# Information Technology University, Lahore

## Electrical Machines

## BSEE-19 Fall 2021

## Assignment No. 5

## CLO-3

**Issue Date: Saturday 29. 1, 2022**

**Due Date: Saturday 5. 2, 2022 (Upload on Google classroom before 5:00 pm)**

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**CLO1:** Understand fundamental theories and laws on magnetics & magnetically coupled circuits.

**CLO2:** Understand the operation of Transformers, synchronous machines, induction motors and DC machines.

**CLO3:** Perform the equivalent circuit Analysis of transformers, AC Machines and DC machines.

**Carefully Read Instructions**

1. Please review the University Plagiarism Policy.
2. Late submission will not be accepted.
3. Assignment should be upload as pdf file.
4. The name of file should be your Roll Number as BSEEXXXX.
5. Handwriting must be very neat and legible. You may lose points otherwise.
6. Please submit your own work only.
7. Please show all steps for full credit.

**Question 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 Ω and an armature resistance of 0.2 Ω. 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 $I_F$ is 10 A. The current of the field circuit is adjustable over the range from 0 to 10 A. Assume that the field current of the generator is adjusted to a value of 5 A. The OCC of this generator is shown in Figure 1.

a) What will the terminal voltage of this generator be if it is connected to a Δ-connected load with an impedance of $24 \angle 25^\circ \Omega$ ?
b) Sketch the phasor diagram of this generator.
c) What is the efficiency of the generator at these conditions?

d) 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?
e) What is the new terminal voltage after the load has been added?
f) What must be done to restore the terminal voltage to its original value?

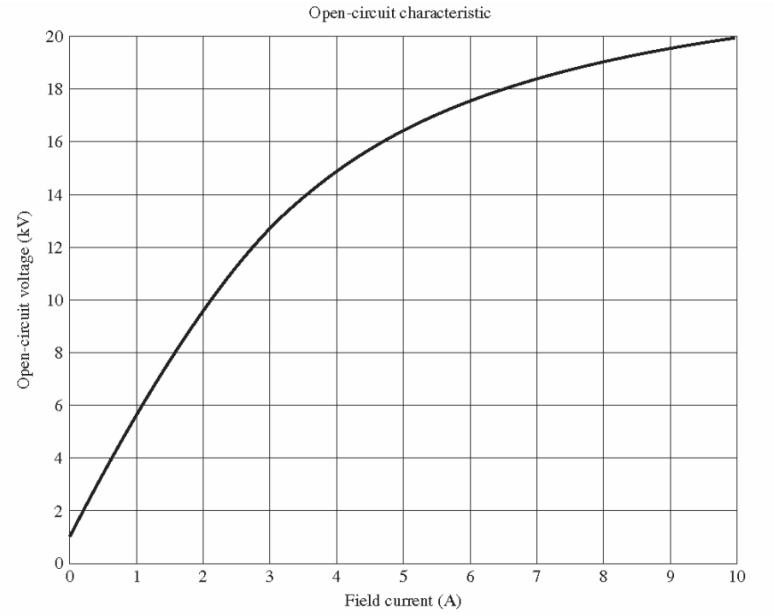


**Figure 1**

**Question 2** A 200-MVA, 12-kV, 0.85-PF-lagging, 50-Hz, 20-pole, Y-connected water turbine generator has a per unit synchronous reactance of 0.9 and a per-unit armature resistance of 0.1. This generator is operating in parallel with a large power system (infinite bus).

a) What is the speed of rotation of this generator's shaft?
b) What is the magnitude of the internal generated voltage $E_A$ at rated conditions?
c) What is the torque angle of the generator at rated conditions?
d) What are the values of the generator's synchronous reactance and armature resistance in ohms?
e) If the field current is held constant, what is the maximum power possible out of this generator? How much reserve power or torque does this generator have at full load?

f) At the absolute maximum power possible, how much reactive power will this generator be supplying or consuming? Sketch the corresponding phasor diagram. (Assume $I_F$ is still unchanged.)

**Question 3** A 460-V 60-Hz four-pole Y-connected induction motor is rated at 25 hp. The equivalent circuit parameters are

$R_1 = 0.15\ \Omega$ $R_2 = 0.154\ \Omega$

$X_M = 20\ \Omega$ $X_1 = 0.852\ \Omega$ $X_2 = 1.066\ \Omega$

$P_{F\&W} = 400$ W $P_{misc} = 150$ W $P_{core} = 400$ W

For a slip of 0.02, find

a) The line current $I_L$
b) The stator power factor
c) The rotor power factor
d) The rotor frequency
e) The stator copper losses $P_{SCL}$
f) The air-gap power $P_{AG}$
g) The power converted from electrical to mechanical form $P_{conv}$
h) The overall machine efficiency $\eta$

**Question 4** A 208-V four-pole 60-Hz Y-connected wound-rotor induction motor is rated at 30 hp. Its equivalent circuit components are

$R_1 = 0.100\ \Omega$ $R_2 = 0.070\ \Omega$

$X_M = 10.0\ \Omega$ $X_1 = 0.210\ \Omega$ $X_2 = 0.210\ \Omega$

$P_{mech} = 500$ W $P_{misc} \approx 0$ $P_{core} = 400$ W

For a slip of 0.05, find

a) The line current $I_L$
b) The stator copper losses $P_{SCL}$
c) The air-gap power $P_{AG}$
d) The power converted from electrical to mechanical form $P_{conv}$
e) The induced torque $\tau_{ind}$
f) The load torque $\tau_{load}$