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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

COURSE NAME: 23EEB201/ Electrical Machines and Drives

II YEAR / IV SEMESTER

Unit II – ELEC4TRICAL MOTORS

Topic : Starting methods of three phase induction motor

starting methods of three phase induction motor

- Three-phase induction motor is one which works on three-phase AC supply, and converts three-phase AC electricity into mechanical energy. Three-phase induction motors are the most extensively used electric motors in industries.
- These motors run at almost a constant speed from no-load to full-load, i.e., they have good speed regulation.
- Although the speed of three-phase induction motors depends on the supply frequency and number of poles in the machine and therefore, it is quite difficult to change their speed.

starting methods of three phase induction motor

Just like any other electric motor, a typical three-phase induction motor also consists of two main parts namely stator and rotor. The stator is a stationary part and carries a three-phase winding, called stator winding. The rotor is a rotating part of the motor and carries a short-circuited winding, called rotor winding.

starting methods of three phase induction motor

The stator winding of a three-phase induction motor is fed from a three-phase balanced AC supply, while the rotor winding derives its working voltage and power from the stator winding via electromagnetic induction. A three-phase induction motor may be considered to be a three-phase transformer with a rotating secondary winding. Therefore, it could be described as a transformer-type AC machine. The only difference is that the induction motor converts electricity into mechanical energy.

Direct On-Line (D.O.L.) Starting

According to the rotor construction, three-phase induction motors are classified into the following two basic types –

- Squirrel-Cage Induction Motor
- Slip-Ring Induction Motor

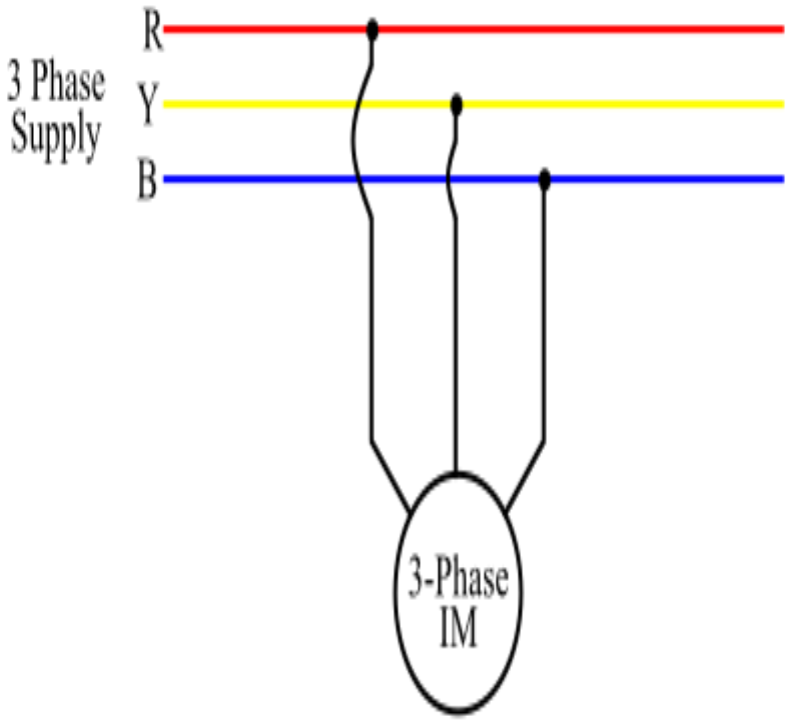
Squirrel Cage Induction Motor Starting Methods

The following four methods are available for starting squirrel cage motors

Direct On-Line (D.O.L.) Starting

As the name suggests, the Induction Motor is started by connecting it directly to three-phase supply. In this method, the motor draws a high starting current (about 4 to 7 times of the rated current) and at low power factor. Therefore, DOL starting is suitable for relatively small motors (up to 10 kW).

Direct On-Line (D.O.L.) Starting

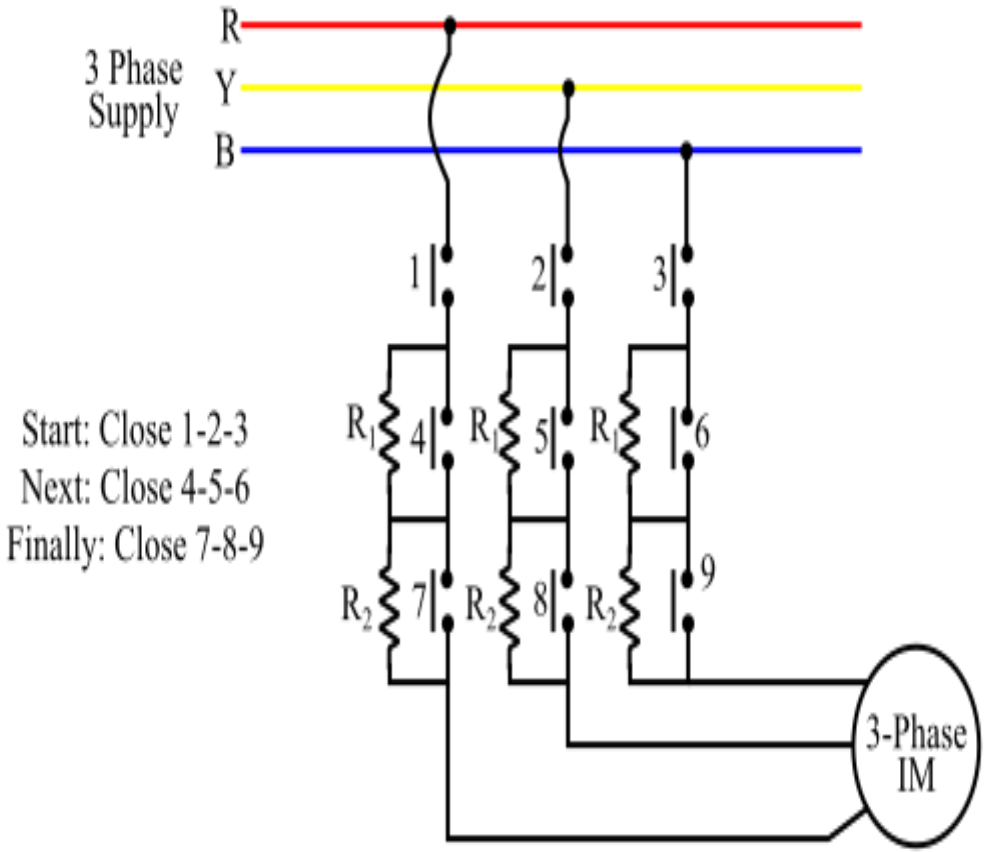


Stator Resistance Starting

Stator Resistance Starting

In this method, external resistance is connected in series with each phase of the stator winding during starting. The external resistance causes voltage to drop across it so that reduced voltage available across the motor terminals. Hence, the starting current is reduced. The starting external resistances are gradually cut out in steps from the stator circuit, as the motor accelerates. When the motor attains the rated speed, the starting resistances are completely cut out and full line voltage is applied across the motor terminals.

Stator Resistance Starting



Start: Close 1-2-3
Next: Close 4-5-6
Finally: Close 7-8-9

Stator Resistance Starting

This method has two drawbacks.

- First, the reduced voltage during starting reduces the starting torque and hence increases acceleration time.
- Secondly, a lot power is wasted in the starting resistances.

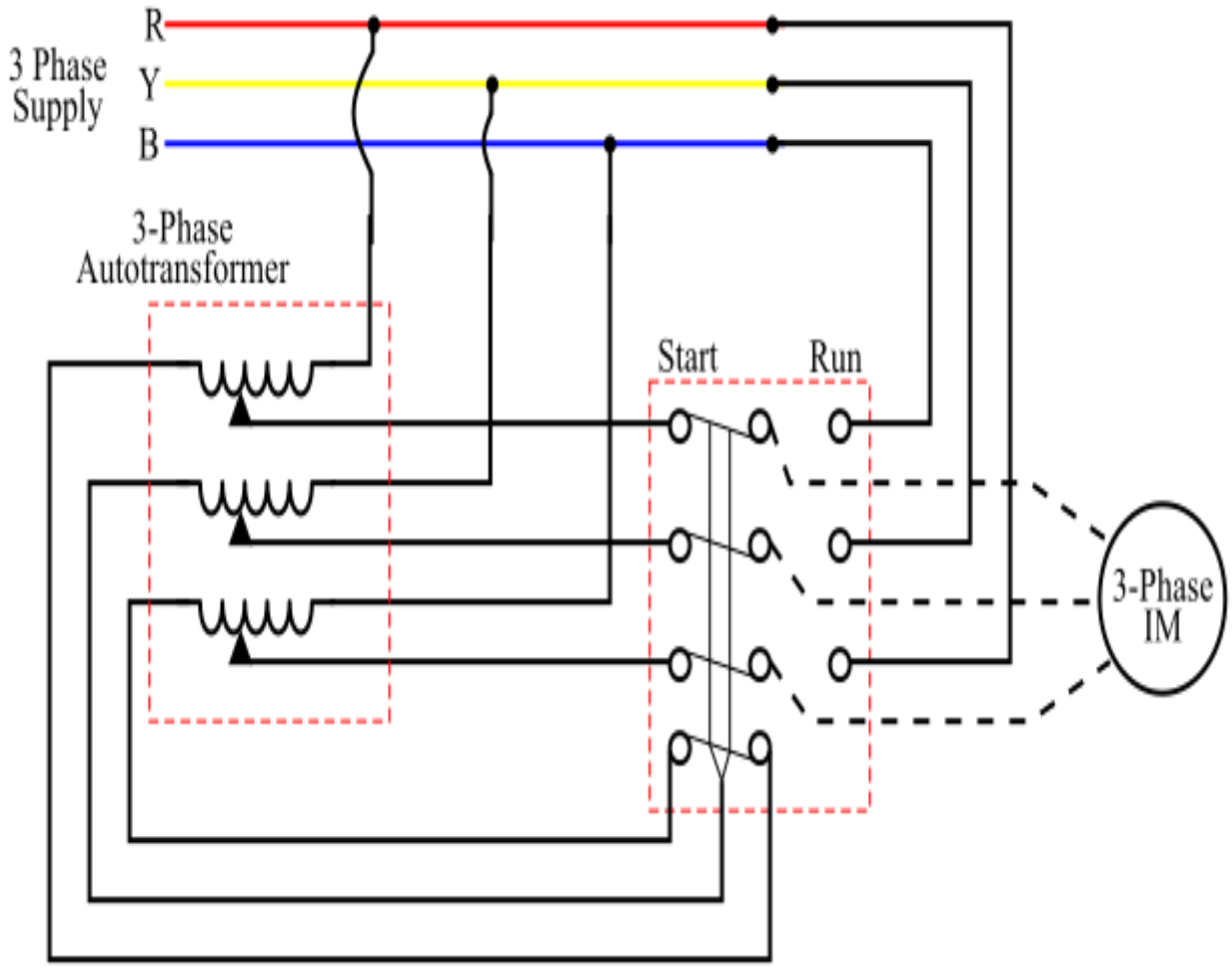
Autotransformer Starting

- In this method, an autotransformer is used to reduce the starting voltage of the induction motor.
- The tapings of the autotransformer is so set that when it is in the circuit, 60 to 80 % of the line voltage is applied to motor during starting and then connecting it to the full-line voltage as the motor attains a sufficient speed.

Autotransformer Starting

- At the instant of starting, the change-over switch is connected to "Start".
- This supplies the reduced voltage to the motor through the autotransformer.
- Consequently, the starting current is limited to safe value. When the motor attains about 80% of rated-speed, the change-over switch is now thrown to "Run".
- This removes the autotransformer from the circuit and full line voltage is applied across the motor terminals.

Autotransformer Starting



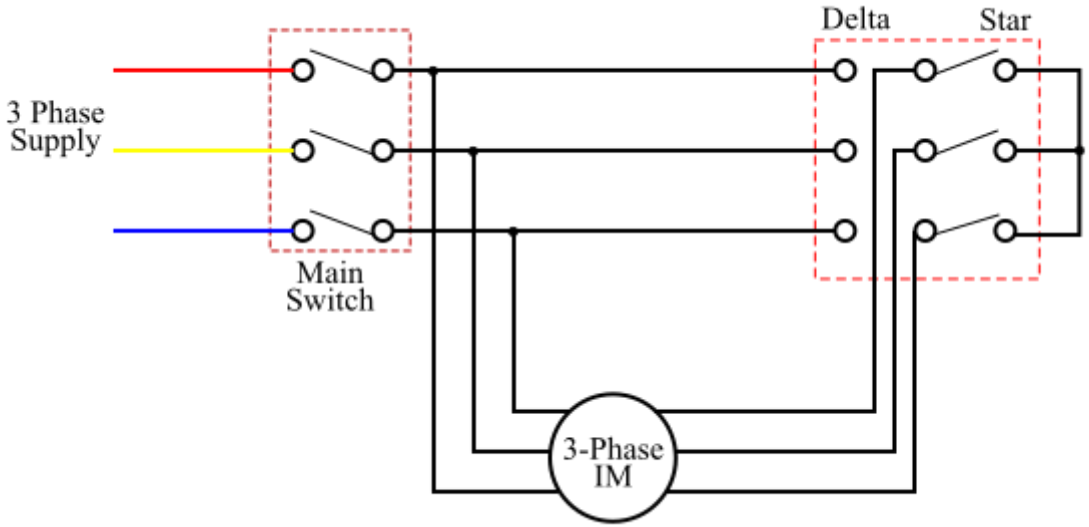
Star-Delta Starting

Star-Delta Starting

In **star-delta starting method** of squirrel cage induction motor, the motor started in star and run in delta, i.e. the stator winding of the motor is designed for delta operation and is connected in star during starting. When the motor attains sufficient speed, the connections are changed to delta.

The six leads of stator winding of the motor are connected to a change-over switch. At the time of starting, the change-over switch is switched to **"Star"** which connects the stator windings in star. Thus, each phase gets $V/\sqrt{3}$ volts, where V is the three phase line voltage. This reduces the starting current. When the motor attains 80% of rated speed, the changeover switch is switched to **"Delta"** which connects the stator windings in delta. Now, each phase gets full line voltage.

starting methods of three phase induction motor



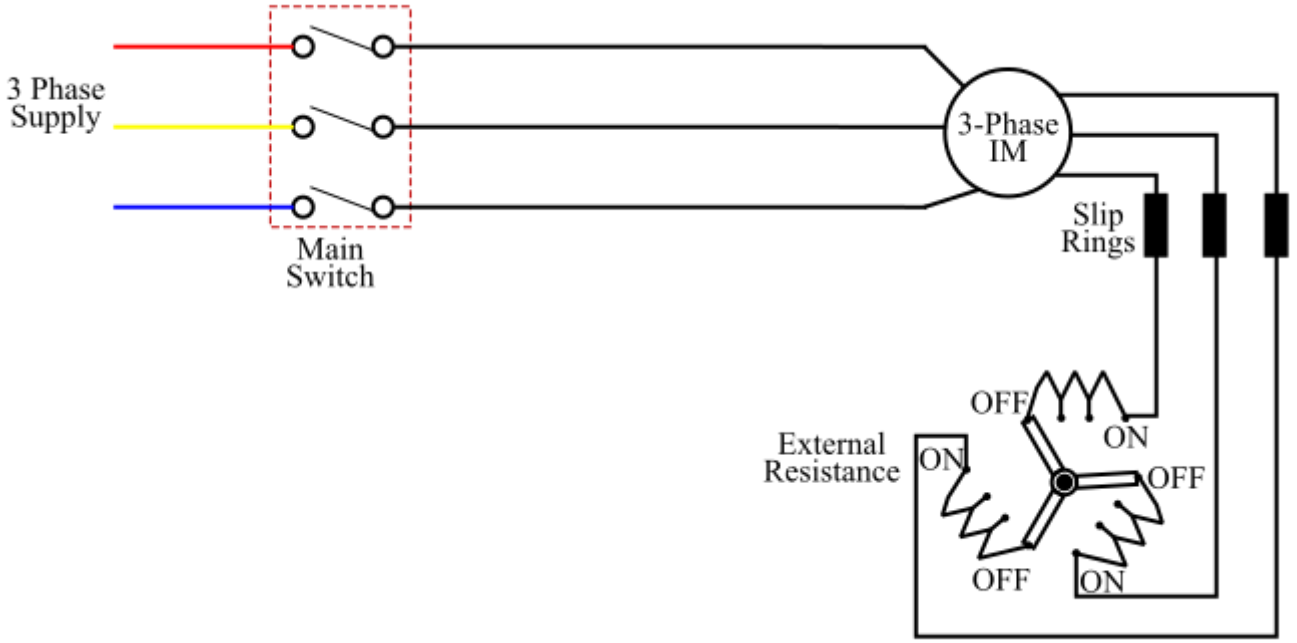
Rotor Resistance Starting

Rotor Resistance Starting

In this method, a **star connected variable resistance** is connected in the **rotor circuit through slip-rings**. The full voltage is applied to the stator windings. At the instant of starting, the handle of variable resistance (rheostat) is set to "OFF" position. This inserts maximum resistance in series with the each phase of the rotor circuit. This reduces the starting current and at the same time starting torque is increased due to external rotor resistance.

As the motor accelerates, the external resistance is gradually removed from the rotor circuit. When the motor attains rated speed, the handle is switched in the "ON" position, this removes the whole external resistance from the rotor circuit.

Rotor Resistance Starting



Applications of Three-Phase Induction Motors

The major applications of three-phase induction motors are given below –

- The squirrel-cage type three-phase induction motors are suitable for driving blowers, fans, machine tools, centrifugal pumps, etc.
- Three-phase induction motors are also used for driving different industrial load like compressors, crushers, conveyors, reciprocating pumps, etc.
- The slip-ring induction motors are best suited for driving loads that require high starting toque like crushers, plungers, cranes, elevators, hoists, conveyors, etc.

Advantages of Three-Phase Induction Motors

Here is a list of some of the major advantages of three-phase induction motors –

- The design and construction of three-phase induction motors are quite simple.
- They have robust construction.
- Three-phase induction motors require less maintenance.
- Three-phase induction motors have self-starting property.
- These motors have reasonably good power factor.
- Three-phase induction motors are more economical.
- They have high efficiency.

Disadvantages of Three-Phase Induction Motors

The major disadvantages of three-phase induction motors are listed below –

- Three-phase induction motors are essentially constant speed motors, and require complex mechanism to change the speed.
- Three-phase induction motors always work on lagging power factor.
- These motors draw very high starting current.