

B.E. (EE) Part-III 6th Semester Examination, 2010

Electrical Machines-IV
(EE-601)

Time : 3 hours

Full Marks : 70

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

FIRST HALF

- a) Using two reaction theory draw the phasor diagram of a salient pole synchronous generator for over-excited condition. From the phasor diagram find the expression for ' $\tan \delta$ ' and ' E_f ' the symbols having usual significance.
- b) A 1500 kW, 3 phase, star connected, 3.3 kV synchronous motor with negligible resistance has reactance of $X_d = 4.01 \text{ ohm/phase}$ and $X_q = 2.88 \text{ ohm/phase}$. All losses may be neglected.
Calculate the excitation emf when the motor is supplying rated load at unity Pf.
Calculate the maximum mechanical power that the motor can supply with excitation held fixed at this value. [5+6]
- a) Find the expression for power in terms of the load angle ' δ ' for a '3 phase' salient pole synchronous motor working at a lagging power factor and hence, draw the power-angle characteristics for a salient pole synchronous motor. Armature resistance may be neglected.
- b) State the disadvantages when a well designed three phase induction motor is used as a synchronous induction motor and comment on the performance of a wound rotor motor running synchronously. Suggest modification to improve its performance as synchronous motor.
- c) Derive an expression for the synchronising torque of two non-salient pole alternators operating in parallel on no-load. (4+4+31)
- a) Show that the locus of the tip of the armature current phasor for a 3 phase synchronous generator at leading power factor is a circle when electromagnetic power is constant. Hence, show that the zero power circle passes through origin.
- b) Show that the maximum power line or the line of stability is a straight line parallel to the E_f phasor and passing through the centre of the circles which are current loci for constant excitation.

- c) A star-connected 8-pole, 50 Hz synchronous motor has synchronous reactance of 11 Ω per phase. On no-load, both the excitation and the terminal voltages are equal to 3.3 kV. Neglect all losses.
- For a sudden decrease in the shaft-load torque, the rotor falls back in space by one mechanical degree. Calculate the synchronising current, synchronising power and synchronising torque tending to restore the rotor to its previous position.
 - With gradual increase in the shaft load, the rotor slides back in space by one mechanical degree. Calculate the armature current. For an armature current of 30 Amp, find the angle in mechanical degrees, through which the rotor slips back. **[4K+2K+4]**
4. a) Describe methods of starting synchronous motors against light load torque. Explain, why at the time of starting synchronous motor with the help of damper winding, field winding terminals should be shorted through high resistance.
- b) Develop the excitation circles for a cylindrical rotor synchronous machine considering motor mode of operation under over-excited condition. How are these circles helpful in studying the steady state behaviour of synchronous machines? **[6+5]**
5. a) Describe the synchronizing procedure to be followed in connecting an alternator to infinite bus bar.
- b) What is capability curve or operating chart of synchronous generator? Describe its basis of development.
- c) Mention effects of loss of excitation of a 3-phase synchronous generator. **[4+4+31]**

SECOND HALF

6. a) Using double revolving field theory explain the torque-slip characteristic of a single phase induction motor and prove that it can not produce any starting torque.
- b) A 2-pole, 50 Hz single phase induction motor has an effective rotor resistance and leakage reactance of 0.4 Ω and 6.0 Ω respectively. If the motor is running at 2700 r.p.m., determine the frequencies of the rotor current components and relative magnitude of the forward and backward fluxes and torques. Neglect magnetizing current and stator impedance. **[5+(2+2+2)]**

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7. a) State the reasons for the inferior performance of single-phase induction motors compared to three phase induction motors.
- b) Describe the design steps of estimating the value of starting capacitance for a single phase induction motor to achieve maximum starting torque and hence, develop the expression for the maximum starting torque. [5+(4+2)]
8. a) Explain the principle of action of a cross field generator and show how constant voltage characteristics can be obtained.
- b) An uncompensated cross-field generator has the following data :
Direct-axis voltage co-efficient = 90 Volt/amp. of armature current;
Quadrature-axis voltage co-efficient = 2290 Volt/amp of control field current;
Quadrature-axis voltage co-efficient = 110 Volt/amp. of armature current;
Armature resistance on each axis, considering brush drop - 5 ohms;
External resistance across-quadrature brushes = 10 ohms;
Control-field resistance = 100 ohms;
Output = 10 amps, at 220 Volts.
- Determine : (i) the quadrature-axis armature current;
(ii) the control-field current;
(iii) the voltage gain;
(iv) the power gain. [5+(1/ix4)]
9. a) Describe, with neat sketches, how speed and power factor of a Schrage motor can be controlled.
- b) An a.c. tachogenerator has an output voltage of constant frequency. How is this achieved? [5+6]
10. a) Explain the operation of a d.c. series motor when connected to an a.c. source. Will a d.c. shunt motor operate when energized from an alternating voltage supply? Explain.
- b) A series motor has total resistance of 25 ohms and a total inductance of 0.2 H. The motor runs at 1000 r.p.m., when it draws 1A from 220 V d.c. source. Determine the speed and p.f. when it draws the same current from 220 V, 50 Hz, 1 ϕ source. [(3+3)+5]