KATHMANDU UNIVERSITY
End Semester Examination
January/February 2024

Level : B.E.
Year : III
Time : 2 hrs. 30mins.

22 JAN 2024

Course : EPEG 302
Semester : I
F. M. : 40

SECTION "B"
[4 Q × 10 = 40 marks]

Attempt *ANY FOUR* questions. *Assume any suitable data if required.*

1.

a. 13.8-kV, 50-MVA, 0.9 power-factor-lagging, 60-Hz, four-pole Y-connected synchronous generator has a synchronous reactance of 2.5 Ohm and an armature resistance of 0.2 Ohm. At 60 Hz, its friction and windage losses are 1 MW, and its core losses are 1.5 MW. The field circuit has a dc voltage of 120 V, and the maximum field current is 10 A. The current of the field circuit is adjustable over the range from 0 to 10 A. The OCC of this generator is shown in Figure 1.

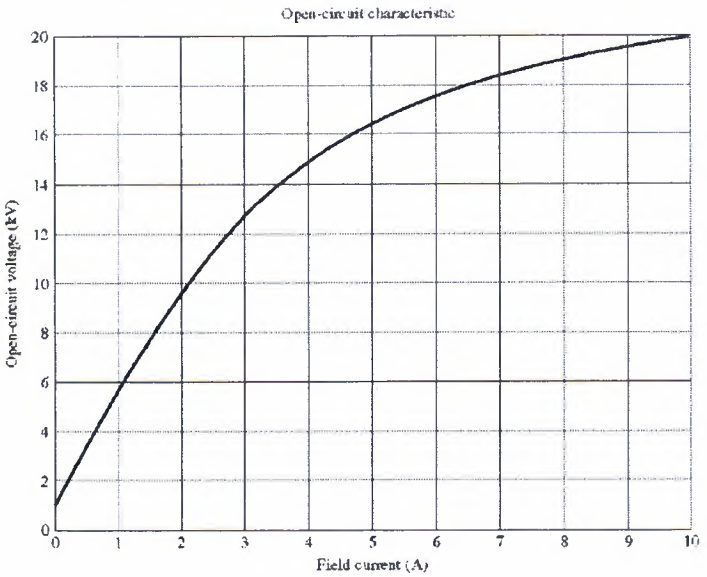

Figure 1. OCC curve for question 1 (a)

i. How much field current is required to make the terminal voltage, V_T (or line voltage) equal to 13.8 kV when the generator is running at no load? What is the internal generated voltage E_A of this machine at rated conditions? What is the phase voltage V_P of this generator at rated conditions? [1]

ii. How much field current is required to make the terminal voltage V_T equal to 13.8 kV when the generator is running at rated conditions? [1]

iii. Suppose that this generator is running at rated conditions, and then the load is removed without changing the field current. What would the terminal voltage of the generator be? [1]

iv. How much steady-state power and torque must the generator's prime mover be capable of supplying to handle the rated conditions? [1]

b. Explain with a suitable diagram, the operating principle of a synchronous motor. [3]

c. The internal generated voltage of a 2-pole, delta-connected, 60 Hz, three phase synchronous generator is 14.4 kV, and the terminal voltage is 12.8 kV. The synchronous reactance of this machine is 4 Ohm, and the armature resistance can be ignored. [3]

i. If the torque angle of the generator $\delta = 18°$, how much power is being supplied by this generator at the current time?

ii. What is the power factor of the generator at this time? Sketch the phasor diagram under these circumstances.

iii. Ignoring losses in this generator, what torque must be applied to its shaft by the prime mover at these conditions?

2.

a. 480-V, 250-kVA, 0.8-PF-lagging, two-pole, three-phase, 60-Hz synchronous generator's prime mover has a no-load speed of 3650 r/min and a full-load speed of 3570 r/min. It is operating in parallel with a 480-V, 250-kVA, 0.85 PF lagging, four-pole 60-Hz synchronous generator whose prime mover has a no load speed of 1800 r/min and a full-load speed of 1780 r/min. The loads supplied by the two generators consist of 300 kW at 0.8 PF lagging. [4]

i. Calculate the speed droops of generator 1 and generator 2.

ii. Find the operating frequency of the power system.

iii. Find the power being supplied by each of the generators in this system.

iv. What must the generator's operators do to adjust the operating frequency to 60 Hz? If the current line voltage is 460 V, what must the generator's operators do to correct for the low terminal voltage.

b. Explain with a phasor diagram to obtain the "V" curve for a synchronous generator. [3]

c. Explain the effect of armature reaction considering lagging and leading loads for an alternator with aid of a phasor diagram. [3]

3.

a. The power crossing the air gap of a 60 Hz, four-pole induction motor is 25 kW, and the power converted from electrical to mechanical form in the motor is 23.2 kW. [3]

i. What is the slip of the motor at this time?

ii. What is the induced torque in this motor?

iii. Assuming that the mechanical losses are 300 W at this slip, what is the load torque of this motor?

b. Explain the working principle of a Scott connection transformer. Obtain a phasor diagram for the T-T connected transformer with unity power factor loads on transformer secondary sides. [4]

c. Describe with a phasor and connection diagram, the parallel operation of two three phase transformers having +30 degree and -30 degree phase shift respectively. [3]

4.

a. Plot the torques-slip characteristic curve of a three phase induction motor and explain the motoring, generating and plugging mode of operation. [3]

b. Explain the relationship between effect of unity and lagging power factor on the developed torque in a three phase induction motor. [3]

c. A 208-V four-pole 60-Hz Y-connected wound-rotor induction motor is rated at 30 hp. Its equivalent circuit components are

R_1 = 0.100 Ohm *R_2 = 0.070 Ohm* *X_M = 10.0 Ohm*
X_1 = 0.210 Ohm *X_2 = 0.210 Ohm*
Pmechanical = 500 W *Pcore = 400 W*

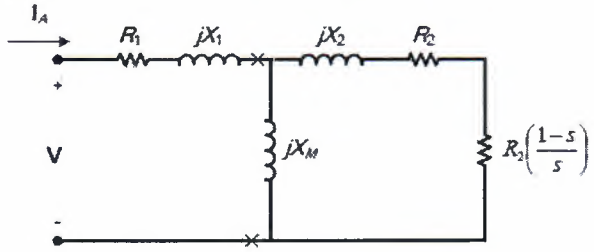

Figure 2. Equivalent circuit for 3 (c)

For a slip of 0.05, find [4]

i. The line current, I_L, stator copper losses, P_{SCL} ,air-gap power, P_{AG}, power converted from electrical to mechanical form, P_{conv}
ii. The induced torque T_{ind} , load torque T_{load}
iii. The overall machine efficiency, and motor speed in revolutions per minute.

5.

a. Two three transformers are connected in parallel. The load 1200 kVA at 0.95 p.f. is to be shared by them. Determine how the load will be shared when transformer 1 has percentage resistance and percentage reactance 1.5% and 4.2% respectively and the transformer 2 has percentage resistance and percentage reactance 1.8% and 4.6% respectively. [3]

b. Two synchronous generators named 'Gen-A', and 'Gen-B' are to be operated in parallel mode. Gen-B is operated at first, therefore, setting the system frequency. Consider two cases with constant excitation: [4]

i. Gen-A is connected at a frequency below the frequency of Gen-B.
ii. Gen-A is connected at frequency slightly above frequency of Gen-B.

Describe the conditions with the frequency (f) versus real power (P_G) diagram or house diagram for the parallel operation of both synchronous generators in the above cases.

c. Write short notes on: [1.5+1.5=3]

i. Induction motor as generator.
ii. Synchronous condenser.

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SECTION "A"
[20Q. × 0.5 = 10 marks]

Choose and encircle in the most appropriate option from each set of choices.

1. The voltage drop in an alternator occurs in
   a. Armature resistance only
   b. Armature resistance and leakage reactance
   c. Armature resistance, leakage reactance and armature reaction
   d. Armature resistance, leakage reactance, armature reaction and earth connections

2. As the speed of an alternator increases the
   a. frequency increases
   b. frequency remains constant but power factor decreases
   c. reactive power increases.
   d. torque decreases.

3. The armature reaction of an alternator influences
   a. Windage losses
   b. Operating speed
   c. Generated voltage per phase
   d. Waveform of generated voltage

4. The active power output of an alternator is 40 kW and the VAR component is -25. The value of the power factor angle will be
   a. 0.625 lagging b. 0.625 leading c. 0.375 leading d. 0.375 lagging

5. If the prime mover of the alternator is kept constant but the excitation is changed then the
   a. Reactive component of the output is changed
   b. Active component of the output is changed
   c. Power factor of the load remains constant
   d. Both active and reactive component is changed

6. The following statement/s is/are incorrect for a synchronous motor
   I. It has starting torque.
   II. It speed varies from no load to full load.
   III. It can operate at lagging, leading and zero power factors.
   a. I, II and III b. Only II c. Only III d. I and II

7. Two similar synchronous generators are working in parallel to supply a common load demand with identical excitations and steam supplies to their prime movers. Now, if the steam supply to the prime mover of one of the generators is increased compared to the other, with field excitation kept unchanged, then
   a. its active power component will remain the same but the reactive power contribution will increase.
   b. its active power will decrease while the reactive power will increase.
   c. both active and reactive components of power will increase.
   d. its active power contribution will increase but reactive power contributions of both will remain unchanged.

8. When two alternators are operating in parallel, if the power input to one of the alternators is cut off, the alternator will
   a. continue to run as a synchronous motor rotating in the same direction.
   b. continue to run as a synchronous motor rotating in opposite direction.
   c. stop running.
   d. get damaged due to burning of stator and rotor windings.

9. If the excitation of an alternator connected to an infinite bus-bar is changed, keeping the power input to its prime mover unchanged, its ..... will change.
   a. kW output b. power-factor c. kVA output d. kVAR output

10. The current source 30 Ampere per phase is applied to an induction motor, having per phase parameter of the machine given as:
   Stator resistance, $R_1 = 4\Omega$, *Stator reactance,* X_1 = *Rotor reactance,* $X_2 = j1\Omega$,
   Rotor resistance, $R_2 = 0.4\Omega$, *Magnetizing reactance,* $X_m = j50\Omega$
   The value of slip at which maximum torque occurs is.....
   a. 0.4 b. 0.00784 c. 0.2 d. 0.7

11. In a double cage induction motor, the inner cage has
   a. High resistance and high leakage reactance.
   b. High resistance and low leakage reactance.
   c. Low resistance and zero leakage reactance.
   d. Low resistance and high leakage reactance.

12. The following statement/s in regard to the induction motor is/are correct
   A. Maximum torque is independent of rotor resistance.
   B. Starting torque is maximum when rotor resistance equals rotor reactance.
   C. torque is very sensitive to any change in supply voltage.
   a. A and B b. A and C c. B and C d. A, B and C

13. Induction generator delivers power at ..... power factor.
   a. Lagging b. Leading c. Unity d. Zero

14. In an induction motor, if the rotor is locked, the rotor frequency of induction motor will be
   a. Equal to the supply frequency b. Less than the supply frequency
   c. More than the supply frequency d. Zero

15. Blocked rotor test of an induction motor corresponds, in case of a transformer, to
a. full load b. half-full load c. no load d. short-circuit operation

16. The ..... connection is used for a distribution transformer in Nepal.
a. Star - Delta b. Delta - Star c. Star - Star d. Delta – Delta

17. A single phase transformer of 2200/220 V having rated l.v. current of 150 A has to undergo open circuit test on h.v side. The instruments used are voltmeter of 200V and ammeter of 1A. Then the results _____
a. will be wrong b. will be accurate
c. of ammeter will burn d. none of the mentioned

18. If all other requirements for parallel operation of transformers are fulfilled, which one of the following pairs of three-phase transformers, with the given VECTOR GROUPS, can be operated in parallel?
a. Yd1 and Yy0 b. Yd1 and Dy11
b. Dd6 and Dy1 d. Dd0 and Dy11

19. A three phase transformer, connected in star-delta is compose of three single phase transformers each rated 127 / 13.2 kV. The line to line voltage ratio for the three phase transformer is .....
a. 220 / 13.2 kV b. 127 / 13.2 kV c. 127 / 220 kV d. 220 / 220 kV

20. There is a phase difference of ..... between the corresponding phases of primary and secondary ..... in a star / delta transformer.
a. 30 degrees, voltage b. 60 degrees, voltage
c. Zero degree, current d. 30 degree, current