BITS PILANI K. K. BIRLA GOA CAMPUS

SEMESTER-I, 2022-2023

ELECTRICAL MACHINES (COMPRE) EEE_ECE_INSTR F211 (Part-A)

Date-27/12/2022 Total Marks: 12×3M=36 Duration: 50 min

[Take necessary assumptions with proper justifications whenever required]

[Write your answers up to four decimal places]

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1. At full load condition, the rotor copper loss of a 4 pole 60 Hz, 3 phase Induction Motor is 5% of the airgap power. Determine the speed of the rotor (Nr, in RPM) of the Induction motor at full load. **[3]**

2. The magnitude of line to line excitation emf induced in a 6.6 kV, 60 Hz, Y connected synchronous motor is 8.6 kV. The synchronous impedance is $2 + j20$ Ω/phase. The motor is drawing a total real power of 1200 kW from the supply mains. Determine the load angle (delta, in degree). **[3]**

3. A 60 pole, three phase 50 Hz, 110 kW, 6.6 kV, Y connected synchronous generator has full load efficiency of 95%. Determine the torque of the prime mover (T_prime, in kN-m) coupled with the shaft of the generator at full load. **[3]**

4. A 400 V/100 V single phase, 50 Hz transformer is excited from an ac voltage source of 40 Hz at the low voltage side. For the rated exciting current at LV side to be maintained constant, for both 50 Hz and 40 Hz supply, determine the magnitude of the supply voltage (Vac_40, in V) at low voltage side with 40 Hz frequency. Consider the approximate equivalent circuit of the transformer. **[3]**

5. Full pitched coils are used in a 3 phase, 6 pole, 60 Hz induction motor. Determine the coil span in mechanical degree (Cspan, in degree (m)). **[3]**

6. A 220 V, 4.4 kW dc shunt generator, having armature resistance of 0.5 ohm, operates at rated terminal voltage with rated load. The machine is now operated as dc shunt motor at the same terminal voltage with the same armature current. The flux/pole of the machine is increased by 10% as the operation is changed from generator to motor. If the shunt field current is neglected for the machine, determine ratio of generator to motor speed (Ng:Nm). **[3]**

7. Consider a single-phase AC circuit in which a series combination of resistance and inductor is excited by an AC voltage source. At 100 Hz source frequency, the RMS voltages across the resistance and inductor are same which is $\sqrt{10}$ V. If the source frequency is changed to 50 Hz, determine the new RMS voltage (in V) across the resistance. **[3]**

8. The armature resistance of a permanent magnet dc motor is 0.8 Ω. At no load, the motor draws 1.5 A from a supply voltage of 25 V and runs at 1500 rpm. Find the efficiency (eta_M, in percentage) of the motor while it is operating on load at 1500 rpm drawing a current of 3.5 A from the same source. **[3]**

9. A 220 V, DC shunt motor is operating at a speed of 1440 rpm. The armature resistance is 1.0 Ω and armature current is 10 A. Find the extra resistance (R_ext, in Ω) to be inserted in the armature circuit to maintain the same speed and torque, while the excitation of the machine is reduced by 10% due to armature reaction. **[3]**

10. A 200 V, 5 kW DC shunt motor has armature resistance of 1 ohm and shunt field resistance of 100 ohm. At no load the motor draws a current of 6 A from the supply and runs at speed of 1000 RPM. Find the no load torque (T_nl, in N-m). **[3]**

11. A three-phase star connected, 6-pole synchronous generator has a synchronous speed of 800 rpm. The stator has 6 slots per pole per phase and 14 conductors per slot. Find the flux per pole (phi_P, in mWb) required to generate a line voltage of 480 V on open circuit. The coils used in the synchronous generator are full pitched. **[3]**

12. The OC test and SC test results on a 60 kVA, 2500 V/100 V two winding transformer is given as
    OC test (instruments on LV side): 100 V, 9 A, 600 W
    SC test (instruments on HV side): 120 V, 24 A, 1200 W
    The above two-winding is now connected as an auto transformer with the voltage rating of 2500 V/2600 V. Find out the efficiency of the auto-transformer (eta_autoTF, in %) if the rated load with 0.1 power factor leading is connected to the auto-transformer. **[3]**

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SEMESTER-I, 2022-2023

ELECTRICAL MACHINES (COMPRE) EEE_ECE_INSTR F211 (Part-B)

Date-27/12/2022 Total Marks: 18×3M=54 Duration: 130 Minutes

[Take necessary assumptions with proper justifications whenever required]

[Write your answers up to four decimal places, If the final answer is a complex number then express it in polar form. Write the final answer within a box]

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1. Consider a 6 pole, Y connected, 3 phase 400 V, 50 Hz induction motor, that gives the following readings after performing the No load and the Blocked rotor test.

   No load test: 400 V, 7.5 A, 701.4806 W

   Blocked rotor test: 150 V, 35 A, 4001.0373 W

   The per phase stator resistance is 0.545 Ω. The ratio of stator leakage reactance to the reflected rotor leakage reactance is 2:1. At full load the induction motor is running at 960 rpm.

   a) Determine the per phase stator leakage reactance, magnetizing reactance and standstill rotor leakage reactance reflected to stator (in Ω). **[6]**
   b) Determine the per phase rotor resistance reflected to stator (in Ω). **[2]**
   c) Considering the rotor circuit as load, determine the per phase Thevenin voltage (in V) and per phase Thevenin impedance (in Ω). Also draw the per phase Thevenin's equivalent circuit at full load, mentioning all the circuit parameters. **[4]**
   d) Determine the net rotational loss of the induction motor (in W). **[1]**
   e) Determine the net mechanical power output (in W) of the induction motor at full load. **[2]**
   f) Determine the efficiency (in %) of the induction motor at full load condition. **[3]**

2. In the electrical machine lab, no load test on dc separately excited generator gives the following readings at 1100 RPM

I_f (A)	0	0.20	0.40	0.60	0.80	1.00	1.20	1.40
E_a (V)	5.5	55	110	154	187	209	220	225.5

   Where I_f is the field current and E_a is the no load generated emf in the generator. The armature resistance of the generator is 0.5 Ω. The separately excited generator is connected as dc shunt generator with the shunt field resistance of 180 Ω. The dc shunt generator is driven at 1100 RPM.

   a) Determine the critical value of shunt field resistance (in Ω) at 1100 RPM. **[2]**
   b) Determine the voltage (in V) on open circuit to which the dc shunt machine will build up (no load emf) for the total shunt field resistance of 180 Ω. Use the algebraic method to solve the problem and take necessary assumptions wherever required. **[6]**
   c) Determine the critical speed (in RPM) for the shunt field resistance of 180 Ω. **[2]**
   d) If for the generator, the terminal voltage is to be fixed to 190 V, determine the armature current (in A) that should flow through the dc shunt generator, when it is rotating at 1100 RPM. Use the algebraic method to solve the problem and take necessary assumptions wherever required. **[4]**

e) Determine the electrical power (in W) delivered to the load connected to the terminal of the dc shunt generator for the condition as mentioned in problem-(d). **[2]**

f) If the armature current is to be restricted to the 50% of the armature current obtained in problem-(d), determine the extra resistance (in Ω) that should be placed in series with the armature of the dc shunt generator. **[2]**

[Neglect the brush voltage drop and the armature reaction]

3. A 3-phase, 50 Hz, Y connected, 8 pole synchronous generator has 2 coil sides per slot and 12 turns per coil. The stator of the synchronous generator has 360 slots on its periphery. The coils used are short-pitched by 2 slots. The flux per pole is 0.05 Wb/Pole which is sinusoidally distributed. Determine

   a) The speed (in RPM) of the prime mover attached to the synchronous generator to maintain the 50 Hz frequency of the generated emf. **[2]**

   b) The coil span (in Electrical degree) of the short-pitched coils. **[2]**

   c) The distribution factor and the pitch factor. **[4]**

   d) The line-to-line induced emf (in kV) in the synchronous generator. **[2]**

   The alternator has a stator resistance of 0.25 Ω per phase and the synchronous reactance of 3.2 Ω per phase. For a lagging load current of 100 A at 0.8 power factor, determine

   e) The magnitude of line-to-line terminal voltage (in kV). **[4]**

   f) The load angle (in Electrical Degree). **[2]**

   g) The net reactive power (in kVAR) generated by the synchronous generator. **[2]**

   [Neglect the armature reaction of the synchronous machine]

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