

ELECTRICAL MACHINE - I

Full Marks - 70

Time : 3 Hours

*The figures in the right-hand margin indicate marks.*

*Answer Question No. 1 which is compulsory and any five from the rest.*

IWL

1. Answer the following : 2×10
- (a) A 6-pole d.c. generator has 300 conductors and e.m.f. induced per conductor = 5V. What is the generator voltage, if it is (i) lap wound (ii) triplexwave - wound.
- (b) What is the mechanical power delivered by a motor running at 1000r.p.m, if the developed torque is 40 N.m ?

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- (c) Find the cross-magnetizing ampere-turns per pole of 4-pole wave-wound generator with 722 conductors delivering 100A on full load and brush lead of  $8^\circ$ .
- (d) Draw the torque-speed and torque-current characteristics of d.c. shunt motor.
- (e) Why a dc. series motor is used to start heavy loads ?
- (f) What is the magnetizing current of a 230/2300 Volts transformer if the no load current is 5A at 0.25 power factor lagging ?
- (g) Determine the saving of copper, if 2000/200 Volt single winding transformer is converted to an autotransformer having the same output and voltage transformation ratio.
- (h) An 3-phase alternator has 9 slots/pole. If the coil spans 7 slot pitches, what are pitch and

distribution factors for fundamental and third harmonic voltage ?

- (i) Explain the significance of Potier reactance in a synchronous alternator and how it is determined ?
- (j) If a field excitation of 10A in a certain alternator gives a current of 150A on short-circuit and terminal voltage of 900V/phase on open circuit, what is the terminal voltage, when the load current is 60A ?

2. (a) A 6-pole lap wound d.c. generator has 100 slots and each coil has 3 turns. The useful flux/pole is 0.02 Wb.

Calculate.

- (i) the speed at which, the generator must be run to generate 300V.
- (ii) what would be the speed if the generator is wave-wound ?

5



(b) A d.c. shunt generator gave the following open-circuit characteristic when driven at 750 r.p.m.

|                   |     |    |     |     |     |
|-------------------|-----|----|-----|-----|-----|
| Field current (A) | 0.5 | 1  | 1.5 | 2   | 2.5 |
| E.M.F. (V)        | 50  | 84 | 105 | 120 | 131 |

What is the critical value of shunt field resistance ? 5

3. (a) Two shunt generators running in parallel supply a total load current of 3000A. Generator 1 : armature resistance  $r_a = 0.05 \Omega$ , field resistance  $R_f = 30 \Omega$ , Generator  $r_a = 0.03 \Omega$ ,  $R_f = 25 \Omega$ . The induced e.m.fs are 400V and 380V, respectively. Calculate :

- current supplied by each generator
- KW output of each generator. 5

(b) A d.c. series motor takes 20A at 100V and runs at 950 r.p.m. Armature resistance is  $0.05 \Omega$  and series field resistance is  $0.2 \Omega$ .

At what speed will it run developing same torque but with a  $10 \Omega$  resistance placed in parallel with the armature ?  $\phi \propto I_f$  5

4. (a) A 200 KVA, 2000/440V, 50 Hz single-phase transformer gave the following test results :

O.C. test : 2000V, 1.8 A 1.75KW on H.V. side

S.C. test : 13V, 300A 1 KW on L.V. side

- Obtain the equivalent circuit as referred to H.V. side.
- find the secondary voltage and efficiency if it delivers full load at 0.8 p.f. lagging. 7

(b) Find all day efficiency of a transformer having maximum efficiency of 98% at 15KVA, p.f. = 1 and loaded as : Full load for 6 hours, Half load for 12 hours and no load for 6 hours. 3

5. (a) A 3-phase 10KVA 400V, 50 Hz, star connected alternator supplies rated load at 0.8 p.f. lagging. If the armature resistance is  $0.5\Omega$  per phase and synchronous reactance is  $10\Omega$  per phase,

Find

(i) voltage regulation

(ii) power angle

(iii) Draw the phasor diagram. 7

(b) Define short circuit ratio of an alternator. Explain how it can be determined from open-circuit and short-circuit test. 3

6. (a) Derive an expression for power flowing from a synchronous generator to an infinite-bus and draw the power angle characteristic. 4

(b) A 4-pole 3-phase starconnected alternator has 60 slots with 4 conductors per slot, coils are

short pitched by 3 slots and the phase spread is  $60^\circ$ . The flux per pole is  $\phi = 0.943 \sin \omega t + 0.3 \sin 3\omega t$  Wb.

Determine

(i) Fundamental voltage induced in the armature winding

(ii) Third harmonic voltage induced in the armature winding. 6

7. (a) Two single-phase transformers A and B rated at 600 KVA and 500 KVA, respectively are operated in parallel to supply a load of 1000 KVA at 0.8 p.f. lagging.

Transformer A :  $r = 3\%$ ,  $x = 6.5\%$

Transformer B :  $r = 1.5\%$ ,  $x = 8\%$

( $r$  and  $x$  represent resistance and reactance of the transformer)

Find the KVA loading and power factor at which each transformer operates. 5



- (b) The full-load armature current of a 440V d.c. shunt motor is 120 A. The armature resistance is  $0.2\ \Omega$  and speed 800 r.p.m. What will be the speed, if the torque is reduced to 60% of its full load value and a resistor of  $1.5\ \Omega$  is included in the armature circuit, the field strength remaining the same? 5

8. Write brief answers to the following questions :

- (a) Speed control of a d.c. shunt motor. 4
- (b) equivalent circuit and phasor diagram of an autotransformer (step-up mode). 3
- (c) Salient-pole synchronous machine : phasor diagram and power angle characteristic. 3

*Mishra*