (ii), find the system frequency and generator power if the governor set points of generator 2 are increased by 0.5 Hz.

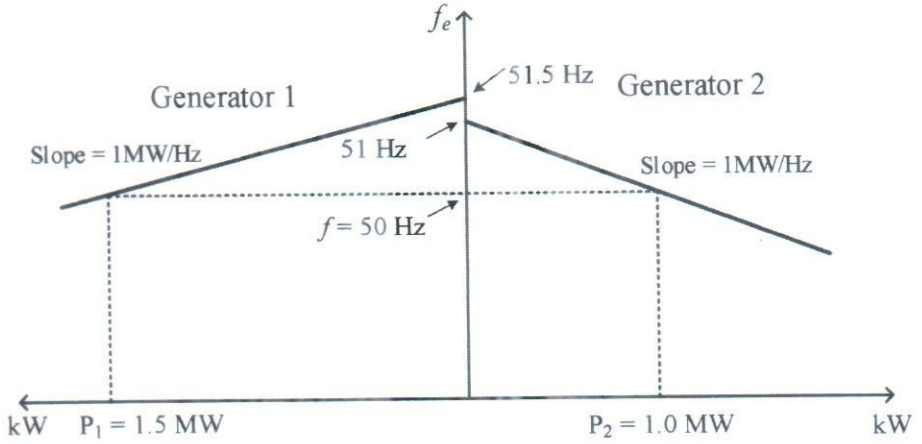

Fig. 5.b

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)**