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 Machine

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

   b) Determine the total impedance (Z_T), source current (I_s), voltages (V_R, V_C) and current across the capacitor (I_C) in the given R-L-C circuit in Fig. 1. **13** **(CO3, PO2)**

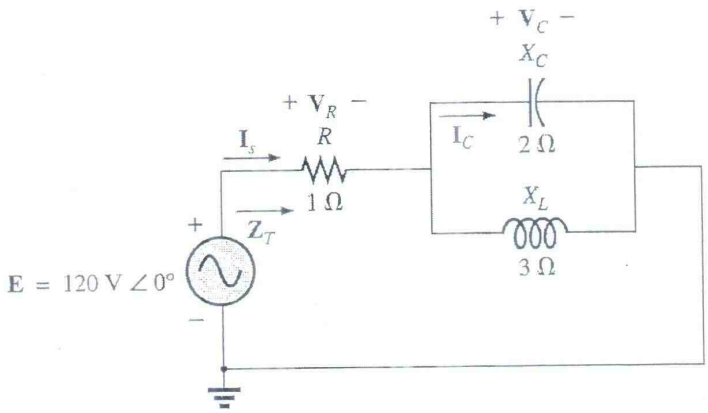

Fig. 1

2. a) Discuss different power stages in DC generators and the conditions to achieve maximum power efficiency in a DC generator. **12** **(CO5, PO2)**

   b) A shunt-type DC generator delivers 195 A current at 250 V. The armature resistance and shunt field resistances are 0.02 Ω and 50 Ω, respectively. The stray losses are equal to 950 W. Determine the following: **13** **(CO5, PO2)**

   i) Electromotive force (E.M.F.) generated.
   ii) Copper (Cu) losses.
   iii) Output power of the DC generator.
   iv) Commercial, mechanical, and electrical efficiencies.

3. a) 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: **12 (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.

   b) A 4-pole, 240 V, wave-connected shunt motor gives 1119 kW when running at 1000 r.p.m. and armature current (I_a) and field currents (I_f) of 50 A and 1.0 A respectively. The motor has 540 conductors with total resistance (R_a) of 0.1 Ω. Assuming a drop of 1 volt per brush, and back E.M.F. is E_b, find **13 (CO5, PO2)**

   (i) Armature torque ($T_a = 9.55 \cdot \frac{E_b I_a}{N}$),
   (ii) Useful flux/pole (ϕ),
   (iii) Rotational losses,
   (iv) Efficiency.

4. a) Explain the simplified equivalent circuit of a loaded transformer (either inductive or capacitive load). Design and formulate current, voltage, and impedances for the following: **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) Define the starting torque of an induction motor. Formulate the relationship between the starting torque and synchronous speed of an induction motor under standstill conditions. **12 (CO5, PO2)**

b) An 8-pole, 3-phase, 50 Hz induction motor has a rotor resistance of 0.025 Ω per phase and a rotor standstill reactance of 0.1 Ω per phase. At what speed is the torque maximum? Evaluate the proportion of maximum torque to the starting torque. **13 (CO5, PO2)**

6. a) Explain the following questions in brief: **12 (CO5, PO2)**

i) The basic difference between an alternator and a generator.

ii) The parallel operation of the alternator with advantages.

iii) Differences between the alternator and synchronous motor.

iv) 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.