Total number of printed pages–5

53 (IE 401) ELMC

2021

ELECTRICAL MACHINES

Paper : IE 401

Full Marks : 100

Time : Three hours

The figures in the margin indicate full marks for the questions.

*Answer **any five** questions.*

1. *(a)* Define a transformer. How is the energy transferred from one circuit to another ? 5

(b) Draw and explain the no-load phasor diagram of a single-phase transformer. 5

(c) A 100 *kVA*, 2400/240 *V*, 50 *Hz* single-phase transformer has an exciting current of 0·64 *A* and a core loss of 700 watts, when its high-voltage side is energised at rated voltage and frequency. Calculate the two components of exciting current. 10

Contd.

2. *(a)* Why is iron used for the construction of transformer core? 5

(b) Describe briefly the various losses in a transformer and explain how each loss varies with the load current. 5

(c) A 5 *kVA*, 1000/200 *V*, 50 *Hz* single-phase transformer gave the following test results:

Open-circuit test (low voltage side): 200 *V*, 1·5 *A*, 90 *W*

Short-circuit test (high voltage side): 50 *V*, 5 *A*, 110 *W*.

Compute the parameters of the approximate equivalent circuit referred to low voltage side. 10

3. *(a)* Draw neat diagram of a 4-pole DC machine. Label all its parts. 5

(b) Derive an expression for the e.m.f. generated in a DC machine. 5

(c) A DC shunt generator gives an open circuit voltage of 240 *V*. When loaded, the terminal voltage falls to 220 *V*. Determine the load current in case, armature-circuit and field winding resistances are 0·1Ω and 50Ω respectively. Neglect the effect of armature reaction. 10

4. *(a)* Discuss the points of similarities between a transformer and an induction machine. 5

(b) Explain the terms air-gap power P_g, internal mechanical power developed P_m and shaft power P_{sh}. 5

(c) A 3-phase, 50 *Hz* induction motor has a full-load speed of 960 *rpm*. Calculate :

(i) Number of the poles

(ii) Slip frequency

(iii) Speed of rotor field with respect to the rotor structure

(iv) Speed of rotor field with respect to stator field.

10

5. *(a)* Draw the circuit diagrams of the following types of motors showing proper direction of currents. Also write the definition for each type within three sentences.

(i) DC shunt motor

(ii) DC series motor

(iii) Long Shunt Compound Motor

(iv) Short Shunt Compound Motor.

10

(b) A 220 V shunt motor takes 105 A. The armature resistance is 0·08 Ω and shunt field resistance is 44 Ω. The motor runs at 950 *rpm*. If iron and friction losses are equal to 2 kW, find —

(i) BHP

(ii) Total torque

(iii) Shaft torque. 10

6. (a) Draw the circuit and phasor diagrams for the following single-phase motors :

(i) Split-phase motor

(ii) Capacitor start motor.

Also write *two* important industrial applications for these motors. 10

(b) At starting, the windings of a 230 V, 50 Hz split phase induction motor have the following parameters :

Main winding : $R = 4\Omega$, $X_L = 7{\cdot}5\Omega$

Starting winding : $R = 7{\cdot}5\Omega$, $X_L = 4\Omega$

Find — *(i)* Current I_m in the main winding *(ii)* Current I_s in the starting winding *(iii)* Phase angle between I_s and I_m *(iv)* Line current and *(v)* Power factor of the motor. 10

7. *(a)* Draw the equivalent circuit and phasor diagram of a loaded alternator. Write the relevant voltage equations from the equivalent circuit. 10

(b) A 1000 kVA, 2300 V, 3–ϕ, star-connected alternator has a resistance of 0·309 Ω / phase. and a synchronous reactance of 3·31 Ω / phase. Calculate the change of line voltage when the rated output of 1000 kVA at power factor of 0·8 lagging is switched off. Assume the speed and the exciting current to remain unaltered. 10