B.Sc. in ME and IPE, 2nd Semester

May 08, 2023

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

Semester Final Examination
Course No.: EEE 4281
Course Title: Electrical Circuits and Electrical Machines

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.

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1. a) Design RC circuits that provide θ (phase angle in degree and $0 < \theta < 90$ degree)) leading and lagging phase shifts and justify the answer. **12 (CO2, PO2)**

   b) Determine the phasor currents I_1 and I_2 in the given magnetically coupled circuit in Fig. 1. **13 (CO3, PO2)**

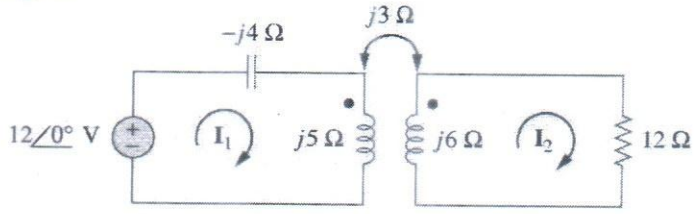

Fig. 1

2. a) With appropriate sketches, illustrate the functionality of the commutator as a mechanical rectifier to obtain DC output from a DC generator. **12 (CO5, PO2)**

   b) A shunt-type DC generator delivers 450 A current at 230 V and the resistance of the shunt field and armature are 50 Ω and 0.03 Ω, respectively as shown in Fig. 2. Calculate the generated EMF. **13 (CO5, PO2)**

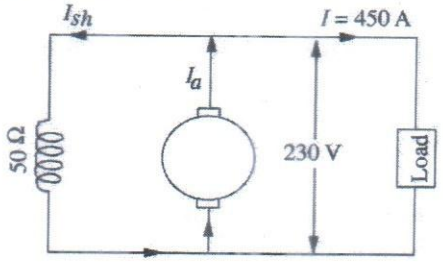

Fig. 2

3. a) Deduce the formula of developed armature torque in a DC motor. **12 (CO5, PO2)**

   b) Discuss the different speed control methods for a shunt-type DC motor. With necessary justifications, distinguish the most preferred to the least preferred method in terms of: **13 (CO5, PO2)**
   - i. Effect of variation of flux,
   - ii. Effect of armature reaction,
   - iii. Associated power loss due to the application of a speed control method,
   - iv. Obtaining maximum speed compared to rated speed,
   - v. Cost of the system.

4. a) Sketch the simplified equivalent circuit of a loaded transformer (either inductive or capacitive load). Design and formulate current, voltage, and impedances for the followings: **12 (CO5, PO2)**
   i. The equivalent circuit is referred to primary.
   ii. The equivalent circuit is referred to secondary.

   b) A 30 kVA, 2400V/120V, 50 Hz transformer has a high voltage winding resistance of 0.1 Ω and a leakage reactance of 0.22 Ω. The low voltage winding resistance is 0.035 Ω and the leakage reactance of 0.012 Ω. Calculate the equivalent winding resistance, reactance, and impedances referred to the high voltage side and low voltage side, respectively. **13 (CO5, PO2)**

5. a) Formulate the relationship between the maximum rotor-torque and synchronous speed of an induction motor under running conditions. **12 (CO5, PO2)**

   b) A 3-phase induction motor is wound for 4 poles and is supplied from a 50 Hz system. Calculate the followings: **13 (CO5, PO2)**
   i. The synchronous speed,
   ii. the speed of the motor when slip is 4%,
   iii. the rotor current frequency when the motor runs at 600 r.p.m.

6. a) Answer the following questions in brief: **12 (CO5, PO2)**
   i. Discuss the basic difference between an alternator and a generator.
   ii. Write down the parallel operation of the alternator with advantages.
   iii. Distinguish the key difference between the alternator and synchronous motor.
   iv. Show the effect of load in the "V-curve" of an alternator.

   b) i. Formulate the power output equation of a cylindrical rotor-type synchronous generator: **13 (CO5, PO2)**

$$P = \left[\frac{EV}{Z_s}\cos(\delta - \theta) - \frac{V^2}{Z_s}\cos\theta\right]$$

Where, P, E, V, Z_s, δ and θ have their definition for synchronous generator operation.

   ii. From the power output equation above, derive maximum power output equations using derivative and approximation methods.