

INDUCTION MACHINES

1. A three-phase, 60 Hz induction motor runs at 1746 rpm when it delivers rated output power.
 - a) Determine the number of poles of the machine.
 - b) Determine the slip at full load.
 - c) Determine the frequency of the rotor current.
 - d) Determine the speed of the rotor field with respect to the
 - Stator;
 - Stator rotating field.

2. A three phase, 60 Hz, six-pole induction machine operates at 3% slip (positive) at full load.
 - a) Determine the speed of the motor and its direction relative to the rotating field.
 - b) Determine the rotor frequency.
 - c) Determine the speed of the stator field.
 - d) Determine the speed of the air gap field.
 - e) Determine the speed of the rotor field relative to
 - The rotor structure.
 - The stator structure.
 - The stator rotating field.

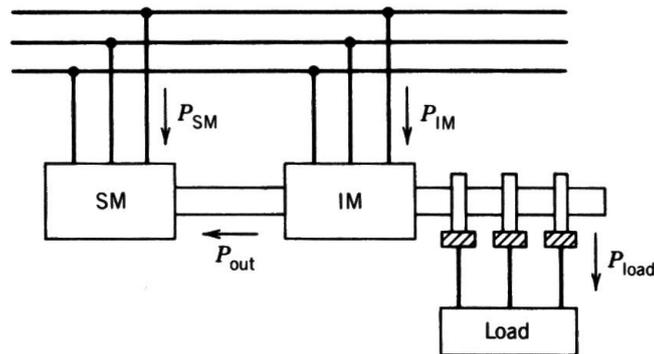
3. Repeat problem 2 if the induction machine is operated at 3% slip (negative).

4. Repeat problem 2 if the induction machine is operated at 150% slip (positive).

INDUCTION MACHINES – 2

5. A three-phase, six pole, 208 V, wound-rotor induction machine has a stator-to-rotor turns of 1:0.5 and both stator and rotor windings are connected in star.
- The stator of the induction machine is connected to a three-phase, 208 V, 60 Hz supply, and the motor runs at 1140 rpm.
 - Determine the operating slip.
 - Determine the voltage induced in the rotor per phase and frequency of the induced voltage.
 - Determine the rpm of the rotor field with respect to the rotor and with respect to the stator.
 - If the stator terminals are shorted and the rotor terminals are connected to a three phase, 208 V, 60 Hz supply and the motor runs at 1164 rpm,
 - Determine the direction of rotation of the motor with respect to that of the rotating field.
 - Determine the voltage induced in the stator per phase and its frequency.
6. The following test results are obtained from a three-phase, 460 V, eight-pole, star-connected squirrel-cage induction machine:
No-load test: 460 V, 60 Hz, 40 A, 4.2 kW
Blocked-rotor test: 100 V, 60 Hz, 140 A, 8.0 kW
Average dc resistance between two stator terminals is 0.152 Ω .
- Determine the parameters of the equivalent circuit.
 - The motor is connected to a three-phase, 460 V, 60 Hz supply, and runs at 873 rpm. Determine the input current, input power, air gap power, rotor copper losses, mechanical power developed, output power, and efficiency of the motor.

7. A three-phase wound rotor induction machine is mechanically coupled to a three-phase synchronous machine as shown in the figure. The synchronous machine has four poles and the induction machine has six poles. The stators of the two machines are connected to a three-phase, 60 Hz power supply. The rotor of the induction machine is connected to a three-phase resistive load. Neglect rotational losses and stator resistance losses. The load power is 1 p.u. and the synchronous machine rotates at the synchronous speed.
- The rotor rotates in the direction of the stator rotating field of the induction machine. Determine the speed, frequency, of the current in the resistive load and power taken by the synchronous machine and by the induction machine from the source.
 - Repeat a) if the phase sequence of the stator of the induction machine is reversed.



INDUCTION MACHINES – 3

8. A three-phase, 460 V, 60 Hz, eight-pole induction machine is driven by a wind turbine. The induction machine has the following parameters:

$$\begin{aligned} R_1 &= 0.015 \, \Omega; & R'_2 &= 0.035 \, \Omega; \\ L_1 &= 0.385 \, \text{mH}; & L'_2 &= 0.358 \, \text{mH}; & L_m &= 17.24 \, \text{mH}. \end{aligned}$$

The induction machine is connected to a 460V infinite bus through a feeder having a resistance of $0.01 \, \Omega$ and an inductance of $0.08 \, \text{mH}$. The wind turbine drives the induction machine at slip of -2.5% .

- a) Determine the speed of the wind turbine;
 - b) Determine the voltage at the terminals of the induction machine;
 - c) Determine the power delivered to the infinite bus and the power factor;
 - d) Determine the efficiency of the system. Assume the rotational and core losses to be 3 kW .
9. A three-phase, 460V, eight-pole wound-rotor induction motor controls the speed of a fan. The torque required for the fan varies as the square of the speed. At full load the motor slip is 0.03 with the slip rings short-circuited. The slip-torque relationship of the motor can be assumed to be linear from no load to full load. The resistance of each motor phase is $0.02 \, \Omega$. Determine the value of resistance to be added to each rotor phase so that the fan runs at 600 rpm .
10. A three-phase, 460V, 60Hz, four-pole wound-rotor induction motor develops full-load torque at a slip of 0.04 when the slip rings are short-circuited. The maximum torque it can develop is 2.5 p.u. The stator leakage impedance is negligible. The rotor resistance measured between two slip rings is $0.5 \, \Omega$.
- a) Determine the speed of the motor at maximum torque.
 - b) Determine the starting torque in per unit. (Full load torque is one per unit torque).
 - c) Determine the value of resistance to be added to each phase of the rotor circuit so that maximum torque is developed at the starting condition.
 - d) Determine the speed at full-load torque with the added rotor resistance of part c).