KATHMANDU UNIVERSITY
End Semester Examination
March/April, 2017

Marks scored:

Level : B. E.
Year : III
Course : EPEG 302
Semester : I
Exam. Roll No. :
Time: 30 mins.
F. M. : 10
Registration No.:
Date MAR 30 2017

SECTION "A"
[20 Q × 0.5 = 10 marks]

Encircle the most appropriate answer to the following questions.

1. The pole pitch of a 4 pole synchronous machine is _____ degrees.
a. 90 electrical b. 90 mechanical c. 180 electrical d. 180 mechanical

2. A six pole synchronous generator revolves at 1000 rpm. The stator has 30 slots and 8 conductors per slot. The flux per pole is 0.06 Wb, distribution factor is 0.965 and pitch factor is 1. The voltage generated in the synchronous generator per phase will be _____V
a. 771.23 b.1542.46 c. 514.15 d. 890.53

3. A synchronous generator is rated for a full load of 3 MW at 0.8 PF lagging. The no-load frequency of the generator is 61 Hz, and its speed droop is 3.4 percent. The full load frequency of the generator is _____Hz.
a. 59 b. 60 c. 61 d. 62

4. For the parallel operation of two synchronous generators the frequency of the oncoming generator should be _____to the frequency of the other generator.
a. equal b. slightly lower c. very lower d. slightly higher

5. Two generators are connected in parallel to supply a load. Generator 1 has a no-load frequency of 61.5 Hz and a slope of 1MW/Hz. Generator 2 has a no load frequency of 61.0Hz and a slope of 1.01MW/Hz. The two generators are supplying a real load totaling 2.5 MW at 0.8 p.f. lagging. The operating frequency of the system will be _____Hz.
a. 59 b. 60 c. 61 d. 62

6. A 470 V, 50 Hz, Y-connected six pole synchronous generator has a per phase synchronous reactance of 1Ω. Its full load armature current is 60 A at 0.8 p.f. lagging and the armature resistance is negligible compared to inductance. The field current has been adjusted so that the terminal voltage is 480V at no load. The terminal voltage of the generator if it is loaded with rated current at 0.8 p.f. lagging is _____V
a. 524.9 b.458.3 c.231 d. 400.2

7. The synchronous generator capability curve is the plot of _____
a. I_A versus I_F b. P versus I_A c. P versus Q d. Q versus I_F

8. A dc test is performed on a 460-V Δ-connected 100-hp induction motor. If V_{DC} = 24 V and I_{DC} = 80 A, the stator resistance R_1 is _____Ω
a. 0.45 b. 0.15 c. 0.3 d. 0.17

9. A 220-V, three-phase, two-pole, 50-Hz induction motor is running at a slip of 5 percent. The speed of the magnetic fields in revolutions per minute is _____r/min.
a. 150 b. 2850 c. 3000 d. 1500

10. During the production of rotating magnetic field in a 3-phase induction motor, if the flux in phase-1 is $\phi_m \sin 60°$ the resultant flux of all the three phases is _____
a. $1.5\phi_m$ and rotated by an angle of 0° degree from the previous position.
b. $0.866\phi_m$ and rotated by an angle of 60° degree from the previous position.
c. $1.5\phi_m$ and rotated by an angle of 60° degree from the previous position.
d. $0.866\phi_m$ and rotated by an angle of 120° degree from the previous position.

11. A 4-pole, 50 Hz, 3 phase induction motor develops a useful toque of 90Nm at full load and1440rpm. If the friction and core loss is 6Nm and the rotor copper loss is 0.6kW, the mechanical power developed in rotor is _____kW.
a. 13.56 b. 14.46 c. 15.66 d. 15.06

12. The slope of the slip ring induction motor's magnetomotive force-flux curve is much shallower than the curve of a good transformer because of _____in the induction motor.
a. slip rings b. rotor resistance c. rotor winding d. air gap

13. A small squirrel-cage induction motor has a starting current of six times the full-load current and a full-load slip of 0.05. If stator-resistance starting method is adopted with motor current limited to 2p.u. , the starting torque in p.u. will be _____p.u.
a. 0.6 b. 1.8 c. 0.2 d. 6

14. For the V-curve of a synchronous motor , the armature current is leading supplying Q to the power system when the field current is _____ the value giving the minimum armature current.
a. greater than b. less than c. equal to d. inversely proportional

15. A three phase synchronous machine has a synchronous reactance of 2.0 Ω per phase and an armature resistance of 0.4Ω per phase. If $E_A = 460\angle -8°$ V and $V_\phi = 480\angle 0°$ V the reactive power consumed by this motor is _____kVAR
a. 47.7 b. 27.53 c. 8.07 d. 4.65

16. A 2.2 kW 4 pole 50 Hz 415 V 3 phase induction motor draws a current of 3A when supplied at its rated voltage and frequency and run as a motor with no mechanical load. The excitation capacitance which must be connected in star to make the machine generate at approximately its rated voltage when driven at slightly above its rate speed is _____μF.
a. 46.4 b. 23 c. 79.5 d. 39.7

17. The cheapest voltage control method for speed control of single-phase induction motors uses_____
a. auto-transformers b. SCR and TRIAC c. resistance d. pole changing

18. Two transformers are connected in parallel. The load 200kVA at 0.9 power factor lagging is to be shared by them. The transformer-1 has percentage resistance and percentage reactances 1.2% and 5.2% respectively and the transformer-2 has percentage resistance and percentage reactances 1.6% and 4.2% respectively. The load shared by transformer-1 is _____kVA.
a. $100.7\angle -30.1°$ b. $108.8\angle -22.25°$ c. $110.2\angle -32.25°$ d. $98.8\angle -30.25°$

19. The _____ test is a type of dielectric tests to be performed on a transformer.
a. temperature rise b. turn ratio c. sound level d. lightning impulse

20. For the Yd11 vector group of a three phase transformers, the HV winding _____ to LV winding.
a. lags by 11° b. leads by 11° c. lags by 30° d. leads by 30°

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SECTION "B"

Attempt *ANY FIVE* questions. Assume necessary data if required.

1. a. A 2300-V 1000-kVA 0.8-PF-lagging 60-Hz two-pole Y-connected synchronous generator has a synchronous reactance of 1.1 Ω and an armature resistance of 0.15Ω. At 60 Hz, its friction and windage losses are 24 kW, and its core losses are 18 kW. The field circuit has a dc voltage of 200 V, and the maximum I_F is 4.5 A. The resistance of the field circuit is adjustable over the range from 20 to 200Ω. The open circuit characteristic of this generator is shown in Figure-1. [4]

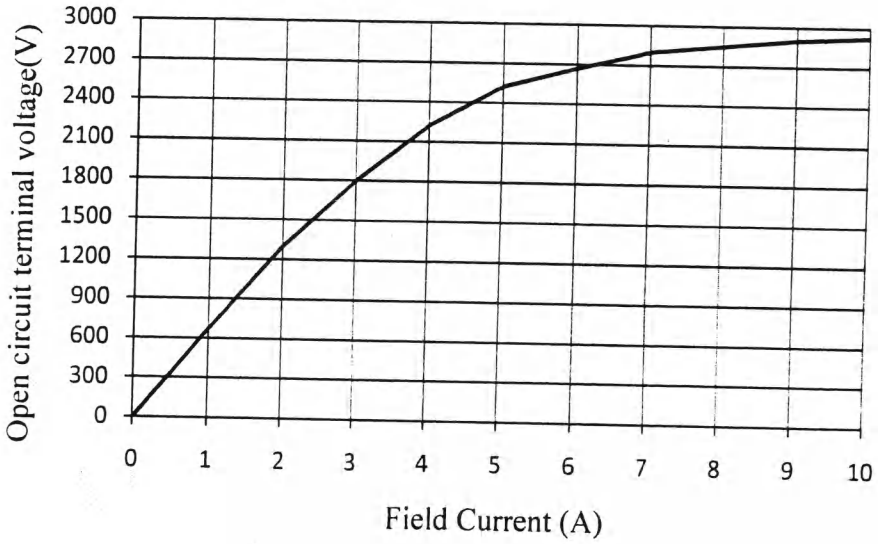

Figure-1

(i) What will the terminal voltage of this generator be if it is connected to a Δ-connected load with an impedance of $20\angle\angle 30°\Omega$?
(ii) Sketch the phasor diagram of this generator.
(iii) What is the efficiency of the generator at these conditions?
(iv) Now assume that another identical Δ-connected load is to be paralleled with the first one. What happens to the phasor diagram for the generator?
(v) What is the new terminal voltage after the load has been added?
(vi) What must be done to restore the terminal voltage to its original value?

b. There are different ways to perform three-phase transformation with only two transformers. Explain using their connection diagrams the V-V connection and the three phase T connection to perform three-phase transformation with only two transformers. [2]

c. Tapping is performed on transformers in order to alter the number of turns. The number of turns can be altered by off load tap changing method or on load tap changing method. Explain with suitable diagram and switching sequences how off load tap changing is implemented. [2]

2. a. A generating station for a power system consists of four 120-MVA 15-kV 0.85-PF-lagging synchronous generators with identical speed droop characteristics operating in parallel. The governors on the generators' prime movers are adjusted to produce a 3-Hz drop from no load to full load. Three of these generators are each supplying a steady 75 MW at a frequency of 60 Hz, while the fourth generator (called the *swing generator*) handles all incremental load changes on the system while maintaining the system's frequency at 60 Hz. [4]

(i) At a given instant, the total system loads are 260 MW at a frequency of 60 Hz. What are the no-load frequencies of each of the system's generators?

(ii) If the system load rises to 290 MW and the generator's governor set points do not change, what will the new system frequency be?

(iii) To what frequency must the no-load frequency of the swing generator be adjusted in order to restore the system frequency to 60 Hz?

(iv) If the system is operating at the conditions described in part *(iii)*, what would happen if the swing generator were disconnected from the power line?

b. Induction motors are being used as induction generators for pico-hydro power plants in rural communities. With suitable diagrams explain how this is done and elaborate the need of capacitors for this purpose. [2]

c. A single-phase induction motor has no intrinsic starting torque. There are three major starting techniques to start these motors. Capacitor start and capacitor run techniques are one among them. With suitable connection diagrams and the speed versus torque curves differentiate between a capacitor start and capacitor run single phase induction motors.[2]

3. a. A 480-V, 50-Hz, Y -connected, six-pole synchronous generator is rated at 50 kVA at 0.8 PF lagging. It has a synchronous reactance of 1.0 Ω per phase. Assume that this generator is connected to a steam turbine capable of supplying up to 40 kW. The friction and windage losses are 1.5 kW, and the core losses are 1.0 kW. [4]

(i) Sketch the capability curve for this generator, including the prime-mover power limit.

(ii) Can this generator supply a line current of 56A at 0.7 PF lagging? Why or why not?

(iii) What is the maximum amount of reactive power this generator can produce?

(iv) If the generator supplies 30 kW of real power, what is the maximum amount of reactive power that can be simultaneously supplied?

b. A wound-rotor induction motor is operating at rated voltage and frequency with its slip rings shorted and with a load of about 25 percent of the rated value for the machine. If the rotor resistance of this machine is doubled by inserting external resistors into the rotor circuit, explain what happens to the following: (i) Slip s (ii) Motor speed n_m (iii) The induced voltage in the rotor (iv) The rotor current (v) τ_{ind} (vi) P_{out} (vii) P_{RCL} (viii) Overall efficiency η. [2]

c. To start a three-phase induction motor different methods are adopted. Describe the different methods of starting used for squirrel-cage induction motors. [2]

4. a. A 208-V, 60 Hz, six-pole Y-connected 25-hp design class B induction motor is tested in the laboratory, with the following results:

No load:	208 V,	22.0 A,	1200 W,	60 Hz
Locked rotor:	24.6 V,	64.5 A,	2200 W,	15 Hz
DC test:	13.5 V,	64 A		

Assume, $X_1 = 0.4X_{LR}$ and $X_2 = 0.6X_{LR}$ for design class B induction motors. Find the equivalent circuit of this motor. [4]

b. The arrangement of stator phase windings in slots may be of different types. Distributed winding is one of the types for the stator phase connections. Describe about distributed winding connection with a diagram showing the three phase distributed winding connection. [2]

c. When a synchronous generator is connected to an infinite bus the frequency of the infinite bus remains unchanged. With a proper house diagram explain what happens to the system load if the governor set points of the synchronous generator are increased. [2]

5. a. A three phase 400V induction motor gave the following test readings:

No load:	400V	6A	p.f. = 0.087
Short circuit:	100V	12A	720W

Draw the circle diagram. If the normal rating is 5.6kW, find from the circle diagram, the line current, power factor, efficiency and slip at full load. Also determine the $\frac{maximum\ torque}{full\ load\ torque}$, and maximum output power from the motor. Assume the rotor copper loss is half the total copper loss. [6]

b. The frequency of a synchronous generator is to be maintained despite of the load changes. Explain the two different frequency control approaches, speed governor control and load governor control to maintain the frequency of the generator with suitable diagrams. [2]

6. a. A 480-V, 100-kW, 50-Hz, four-pole, Y-connected synchronous motor has a rated power factor of 0.85 leading. At full load, the efficiency is 91 percent. The armature resistance is 0.08 Ω, and the synchronous reactance is 1.0 Ω. Find the input power and the power converted from electrical to mechanical. [2]

b. If a load is attached to the shaft of a synchronous motor, the motor will develop enough torque to keep the motor and its load turning at a synchronous speed. If the load on the shaft of the motor is increased there is a change in the motor's performance. Explain the effect of load increment on a synchronous motor, using its phasor diagrams. [2]

c. A 50-kW, 440-V, 50-Hz, six-pole induction motor has a slip of 6 percent when operating at full-load conditions. At full-load conditions, the friction and windage losses are 300 W, and the core losses are 600 W. Find the following values for full-load conditions: (i) the shaft speed n_m (ii) the output power in watts (iii) the load torque τ_{load} in Newton-meters (iv) the induced torque τ_{ind} in Newton-meters. [2]

d. A simple power system is shown in figure-2. The system consists of a 480V generator connected to an ideal 1:10 step-up transformer, a transmission line, an ideal 20:1 step down transformer and a load. The impedance of the transmission line is 20+j60Ω, and the impedance of the load is $10\angle 30°\Omega$. The base values for this system are chosen to be 480V and 10kVA at the generator. Find the per unit equivalent circuit of this system. [2]

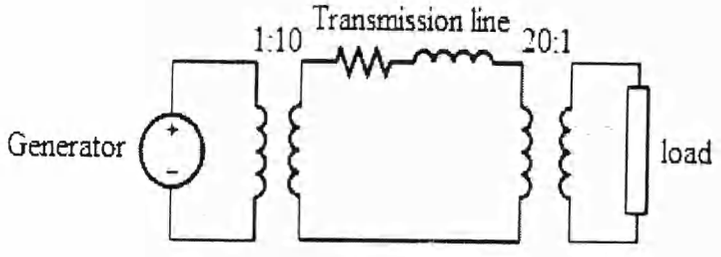

Figure-2