Construction, Starting and Reversing of 3-phase Induction Motors

Objective:

a. To study the construction of a 3-phase induction motor
b. To study the different starting methods of 3-phase induction motors
c. To study how to reverse the direction of rotation in a 3-phase induction motor.

Theory:

Construction:

The induction motor essentially consists of two parts:

- Stator
- Rotor.

The supply is connected to the stator and the rotor received power by induction caused by the stator rotating flux, hence the motor obtains its name -induction motor.

The stator consists of a cylindrical laminated & slotted core placed in a frame of rolled or cast steel. The frame provides mechanical protection and carries the terminal box and the end covers with bearings. In the slots of a 3-phase winding of insulated copper wire is distributed which can be wound for 2,4,6 etc. poles.

The *rotor* consists of a laminated and slotted core tightly pressed on the shaft. There are two general types of rotors:

- The squirrel-cage rotor,
- The wound (or slip ring) rotor.

In *the squirrel-cage rotor,* the rotor winding consists of single copper or aluminium bars placed in the slots and short-circuited by end-rings on both sides of the rotor.

In the *wound rotor,* an insulated 3-phasewinding similar to the stator winding and for the same number of poles is placed in the rotor slots. The ends of the star-connected rotor winding are brought to three slip rings on the shaft so theta connection can be made to it for starting or speed control.

Methods of Starting:

The most usual methods of starting 3-phase induction motors are:

1. For slip-ring motors- rotor resistance starting

2. For squirrel-cage motors
- direct-on -line starting
- star-delta starting
- Autotransformer starting.

There are two important factors to be considered in starting of induction motors:

♦ the starting current drawn from the supply, and
♦ The starting torque.

The starting current should be kept low to avoid overheating of motor and excessive voltage drops in the supply network. The starting torque must be about 50 to 100% more than the expected load torque t ensure that the motor runs up in a reasonably short time.

a. **Rotor resistance starting**

By adding eternal resistance to the rotor circuit any starting torque up to the maximum torque can be achieved; and by gradually cutting out the resistance a high torque can be maintained throughout the starting period. The added resistance also reduces the starting current, so that a starting torque in the range of 2 to 2.5 times the full load torque can be obtained at a starting current of 1 to 1.5 times the full load current.

b. **Direct-on-line starting**

This is the most simple and inexpensive method of starting a squirrel cage induction motor. The motor is switched on directly to full supply voltage. The initial starting current is large, normally about 5 to 7 times the rated current but the starting torque is likely to be 0.75 to 2 times the full load torque. To avoid excessive supply voltage drops because of large starting currents the method is restricted to small motors only.
To decrease the starting current cage motors of medium and larger sizes are started at a reduced supply voltage. The reduced supply voltage starting is applied in the next two methods.

c. **Star-Delta starting**

This is applicable to motors designed for delta connection in normal running conditions. Both ends of each phase of the stator winding are brought out and connected to a 3-phase change -over switch. For starting, the stator windings are connected in star and when the machine is running the switch is thrown quickly to the running position, thus connecting the motor in delta for normal operation.

The phase voltages & the phase currents of the motor in star connection are reduced to $1/\sqrt{3}$ of the direct -on -line values in delta. The line current is 1/3 of the value in delta.

A disadvantage of this method is that the starting torque (which is proportional to the square of the applied voltage) is also reduced to 1/3 of its delta value.

d. Auto-transformer starting

This method also reduces the initial voltage applied to the motor and therefore the starting current and torque. The motor, which can be connected permanently in delta or in star, is switched first on reduced voltage from a 3-phase tapped auto -transformer and when it has accelerated sufficiently, it is switched to the running (full voltage) position. The principle is similar to star/delta starting and has similar limitations. The advantage of the method is that the current and torque can be adjusted to the required value, by taking the correct tapping on the autotransformer. This method is more expensive because of the additional autotransformer.

Reversing:

Reversing the connections to any two of the three motor terminals can reverse the direction of rotation of 3-phase induction motor

Procedure

1. Study the construction and the various parts of the 3-phase induction motor.
2. For rotor resistance starting, connect the slip-ring motor as shown in FIG.1. Start the motor with full starting resistance and then decrease the resistance in steps down to zero. Take observations of the stator & rotor currents
3. For direct-on -line starting , connect the cage motor as shown in FIG.2
4. For star-delta starting , connect the cage motor to the terminals of the star-delta switch (FIG.3)
5. For autotransformer starting, connect the cage motor as shown in FIG.4. Take care at starting that the "Run" switch is open and that it is not closed before the "Start" switch is opened.
6. In each case observe the starting currents by quickly reading the maximum indication of the ammeters in the stator circuit.
7. Reverse the direction of rotation of the motor by reversing of two phases at the terminal box. The reversal has to be made when the motor is stopped and the supply switched off.

Report:

1. Explain the difference between a slip ring and a squirrel -cage motor.
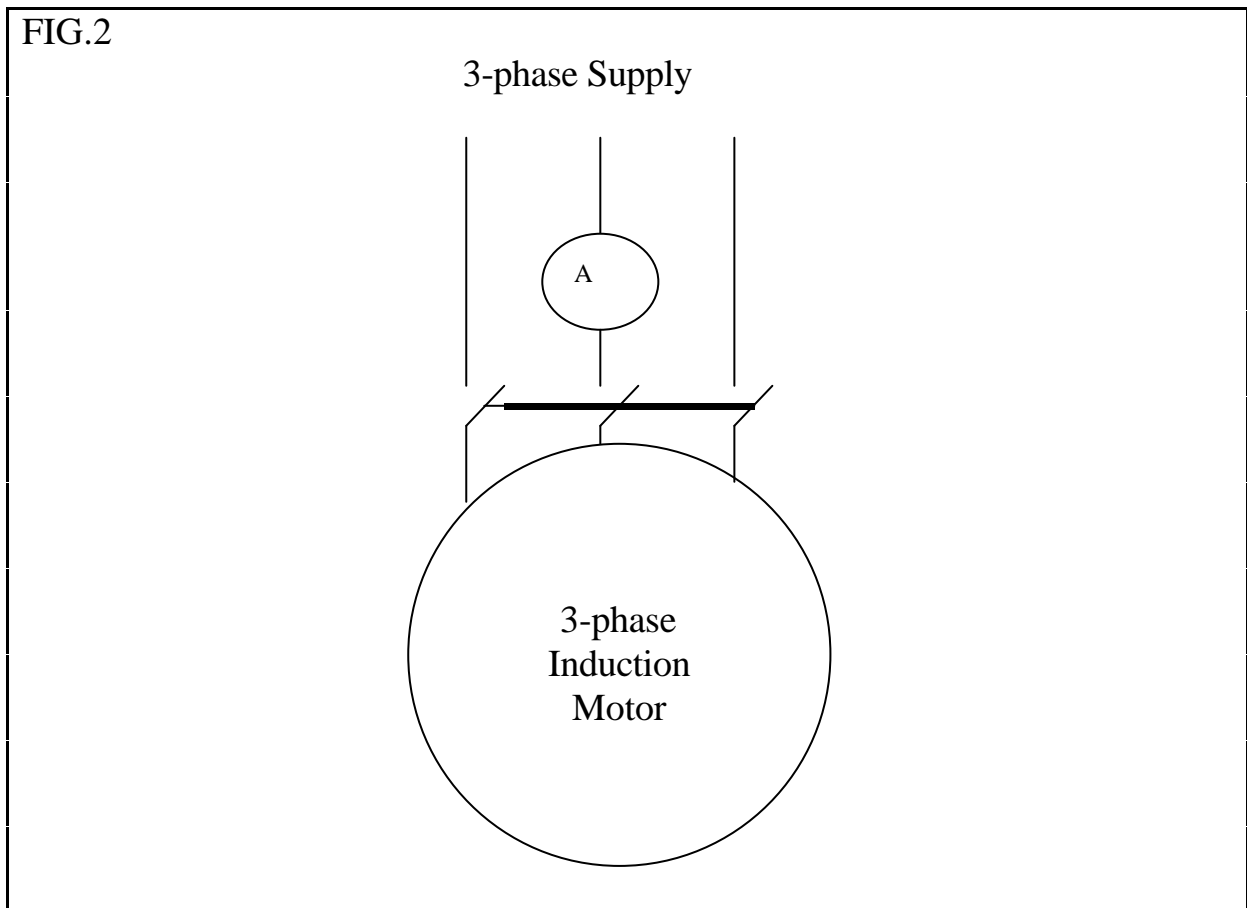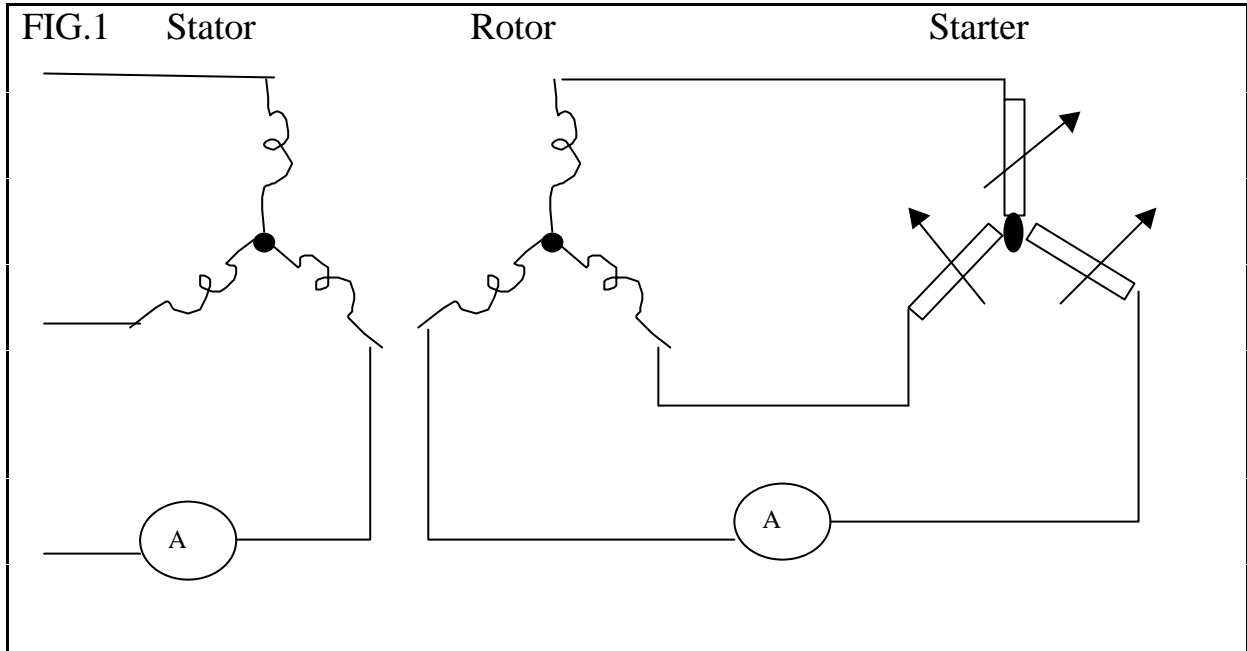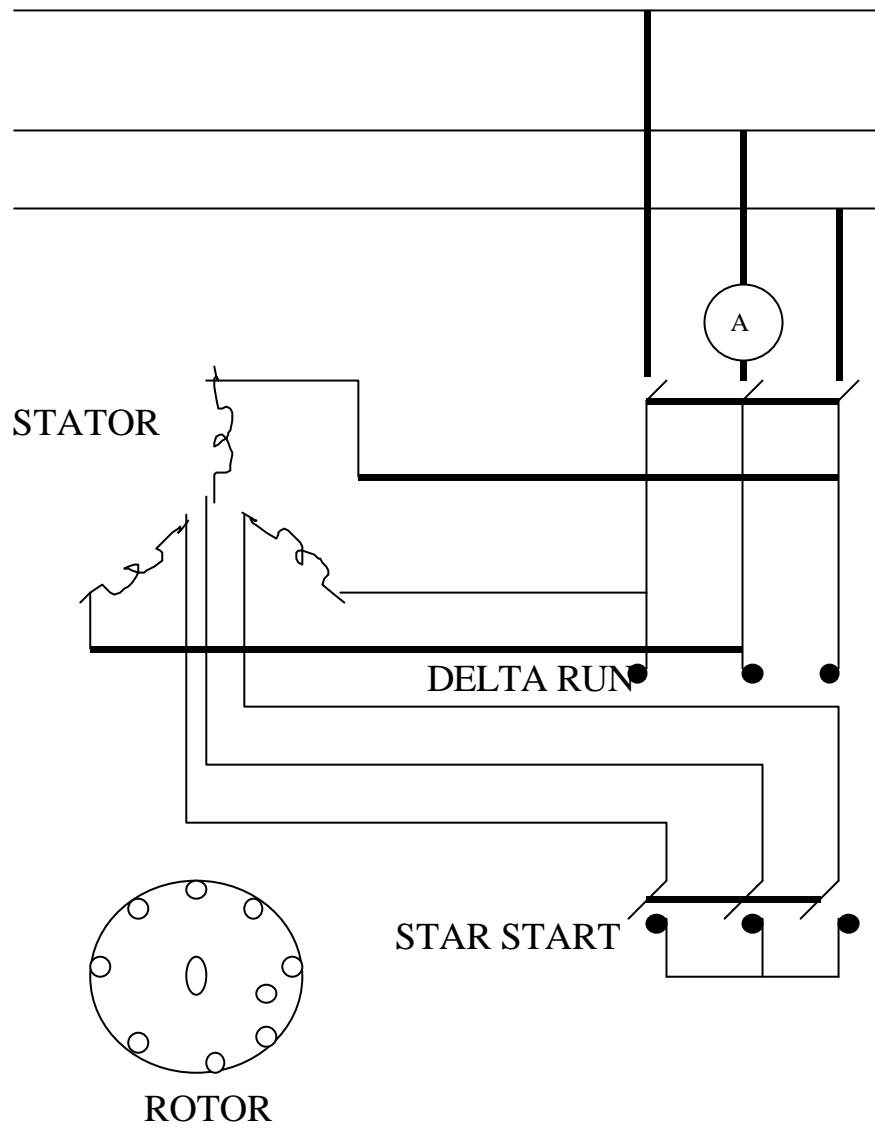2. Discuss the merits & demerits of the various starting methods.

FIG.1   Stator   Rotor   Starter

FIG.2

3-phase Supply

A

3-phase
Induction
Motor

FIG.3

3 phase
Supply

A

STATOR

DELTA RUN

STAR START

ROTOR

FIG.4

3-phase
Supply

Motor

RUN

Autotransformer

A

A

START