

Name and ID

Honor pledge

I promise that I will not give or receive any unauthorized help on this exam, and that all work will be mine.

☐ Yes

☐ No

☐ Abstain

Name and signature

1) A 208 V, 60 Hz, 100 kVA, 0.85 PF lagging, 4-pole, delta-connected *synchronous* generator has a synchronous reactance of $X_s=0.4\ \Omega$ and an armature resistance of $R_A=0.05\ \Omega$. Rotational losses are 7 kW. Suppose the machine is connected to an infinite bus (hence the terminal voltage is fixed) and it is running at the rated conditions.

a) What is the rotor speed in rpm? (3 points)

b) Calculate the phase current (I_A) and line current (I_L) magnitudes. (5 points)

c) Calculate the magnitude and phase of the internal voltage (back emf) \bar{E}_A . (8 points)

d) Calculate the converted power and the induced torque. (8 points)

e) Calculate the generator efficiency. (8 points)

- 2) A three-phase, 460 V, 4-pole, 60 Hz, 1750 rpm, Y-connected, wound-rotor induction motor has rotational losses of 1200 W and the following per-phase equivalent circuit parameters:

$$R_1=0.3 \, \Omega, \quad R_2=0.25 \, \Omega, \quad X_1=X_2=0.5 \, \Omega, \quad X_M=25 \, \Omega$$

Assume the rotor windings are short circuited. Find

- a) The speed of rotation of the magnetic field created by the stator currents with respect to the stator (in rpm),

the speed of rotation of the magnetic field created by the rotor currents with respect to the stator (in rpm),

the speed of rotation of the magnetic field created by the rotor currents with respect to the rotor (in rpm),

full-load (rated) slip,

the frequency of the rotor currents at full-load conditions (10 points)

b) Stator current, rotor current, and induced torque (τ_{ind}) at full-load condition (12 points)

c) Output power, input power, and efficiency at the rated conditions (9 points)

- d) The maximum induced torque and the slip at which maximum torque occurs (Use the approximate values of R_{TH} , V_{TH} and S_{max} for ease of calculations). (11 points)

3) Multiple-choice questions (Select one choice only; 2 point each)

3.1. The rated speed of a three-phase, 6-pole, 50 Hz cage induction motor is more likely to be

- a) 1000 rpm b) 950 rpm c) 3000 rpm d) 2850 rpm

3.2. The rated current of a cage induction motor is 100 A. In steady state, when the motor is supplied with rated stator voltage and runs at no load (no mechanical load is coupled to the motor), the motor current is more likely to be

- a) 2 A b) 20 A c) 100 A d) 500 A

3.3. The rated current of a cage induction motor is 100 A. When the motor is supplied with rated stator voltage, the motor starting current is more likely to be

- a) 2 A b) 20 A c) 100 A d) 500 A

4) True/False questions (2 point each)

Next to each statement write T (True) or F (False).

- a) ---- In the equivalent circuit of the synchronous generator, the voltage E_A models the voltage induced in the stator windings due to the flow of currents in the stator.
- b) ---- The BEMF of a synchronous generator varies linearly with the rotor speed.
- c) ---- The BEMF of a synchronous generator varies linearly with the field flux.
- d) ---- When the stator terminals of a synchronous generator are open, the voltage measured at the terminals is the BEMF.
- e) ---- The steady state stability limit of a synchronous generator is reached when the power angle becomes zero.
- f) ---- Induction motors are also called asynchronous machines because the magnetic fields of the stator and rotor rotate at different speeds.
- g) ---- At no-load condition, the slip of an induction motor is very close to 0.
- h) ---- In a cage induction motor, the rotor Ohmic resistance at starting is larger than its Ohmic resistance in the full load conditions.
- i) ---- In a cage induction motor, the rotor leakage reactance at starting is larger than its leakage reactance in the full load conditions.
- j) ---- If the rotor resistance of an induction motor increases, the speed at which maximum torque occurs increases.