KATHMANDU UNIVERSITY
End-Semester Examination
February/March, 2019

Marks Scored:

Level : B.E.
Year : III
Course : EPEG 302
Semester: I

Exam Roll No.:
Time : 30 mins.
F.M. : 10

Registration No.:
Date FEB 2 0 2019

SECTION "A"
[20 Q x 0.5=10 marks]

Choose the most appropriate answer.

1. The neutral terminal is fundamental to three phase star to star connection for
   a. Suppression of harmonics.
   b. Passage of unbalanced currents due to unbalanced loads.
   c. Provision of dual electric service.
   d. Balancing of phase voltage with respect to line voltages.

2. A load of 500 kVA at 0.8 power factor lagging is to be shared by two three phase transformers A and B of equal ratings. If the equivalent delta impedances as referred to secondary are (2+j6) Ω for A and (2+j5) Ω for B, the load supplied by transformer A is
   a. $230.7 \angle 38.7^0$.
   b. $230.7 \angle -38.7^0$.
   c. $270 \angle 40.28^0$.
   d. $270 \angle -40.28^0$.

3. A three phase, 50 Hz transformer has a delta connected primary and star connected secondary, the line voltage being 22,000V and 400V respectively. The secondary has a star connected balanced load at 0.8 power factor lagging. The line current on the primary side is 5A. The phase current in each coil of primary and in each secondary line are respectively
   a. $5/\sqrt{3}$A and 275 A.
   b. 5A and 275 A.
   b. $5/\sqrt{3}$A and $275/\sqrt{3}$ A.
   d. 5 A and $275/\sqrt{3}$ A.

4. The tapping are provided in three phase transformer at
   a. At the phase end of LV side.
   b. At the phase end of HV side.
   c. At the neutral side end of HV side.
   d. At the middle of HV side.

5. Sandwich windings are implemented in
   a. Core type transformer.
   b. Shell type transformer.
   c. Distribution transformer.
   d. Power transformer.

6. In a core type transformer
   a. HV winding is placed near to the core limb.
   b. LV winding is placed near to the core limb.
   c. Any of the HV or LV winding can be placed near to the core limb.
   d. HV and LV windings are placed in different core limbs.

7. Breather is provided in transformers to
   a. Absorb moisture of air during breathing.
   b. Provide cold air in transformer.
   c. Absorb moisture in air entering transformer.
   d. Filter the transformer oil.

8. A squirrel cage induction moor runs at constant speed only so long as
   a. Torque developed by it remains constant.
   b. Its supply voltage remains constant.
   c. Its torque exactly equals the mechanical load.
   d. Stator flux remains constant.

9. When applied rated voltage per phase is reduced by one half, the starting torque of an induction motor becomes ..... of the starting torque with full voltage.
   a. 1/2. b. 1/4. c. $1/\sqrt{2}$. d. $\sqrt{3}/2$.

10. A 6 pole, 50 Hz three phase induction motor is running at 950 rpm and has a rotor copper loss of 5 kW. Its motor input is
   a. 100 kW. b. 10 kW. c. 95 kW. d. 5.3 kW.

11. Pull out torque of a squirrel cage induction motor occurs at that value of slip, where rotor power factor equals
   a. Unity. b. 0.707. c. 0.866. d. 0.5.

12. A three phase, 4 pole, 50 Hz induction motor runs at a speed of 1440 rpm. The rotating field produced by the rotor at a speed of ..... rpm with respect to the stator
   a. 1500 rpm. b. 1440 rpm. c. 60 rpm. d. 0 rpm.

13. The torque developed by a three phase induction motor depends upon
   a. Speed, frequency and number of poles.
   b. Voltage, current and stator impedances.
   c. Synchronous speed, rotor speed and frequency.
   d. Rotor emf, rotor current and rotor pf.

14. The star connected rotor of an induction motor has a standstill impedance of (0.4+j4) ohm per phase and the rheostat impedance per phase is (6+j2) ohm. The motor has an induced emf of 80V between slip rings a standstill when connected to its normal supply voltage. The rotor current at standstill is
   a. $5.27\ A \angle 43.15^0$. b. $5.27\ A \angle -43.15^0$.
   c. Infinite. d. $3.32\ A \angle -16.7^0$.

15. A double squirrel cage induction motor has outer cage of higher resistance metal bars primarily for the purpose of increasing its
   a. Speed regulation. b. Starting torque.
   c. Efficiency. d. Starting current.

16. In a circle diagram of an induction motor, point of maximum point lies on the tangent drawn parallel to
    a. Output line.
    b. Torque line.
    c. Vertical axis.
    d. Horizontal axis.

17. In a synchronous motor the magnitude of stator back e.m.f depends on
    a. Speed of the motor.
    b. Load on the motor.
    c. Both the speed and rotor flux.
    d. DC excitation only.

18. A synchronous machine is called doubly excited machine because
    a. It can be overexcited.
    b. It has two set of rotor poles.
    c. Both its stator and rotor are excited.
    d. It needs twice the normal exciting current.

19. Synchronous capacitor is
    a. An ordinary static capacitor bank.
    b. An over excited synchronous motor driving mechanical load.
    c. An over excited synchronous motor running without mechanical load.
    d. An under excited synchronous motor running without mechanical load.

20. Two water turbine driven identical alternators are running in proper synchronism and carry equal loads. If excitation of one alternator is increased without changing its input water turbine supply
    a. It will keep supplying same load.
    b. kVAR supplied by it would decrease.
    c. Its power factor will increase.
    d. kVA supplied by it would decrease.

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SECTION "B"

[5 Q.×8=40 marks]

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

1.

a. 480-V, 60 Hz, 400-hp 0.8 pf leading 8-pole Δ connected synchronous motor has a synchronous reactance of 0.6 Ω and negligible armature resistance. Assume that emf, $\mathbf{E}_A$ is directly proportional to the field current I_F and that $\mathbf{E}_A$= 480 V when, I_F= 4 A.

i. What is the speed of this motor?

ii. If this motor is initially supplying 400 hp at 0.8 PF lagging, what are the magnitudes and angles of $\mathbf{E}_A$ and $\mathbf{I}_A$?

iii. How much torque is this motor producing? What is the torque angle, δ? How near is this value to the maximum possible induced torque of the motor for this field current setting?

iv. If $\mathbf{E}_A$ is increased by 30 percent, what is the new magnitude of the armature current? What is the motor's new power factor?

[1+1+1+1]

b. Explain the effect of an increase in the load on operation of a synchronous motor with the aid of a phasor diagram. What happens when synchronous motor is operated with no load? [2+2]

2.

a. Three physically identical synchronous generators are operating in parallel. They are all rated for a full load of 100 MW at 0.8 pf lagging. The no-load frequency of generator A is 61 Hz, and its speed droop is 3 percent. The no-load frequency of generator B is 61.5 Hz, and its speed droop is 3.4 percent. The no load frequency of generator C is 60.5 Hz, and its speed droop is 2.6 percent.

i. If a total load consisting of 230 MW is being supplied by this power system, what will the system frequency be and how will the power be shared among the three generators?

ii. Develop an equation showing the system frequency as a function of the total power supplied to all loads.

[2+1]

b. A dc current must be supplied to the field circuit on the rotor and since the rotor is rotating, a special arrangement is required to get the dc power to its field windings. Explain about the brushless exciter circuit approach employed on the rotor windings to generate field flux of the machine. [2]

c. Explain the effect of armature reaction on a synchronous generator for leading power factor loads, lagging power factor loads and unity power factor loads. [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.
   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?

[1+1+1]

b. A 460V, four pole, 75-hp 60-Hz, Y-connected three-phase induction motor develops its full-load inducedtorque at 3.5percent slip when operating at 60 Hz and 460 V. The per-phase circuit model impedances of the motor are

$R_1 = 0.058\ \Omega$ $X_M = 18\ \Omega$
$X_1 = 0.32\ \Omega$ $X_2 = 0.386\ \Omega$

Mechanical, core, and stray losses are neglected.
   i. Find the value of rotor resistance, R_2.
   ii. Find maximum torque, maximum slip, and the rotor speed at maximum torque for this motor.
   iii. Find the starting torque of this motor.

[1+1+1]

c. Derive the induction motor induced torque equation using Thevenin's Theorem to the per phase equivalentcircuit of the induction motor. [2]

4.

a. 220-V 1.5-hp 50-Hz six-pole capacitor-start induction motor has the following main winding impedances:
$R_1 = 1.30\ \Omega$ $X_1 = 2.01\ \Omega$ $X_M = 105\ \Omega$
$R_2 = 1.73\ \Omega$ $X_2 = 2.01\ \Omega$
At a slip of 0.05, the motor's rotational losses are 291 W. The rotational losses may be assumed constant over the normal operating range of the motor. Find the following quantities for this motor at 5 percent slip,
   i. Stator current, stator power factor.
   ii. Input power, air gap power, converter power and output power.
   iii. Induced torque, load torque and efficiency.
   iv. Draw the equivalent circuit of the motor.

[1+1+1+1]

b. Explain the V-curve characteristic of a synchronous generator showing the effect of change in field current supplying constant loadwith the aid of a phasor diagram indicating load angle, δ, power factor angle, φ, armature current, I_a, e.m.f, E_A and synchronous reactance, X_s. [4]

5.

a. 14,400/480-V three-phase Y-Δ-connected transformer bank consists of three identical 100-kVA 8314/480-V transformers. It is supplied with power directly from a large constant-voltage bus. In the short-circuit test, the recorded values on the high-voltage side for one of these transformers are

V_{SC}= 510 V I_{SC} = 12.6 A P_{SC}= 3000 W

i. If this bank delivers a rated load at 0.8 PF lagging and rated voltage, what is the line-to-line voltage on the primary of the transformer bank?

ii. What is the voltage regulation under these conditions?

[2+1]

b. A 13.8-kV single-phase generator supplies power to a load through a transmission line. The load's impedance is Z_{load}= 500 $\angle 36.87^0$, and the transmission line's impedance is $Z_{line} = 60 \angle 60^0$.

i. If the generator is directly connected to the load as presented in Figure 1, what is the ratio of the load voltage to the generated voltage? What are the transmission losses of the system?

ii. What percentage of the power supplied by the source reached the load and what is the efficiency of the transmission system?

iii. If a 1:10 step-up transformer is placed at the output of the generator and a 10:1 transformer is placed at the load end of the transmission line as shown in Figure 2, what is the new ratio of the load voltage to the generated voltage? What are the transmission losses of the system now? (Note: The transformers may be assumed to be ideal.)

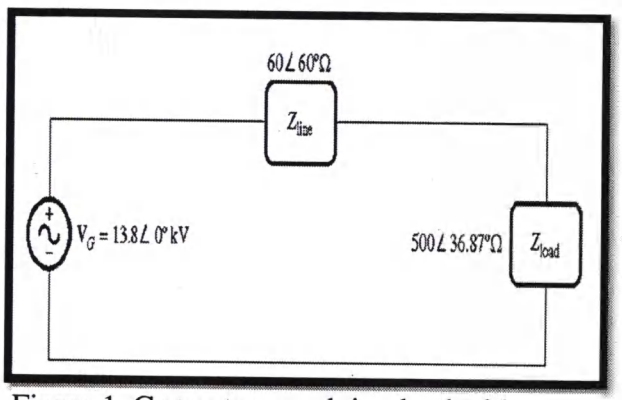

Figure 1. Generator supplying load with no transformer

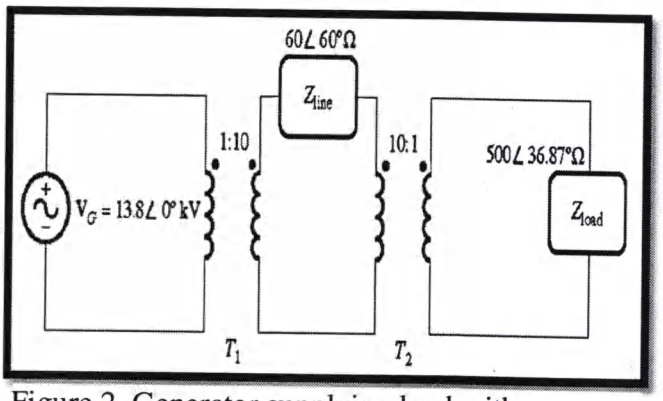

Figure 2. Generator supplying load with transformer

iv. What percentage of the power supplied by the source reached the load now?
v. Compare the efficiencies of the transmission system with and without transformers.

[1+1+1+1+1]

6.

a. Obtain the expression for power developed by a cylindrical rotor synchronous generator.

[2]

b. A synchronous motor is drawing 50 A from 400 V, three-phase Y supply at unity pf with a field current of 0.9. The synchronous reactance of the motor is 1.3 Ω.
   i. Find the power angle.
   ii. With the mechanical load remaining constant, find the value of the field current which would result in 0.8 leading power factor. Assume linear magnetization.

[1 + 1]

c. A small industrial plant is supplied by an external 480 V three-phase power supply. The plant includes three main loads. Load 1 is 100 kW induction motor running a 0.9 power factor lagging and load 2 is 80 kVA induction motor running at 0.8 power factor lagging. Load 3 is a synchronous motor and is rated at 100 hp, 460 V, and 0.8 power factor leading. The synchronous reactance is 1.1 pu and armature resistance is 0.01 pu.
   i. If the switch on the synchronous motor is open, how much real, reactive, and apparent power isbeing supplied to the plant? What is the current in the transmission line?
   ii. The switch is now closed and the synchronous motor is supplying rated power at rated power factor. How much real, reactive, and apparent power is being supplied to the plant? What is the currentin the transmission line?

[2 + 2]