Dronacharya Group of Institutions, Greater Noida
Electrical & Electronics Engineering Department
Question Bank

Subject: EMEC-II (NEE-401) **Course: B. Tech 4th Sem (EEE)**

UNIT I

1. Discuss the zero power factor method to find voltage regulation of an alternator.
2. What are the necessary conditions for parallel operation of alternators? Also explain parallel operation of alternators.
3. Discuss the operation of synchronous machine connected to an infinite bus bar for different excitations.
4. A 3-phase, 10 KVA, 400V, 50 Hz, star connected alternator supplies the rated load at 0.8 power factor lagging. If the armature resistance is 0.5 ohm and synchronous reactance is 10 ohm, find the power angle and voltage regulation.
5. Derive an expression for the emf generated in the armature winding of a synchronous machine. Also explain how harmonics in the emf wave are eliminated by short pitched winding.
6. State the advantages and disadvantages of using distributed windings and short-pitched windings. Also derive the expression for distribution factor and pitch factor.
7. Calculate the rms value of induced emf per phase of a 10 pole, 3-phase, 50 Hz, alternator with 2 slots/pole/phase and 4 conductors/slot. Assume coil span of 150^o. Flux/pole has a harmonic component of 20% of the fundamental. What is the value of line to line emf?
8. A 50 Hz, 6-pole synchronous generator has 36 slots. It has two-layer winding with full-pitched coils of 8 turns each. The flux/pole is 0.015 Wb (sinusoidally distributed). Determine the induced emf (line to line) if the coils are connected to form (a) 2-phase winding (b) star connected 3-phase winding.
9. A 4-pole, 3-phase synchronous motor fed from 50 Hz mains is mechanically coupled to a 24-pole, 3-phase synchronous generator. At what speed will the set rotate? What is the frequency of emf induced in the generator?
10. Calculate the fundamental, 3^{rd} and 5^{th} harmonic breadth factor for a stator with 36 slots wound for 3-phase, 4-poles.
11. Discuss the nature of armature reaction flux in a salient pole synchronous machine in case armature current (i) lags the excitation emf E_f by 90^o (ii) leads E_f by 90^o and (iii) is in phase with E_f.
12. Explain the method of determining the voltage regulation of an alternator by ASA method.
13. Explain how open circuit and short circuit tests are conducted on a synchronous machine?
14. A 3ϕ, 5 kVA, 208V, 4-pole, 60 Hz, star connected synchronous machine has negligible stator winding resistance and a synchronous reactance of 8 ohms per phase at rated terminal voltage. Determine the excitation voltage and the power angle when the machine is delivering rated kVA at 0.8 PF lagging. Draw the phasor diagram for this condition.
15. A 3-phase synchronous generator produces an open-circuit line voltage of 6928 V when exciting current is 50 A. the AC terminal are then short-circuited, and the 3-line currents are found to be 800 A. calculate (a) the synchronous reactance per phase. (b) the terminal voltage if three 12 Ω resistors are connected in star across the terminals.
16. The following data are taken from the open and short circuit characteristics of a 45-kVA, 3-phase, Y-connected, 220V (line-to-line), 6-pole, 60 Hz synchronous machine. From the open circuit characteristics:

Line-to-Line voltage = 220V, Field current = 2.84A
From the short circuit characteristic:

Armature Current (A)	118	152
Field Current (A)	2.20	2.84

From the air-gap line:
Field current=2.20A, Line-to-line voltage = 202V
Compute the unsaturated value of the synchronous reactance, its saturated value at rated voltage, and the short-circuit ratio. Express the synchronous reactance in ohms per phase and in per unit on the machine rating as a base.

17. Calculate the saturated synchronous reactance (in Ω/phase and per unit) of a 85 kVA synchronous machine which achieves its rated open-circuit voltage of 460 V at a field current 8.7 A and which achieves rated short-circuit current at a field current of 11.2 A.

18. A 3-phase, 1500 kVA, star connected, 50-Hz, 2300V alternator has a resistance between each pair of terminals as measured by direct current is 0.16Ω. Assume that the effective resistance is 1.5 times the ohmic resistance. A field current of 70A produces a short circuit current equal to full load current of 376A in each line. The same field current produces an emf of 700V on open circuit. Determine the synchronous reactance of the machine and its full load regulation at 0.8 power factor lagging.

19. A 3-phase star connected alternator is rated at 1600 kVA, 13500V. The armature effective resistance and synchronous reactance are 1.5 Ω and 30 Ω respectively per phase. Calculate the percentage regulation for a load of 1280 kW at power factor of (a) 0.8 leading, (b) unity, and (c) 0.8 lagging.

20. A 3-phase, star-connected, 2000kVA, 2000V, 50 Hz alternator gave the following open-circuit and short circuit readings:

Field current (A)	10	20	25	30	40	50
O.C. voltage (V)	800	1500	1760	2000	2350	2600
S.C. armature current (A)		200	250	300		

The armature effective resistance per phase is 0.2Ω. Draw the characteristic curves and determine the full-load percentage regulation at (a) 0.8 power factor lagging, (b) 0.8 power factor leading.

21. A 5000 kVA, 6600 V, 3-phase, star connected alternator has a resistance of 0.75 Ω per phase. Estimate by zero power factor the regulation for a load of 500 A at power factor (a) unity, (b) 0.9 leading, (c) 0.71 lagging, from the following open circuit and full load, zero-power factor curves:

Field current (A)	Open-circuit terminal voltage (V)	Saturation curve, zero p.f. Voltage
32	3100	0
50	4500	1850
75	6600	4250
100	7500	5800
140	8300	7000

UNIT II

1. A 400V, 3-phase, delta-connected synchronous motor has an excitation emf of 600V and synchronous impedance per phase of $0.3 + j6\Omega$. Calculate the net power output, efficiency, line current and power factor when the machine is developing maximum mechanical power (gross). Windage, friction and core losses may be assumed to be 2.4 kW.
2. A 3300V, star-connected synchronous motor is operating at constant terminal voltage and constant excitation. Its synchronous impedance is $0.8 + j5\Omega$. It operates at a power factor of 0.8 leading when drawing 800 kW from the mains. Find its power factor when the input is increased to 1200 kW, excitation remaining constant.
3. A 1500 kW, 3-phase, star-connected, 3.3 kV synchronous motor has reactances of $X_d = 4.01$ and $X_q = 2.88\Omega/phase$. All losses may be neglected. Calculate the excitation emf when the motor is supplying rated load at unity power factor. Also calculate the maximum mechanical power that the motor can supply with excitation held fixed at this value.
4. A 1000 kVA, 6.6 kV, 50 Hz, Y-connected synchronous generator has a no-load voltage of 11.4 kV at a certain field current. The generator gives rated terminal voltage at full load 0.75 lagging power factor at the same field current. Calculate: (a) the synchronous reactance (armature resistance being negligible) (b) the voltage regulation (c) the torque angle (d) the electrical power developed and (e) the voltage and kVA rating, if the generator is reconnected in delta.
5. A 22 kV, 3-phase, Y-connected turbo-alternator with a synchronous impedance of $j1.2\Omega/phase$ is delivering 230 MW at UPF to 22 kV grid. With the turbine power remaining constant, the alternator excitation is increased by 30%. Determine machine current and power factor based upon linearity assumption. At the new excitation, the turbine power is now increased till the machine delivers 275 MW. Calculate the new current and power factor.
6. The full load current of a 3.3 kV, Y-connected synchronous motor is 160 A at 0.8 power factor lagging. The resistance and reactance of the motor are 0.8Ω and 5.5Ω per phase respectively. Calculate the excitation emf, torque angle, efficiency and shaft output of the motor. Assume the mechanical stray load loss to be 30 kW.
7. A 4-pole, 50 Hz, 22 kV, 500 MVA synchronous generator having a synchronous reactance of 1.57 pu is feeding into a power system, which can be represented by a 22 kV infinite bus in series with a reactance of 0.4Ω. The generator excitation is continually adjusted (by means of an automatic voltage regulator) so as to maintain a terminal voltage of 22 kV independent of the load on the generator. Draw the phasor diagram, when the generator is feeding 250 MVA into the power system. Calculate the generator current, its power factor and real power fed by it. What is the excitation emf of the generator?
8. A 6.6 kV, Y-connected, 3-phase, synchronous motor operates at constant voltage and excitation. Its synchronous impedance is $2 + j20\Omega/phase$. The motor operates at 0.8 leading power factor while drawing 800 kW from the mains. Find the motor power factor which is loaded to draw increased power of 1200 kW.
9. A 440 V, 50 Hz, $\Delta -$connected synchronous generator has a direct axis reactance of 0.12Ω and a quadrature axis reactance of 0.075Ω/phase; the armature resistance being negligible. The generator is supplying 1000A at 0.8 lagging pf. (a) find the excitation emf neglecting saliency and assuming $X_s = X_d$ (b) find the excitation emf accounting saliency.
10. A 1500 kVA, Y-connected, 6.6 kV salient pole synchronous motor has $X_d = 23.2\Omega$ and $X_q = 14.5\Omega/phase$ respectively; armature resistance being negligible. Calculate the excitation emf when the motor is supplying rated load at 0.8 leading power factor. What maximum load the motor can supply without loss of synchronism, if the excitation is cut off? What will be the value of torque angle under this condition?

UNIT III

1. Show that when 3-phase sinusoidally varying ac supply is fed to the stator of a 3-phase induction motor, a rotating magnetic field is produced that rotates in the air-gap at the synchronous speed and whole magnitude is 3/2 times the amplitude of the phase emf.
2. A 208-V, 10hp, 4- pole, 60 Hz, Y-connected induction motor has a full-load slip of 5 percent
   (i) What is the synchronous speed of this motor?
   (ii) What is the rotor speed of this motor at rated load?
   (iii) What is the rotor frequency of this motor at rated load?
   (iv) What is the shaft torque of this motor at rated load?
3. Develop an expression to show that the torque developed in 3-phase induction motor depends on supply voltage, rotor resistance and slip. Also derive the condition for maximum torque.
4. A 6- pole, 50 Hz, 3-phase induction motor running on full load develops a useful torque of 160 Nm, when the rotor EMF makes 120 complete cycles per minute. Calculate the shaft power output. If the mechanical torque lost in friction and that for core loss is 10 Nm. Compute: (a) the copper loss in rotor winding (b) the input to the motor and (c) the efficiency. The total stator loss is given to be 800 W.
5. The power input to the rotor of a 400 V, 50 Hz, 6-pole, 3-phase, induction motor is 80 kW. The rotor EMF is observed to make 100 complete alterations per minute. Calculate slip, mechanical power developed and rotor copper loss.
6. Draw and explain the torque-slip characteristic of a typical 3-phase induction motor. Mark the starting torque and maximum torque. Also explain how the starting torque and maximum torque vary with rotor circuit resistance.
7. Discuss the relative advantages and disadvantages of squirrel cage and wound rotor induction motors.
8. Prove that for a three phase induction motor, rotor copper loss is slip times the power input of the rotor.
9. The power input to a three phase induction motor is 50 kW and the corresponding stator losses are 2 kW. Calculate the total mechanical power developed and the rotor I^2R loss when the slip is 3%.
10. Explain no load test and blocked rotor test on 3-phase induction motor.
11. A 3-phase, 400V, 50 Hz star connected induction motor has the following constant in ohms/phase referred to stator: $r_1 = 0.15\Omega, r_2 = 0.12\Omega, x_2 = 0.45\Omega \; and \; X_{\emptyset} = 28.5\Omega$. Fixed losses (core, friction and windage) =400W. Calculate stator current and output torque at a slip of 0.04.
12. A 10kW,400V, 4 pole delta-connected squirrel cage induction motor gave the following test results:
   No load test: 400V, 8A, 250 watts
   Blocked-rotor test: 90V, 35A, 1350 watts.
   The dc resistance of the stator winding per phase measured immediately after the blocked-rotor test is 0.6 ohm. Calculate the rotational losses and the equivalent circuit parameters.

UNIT IV

1. What are the different starting methods of 3-phase induction motor? Describe with the help of neat and clean diagram.
2. Design a 4-step starter for a 3-phase wound rotor induction motor. The full load slip is 2.5% and the maximum starting current is limited to 1.6 times its full load value. Rotor resistance per phase is 0.02 ohms. Derive the formula used for calculating the resistance sections and state the various assumptions made.
3. Discuss the relative merits and demerits of single cage and double cage induction motors.
4. A 4-pole, 50 Hz, double cage, 3-phase induction motor has per phase leakage impedances of $(0.05 + j0.4)\Omega$ and $(0.5 + j0.1)\Omega$ for the two cages at supply frequency. Calculate the relative values of torques developed by the two cages (i) at starting and (ii) at a full load slip of 5%.
5. Explain different methods of speed control of 3-phase induction motor with the help of suitable diagram.
6. A 440 V, 50 Hz, 4-pole, 3-phase, delta-connected motor has a leakage impedance of $\left(0.3 + j5.5 + \frac{0.25}{s}\right)\Omega/phase$ (delta phase) referred to stator. The stator to rotor voltage ratio is 2.5. Determine the external resistance to be inserted in each star phase of the rotor winding such that the motor develops a gross torque of 150 Nm at a speed of 1250 rpm.
7. A 3-phase, 25 kW, 400 V, 50 Hz, 8-pole induction motor has rotor resistance of 0.08 Ω and standstill reactance of 0.4Ω. The effective stator/rotor turn ratio is 2.5/1. The motor is to drive a constant torque load of 250 Nm. Neglect stator impedance. (a) Calculate the minimum resistance to be added in rotor circuit for the motor to start up on load. (b) At what speed would the motor run, if the added rotor resistance is (i) left in the circuit, and (ii) subsequently short circuited.
8. A 50 Hz, 3-phase induction motor has a rated voltageV_1. The motor's breakdown torque at rated voltage and frequency occurs at a slip of 0.2. The motor is instead run from a 60 Hz supply of voltageV_2. The stator impedance can be neglected. (a) If $V_2 = V_1$, find the ratio of currents and torques at starting. Also find the ratio of maximum torques. (b) Find the ratio V_2/V_1 such that the motor has the same values of starting current and torque at 50 and 60 Hz.
9. The impedances at standstill of the inner and outer cages of a double cage rotor are $(0.01 + j0.5)\Omega$ and $(0.05 + j0.1)\Omega$ respectively. The stator impedance may be assumed to be negligible. Calculate the ratio of the torques due to the two cages (i) at starting, and (ii) when running at a slip of 5%.
10. The results of the no-load and blocked-rotor tests on a 3-phase, Y-connected 10 kW, 400V, 17A, 50 Hz, 8-pole induction motor with a squirrel cage rotor are given below:
    No-load test: Line to lone voltage = 400 V, Total input power = 467 W, Line current = 6.8 A.
    Blocked-rotor tests: Line to lone voltage = 180 V, Total input power = 1200 W, Line current = 17 A. The dc resistance of the stator measured immediately after the blocked-rotor test is found to have an average value of 0.68 Ω/phase. Calculate the parameters of the circuit model of the induction motor.

UNIT V

1. A 2-phase induction motor with stator voltages V_r and V_c which are unequal but in space quadrature, produces some starting torque. Show that the same starting torque is produced by 2-phase balanced voltages of magnitude $\sqrt{V_r V_c}$.
2. Give the constructional features of a single phase induction motor.
3. Explain the double revolving –field theory as applied to a single phase induction motor.
4. Derive the equivalent circuit of a single-phase induction motor with the help of double revolving field theory.
5. Draw and explain the phasor diagram of a single-phase series motor.
6. Show with the help of phasor diagrams that a compensated series motor possesses better speed-torque characteristics better power factor operation and improved commutation as compared to an uncompensated series motor.
7. Explain the constructional features of a Schrage motor. How does it differ from an ordinary induction motor?