B.E.(EE) Part-III 5th Semester Final Examination, 2013

Electrical Machines-III (EE-501)

Time: 3 hours **Full marks: 70**

Use separate answer script for each half.
Answer SIX questions, taking THREE from each half.
Two marks are reserved for neatness in each half.

FIRST HALF

1. a) For a 3-phase, 247 MVA, 15.75 kV, 0.85 lag , star-connected alternator answer the following:
   i) What type of field configuration is adopted and why?
   ii) Why is it necessary to mention power factor in the above nameplate?
   b) Damper winding is not required for large turbogenerator whereas it is a must for alternators driven by IC engine- Justify.
   c) State the basic principle involved to explain how a three-phase synchronous motor develops running torque. [(3+3)+3+2]

2. a) Enumerate the different tasks of excitation system of large alternators. Draw a simple block diagram to describe in brief the role of AVR in excitation system.
   b) Show that the external characteristics of a three-phase alternator supplying lagging power factor load lies on an ellipse. Draw the above characteristics both for lagging and leading power factor load on the same axes. Assume field current is adjusted such that rated voltage appears on no load.
   c) Compare the performance of an alternator connected to infinite bus with an isolated alternator supplying its own load when i) prime mover torque is increased and ii) field current is increased. [(2+1)+(3+1)+(2+2)]

3. a) Why does the speed of a dc shunt motor driving an alternator drop during OC test of alternator ?
   b) 'The armature leakage reactance of a synchronous machine is slightly less than potier reactance' – Explain.
   c) How does SCR influence the physical size of a synchronous machine?
   d) A 1100V, 50 Hz, 3-phase star-connected cylindrical rotor synchronous motor has its synchronous impedance of (0.7+ j3.2)Ω per phase. It is working at rated voltage, rated frequency with an input of 350 kW. The field current is adjusted to give an electromotive force of 1650V. Calculate armature current, power factor and load angle. [2+2+2+5]

4. a) State the assumptions involved in synchronous impedance method of computation of voltage regulation of alternators.
   b) Discuss how saturation is taken into account in ASA method of computation of voltage regulation of alternators.
   c) The OC characteristics of a 3-phase alternator is as follows:

Field current (A)	20	40	60	84	105	123
OC volt (V)	850	1700	2460	3000	3300	3600

When short circuited and driven at normal speed, an excitation of 50 A gives normal full load stator current. The resistance drop is 2% and the leakage reactance drop is15%. Determine the excitation necessary for full load operation at 0.9 pf leading on 3000V supply. [2+4+5]

5. a) Stating clearly the sign convention of power, show that an overexcited synchronous motor can deliver reactive power when $E_o \cos \delta > E_t$, the symbols having their usual significance. Neglect armature resistance.
   b) A turbo alternator is running overexcited with an excitation voltage 1.4 pu .The machine with synchronous reactance 1.2 pu and negligible armature resistance is delivering 0.5 pu to the bus. If the prime mover torque is increased by 1%, by how much active and reactive power will change? Neglect armature resistance.
   c) A 415V, 3-phase star-connected cylindrical rotor synchronous motor has a synchronous impedance of 0.6 + 7.6 Ω per phase. The largest possible value of open circuit emf is 1.3 times the terminal voltage. Find the maximum HP that can be delivered and the corresponding input current and pf. The core, friction and windage losses may be taken as constant at 800 W. [3+3+5]

SECOND HALF

6. a) Describe the reduced voltage starting of a squirrel-cage induction motor by means of a reactor and a star-delta starter and mention their merits and demerits.
   b) The ratio of maximum torque to full-load torque in a 3-phase squirrel cage induction motor is 2.2:1. Determine the ratio of actual starting torque to full-load torque for the following cases:
      i) Direct starting
      ii) Star-delta starting
      iii) Auto-transformer starting with tapping of 70 %.
   c) Deduce the formula used to calculate the resistance steps for starting a 3-phase wound rotor induction motor and state the various assumptions made. [5+(3+3)]

7. a) Name the different methods of controlling speed of a polyphase induction motor applicable separately for both wound rotor and squirrel cage induction motors.
   b) Discuss the principles of consequent pole technique and pole amplitude modulation method of pole changing for speed control of a squirrel cage induction motor.
   c) A 6-pole lap connected d.c. generator having a commutator ring of diameter 45 cm runs at 1000 r.p.m. The brush width is 2 cm and thickness of mica insulation is 0.2 cm. The load current delivered by the generator is 115A and the shunt field current is 5A. The self-inductance of each coil is 0.1 mH. Determine the reactance voltage if commutation is:
      i) linear
      ii) sinusoidal. [3+4+4]

8. a) Explain the phenomena of crawling and cogging in induction motors.
   b) Give reasons why supply voltage variation of speed control of induction motor is restricted to motors of smaller ratings.
   c) Mention the advantages of low frequency start of a three-phase induction motor.
   d) A 20 kW, 3-phase, 400V, 4-pole, 50 Hz squirrel-cage induction motor when working at rated voltage and frequency develops a full-load torque at 1470 rpm. If the motor is fed from 40 Hz source, with its voltage adjusted to give the same air gap flux as at 50 Hz, then calculate
      i) the magnitude of the 40Hz voltage source and
      ii) the speed at which the motor would now run so that the same full load torque, as at 50Hz, is developed. [3+2+2+4]

9. a) What are interpoles? What should be the polarity of the interpoles with respect to the main poles of a d.c. machine?
   b) Explain the commutation process in a d.c. machine and describe the following terms in reference to a d.c machine:
      i) Accelarated commutation; ii) Linear commutation; iii) Retarded commutation
   c) A 4-pole d.c. generator has an interpole air-gap of 0.01m and 704 lap-wound armature conductors. The flux density in the interpole air-gap is 0.42 wb/m^2. If it delivers 308 kW at 440V, determine the number of turns needed on each interpole. [3+4+4]

10. a) Explain the method to bring a second d.c. shunt generator into parallel operation with one already delivering power. How should their characteristics be related in order that they should satisfactorily share a common load according to their respective ratings?
    b) Eight generators are being run in parallel in a generating station. Each generator has an output current of 1600 A and an induced e.m.f. of 440 V. The generators supply a load having a fixed resistance at a terminal voltage of 420V. If the field of one generator is increased by 10 percent and the fields of others kept constant, what will be the new terminal voltage and output of each machine? Assume the speed to be constant. [6+5]
