Starting and Speed Control of Three-Phase Induction Motors:

- Need for starter.
- Direct on line.
- Star-Delta.
- Autotransformer starting.
- Rotor resistance starting.

Speed control of 3phase induction motors

- by voltage.
- Frequency.
- Rotor resistance methods

Need for starter.

- In a three phase induction motor, the magnitude of an induced e.m.f. in the rotor circuit depends on the **slip of the induction motor.**
- This induced e.m.f. effectively decides the **magnitude of the rotor current**.
- The **rotor current in the running condition** is given by,

$$I_{2r} = \frac{sE_2}{\sqrt{R_2^2 + (s X_2)^2}}$$

Need for starter.

- But **at start, the speed of the motor is zero** and **slip is at its maximum** i.e. **unity**. So *magnitude of rotor induced e.m.f. is very large at start*.
- As rotor conductors are short circuited.
- The **large induced e.m.f. circulates very high current through rotor at start.**

Need for starter.

- In a three phase induction motor, when **rotor current is high**, consequently the **stator draws a very high current** from the supply.
- This current can be of the order of **5 to 8 times the full load** current, at start.
- Due to such heavy inrush current at start there is possibility of **damage of the motor winding**.
- Similarly such sudden inrush of current causes **large line voltage drop.**
- Thus other appliances connected to the same line may be subjected to voltage spikes which may affect their working.

Need for starter.

- To avoid such effects, it is necessary to limit the current drawn by the motor at start.
- The starter is a device which is basically used to **limit high starting current by supplying reduced voltage to the motor at the limit of starting.**
- Such a reduced voltage is applied only for short period and once rotor gets accelerated, full normal rated voltage is applied.

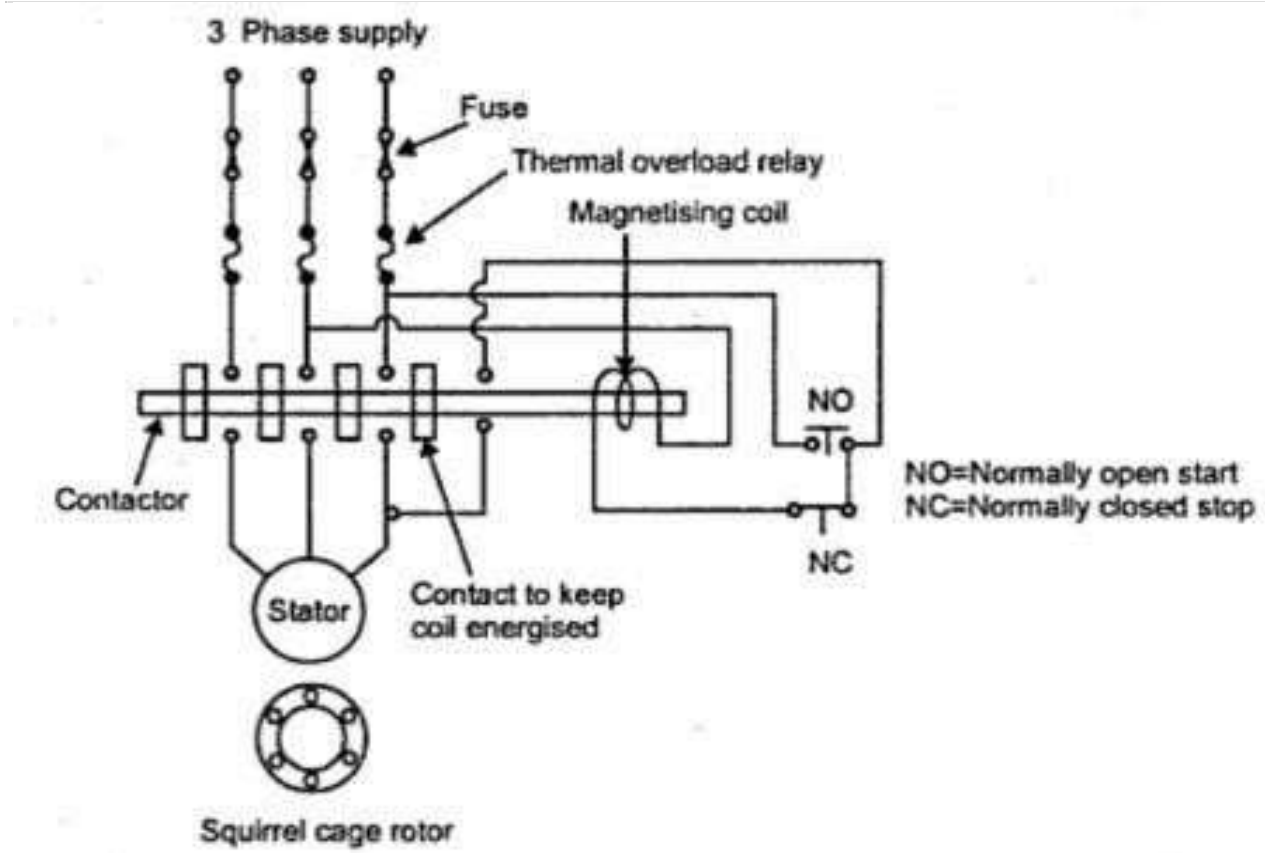
Starting of Three-Phase Induction Motors:

1. Direct on line starter
2. Stator resistance starter
3. Auto-transformer starter
4. Star-delta starter
5. Rotor resistance starter

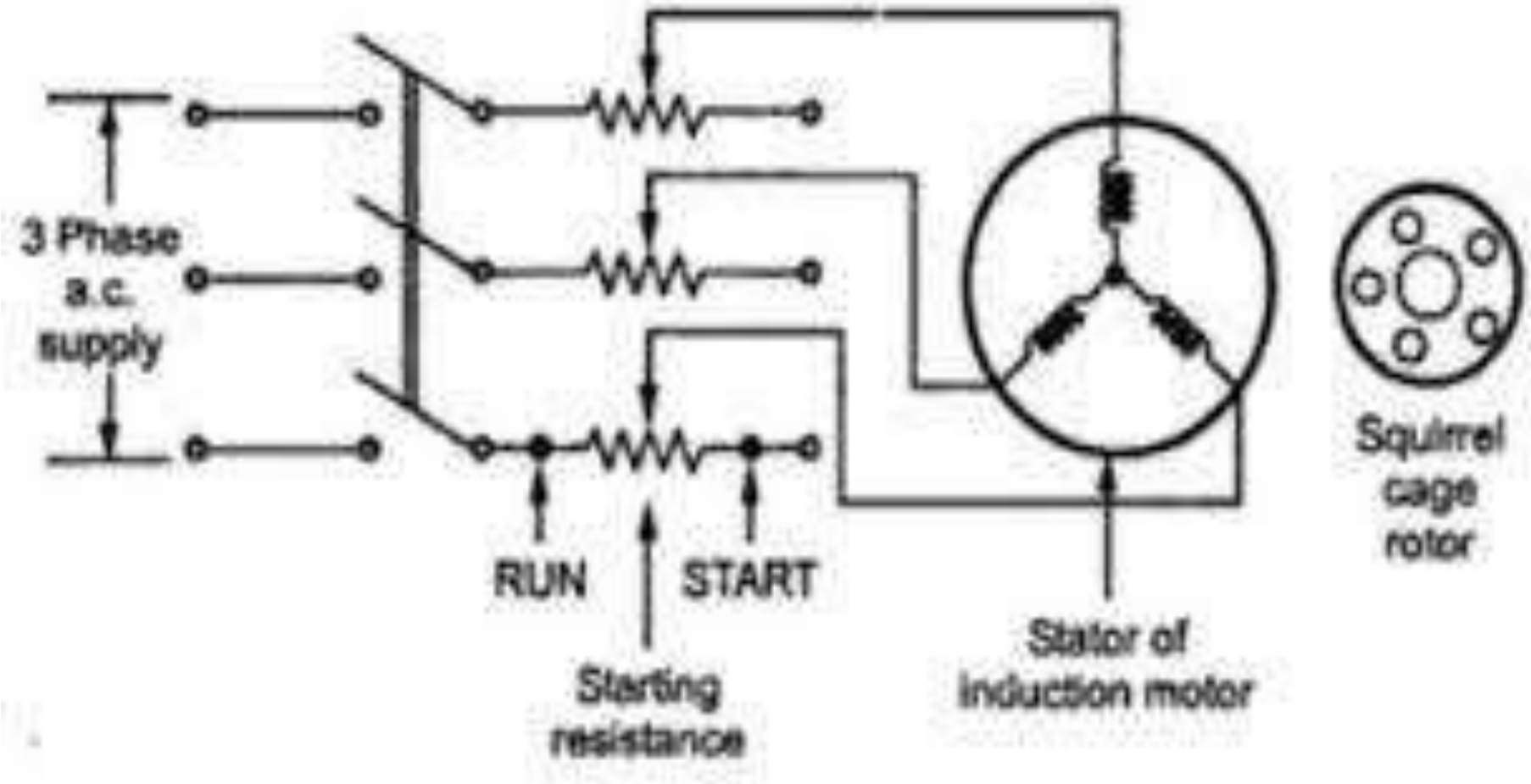
1. Direct on line starter

- In case of small capacity motors having rating less than 5 HP, the starting current is not very high and such motors can withstand such starting current without any starter. Thus there is no need to reduce applied voltage, to control the starting current.

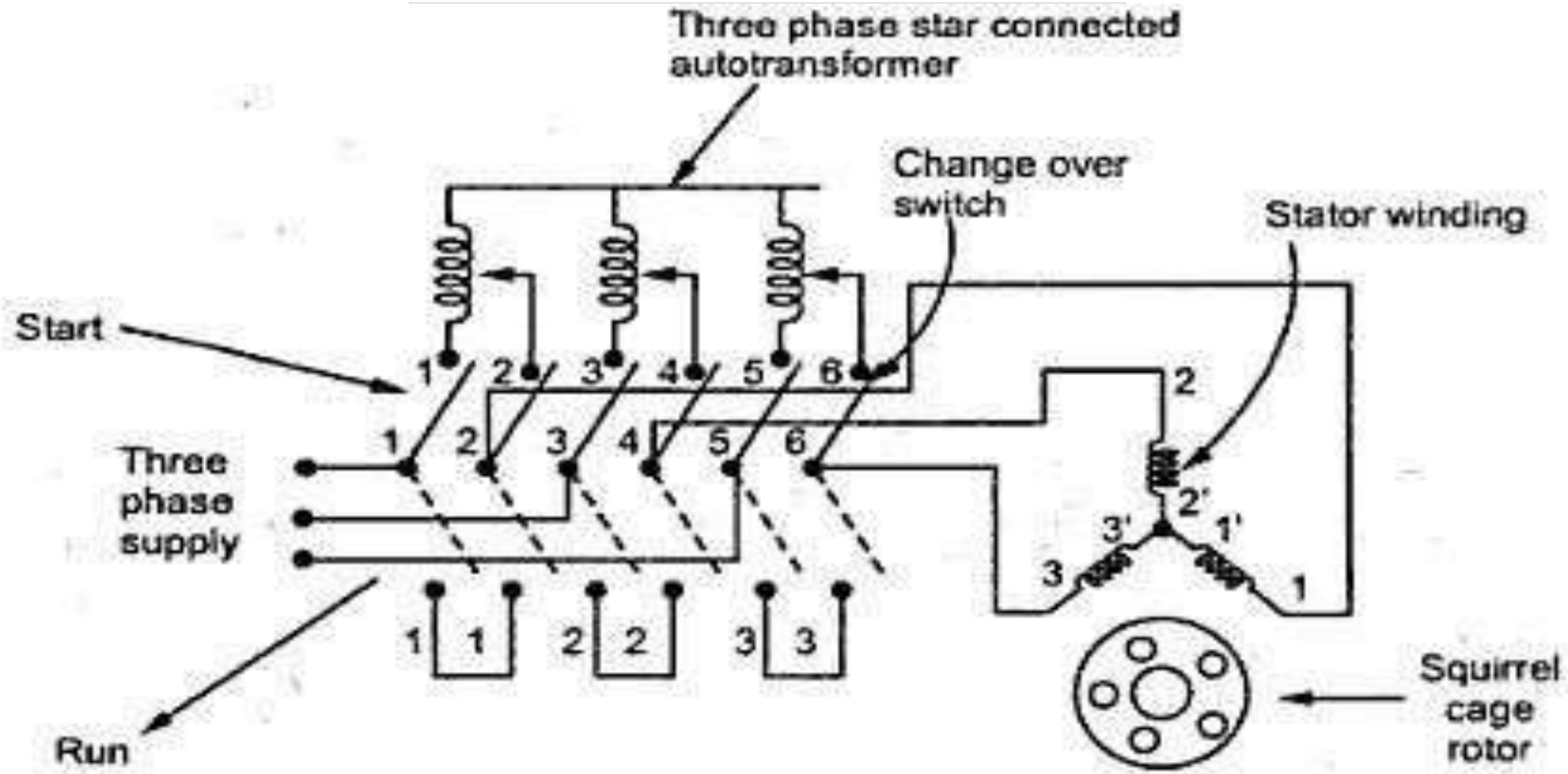
Though this starter does not reduce the applied voltage, it is used because it protects the motor from various severe abnormal conditions like **over loading, low voltage, single phasing**



2.Stator resistance starter



3.Auto-transformer starter



3.Auto-transformer starter

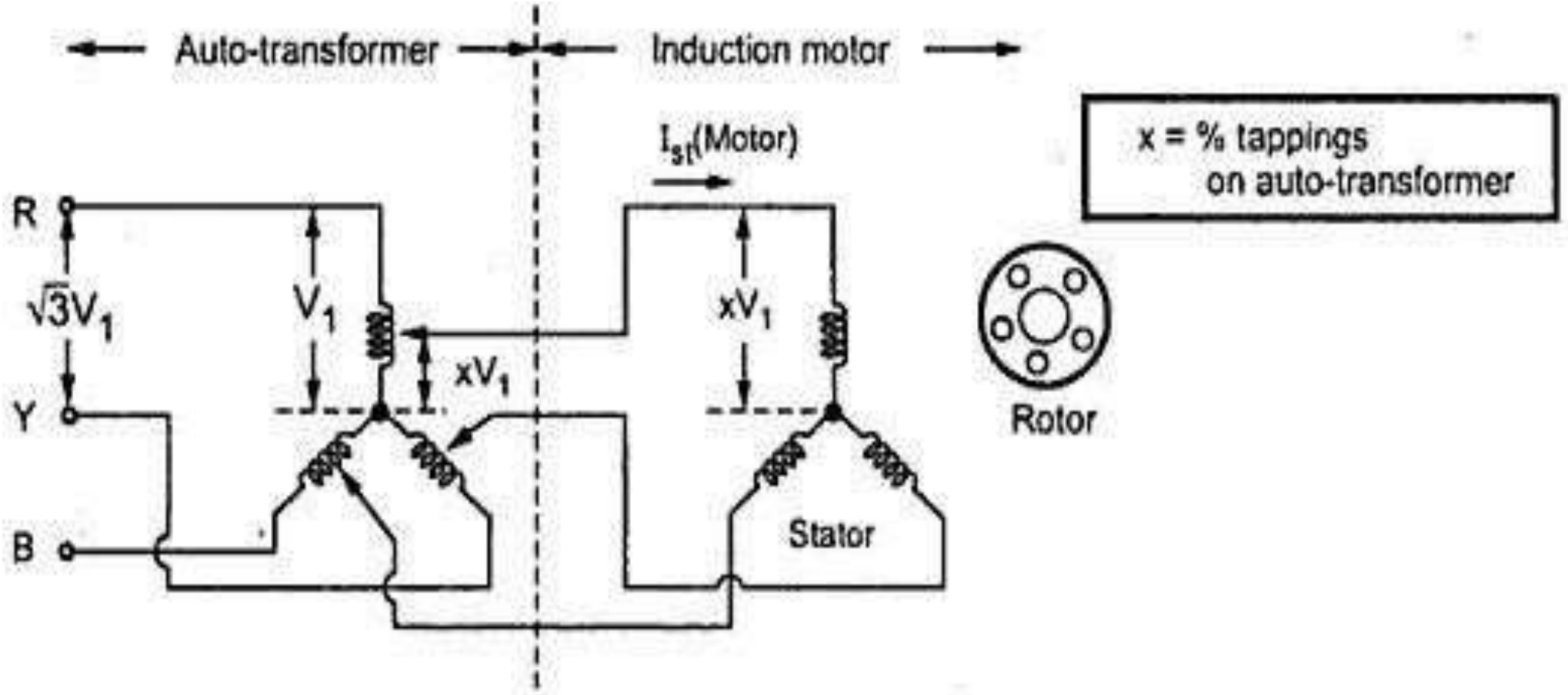
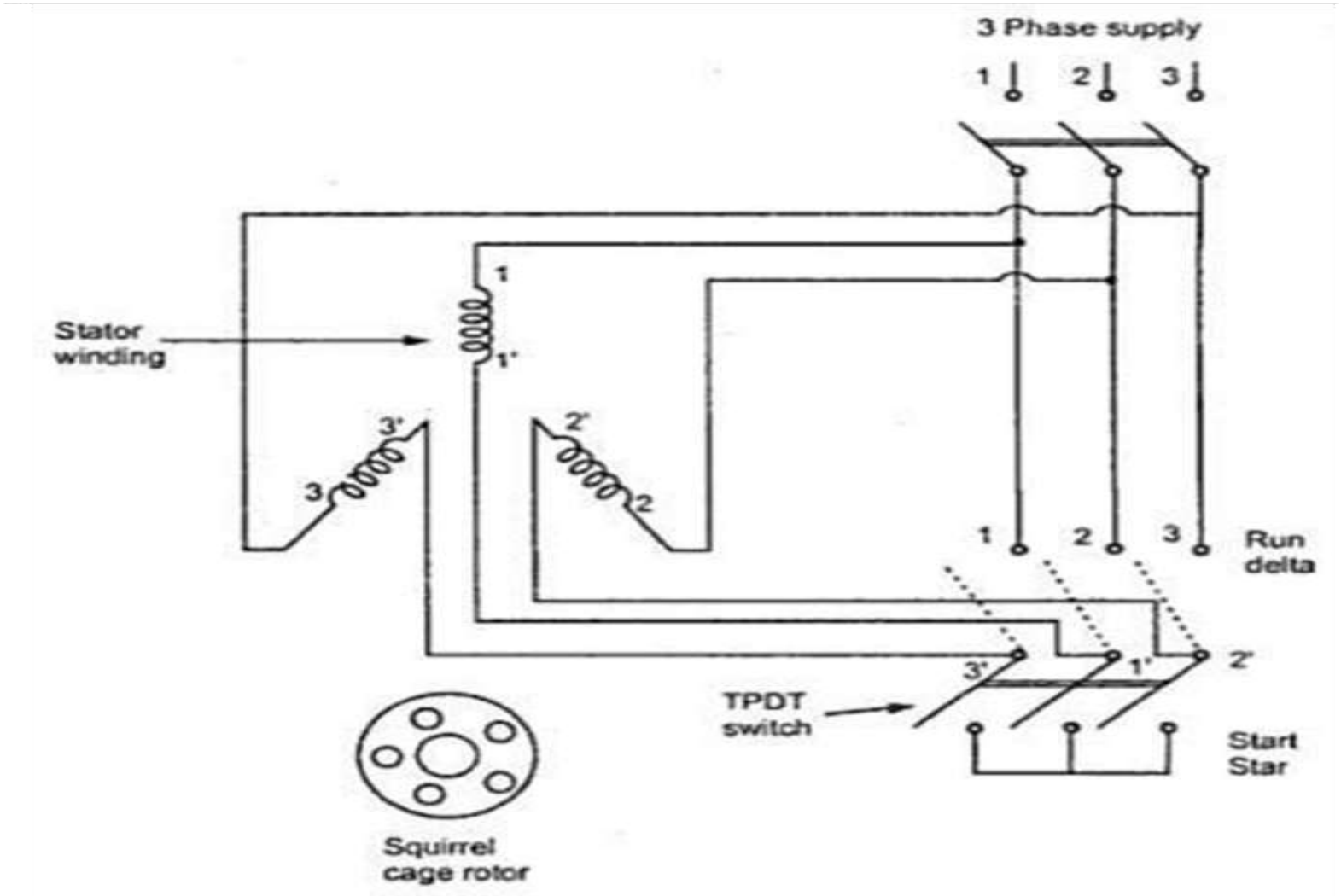
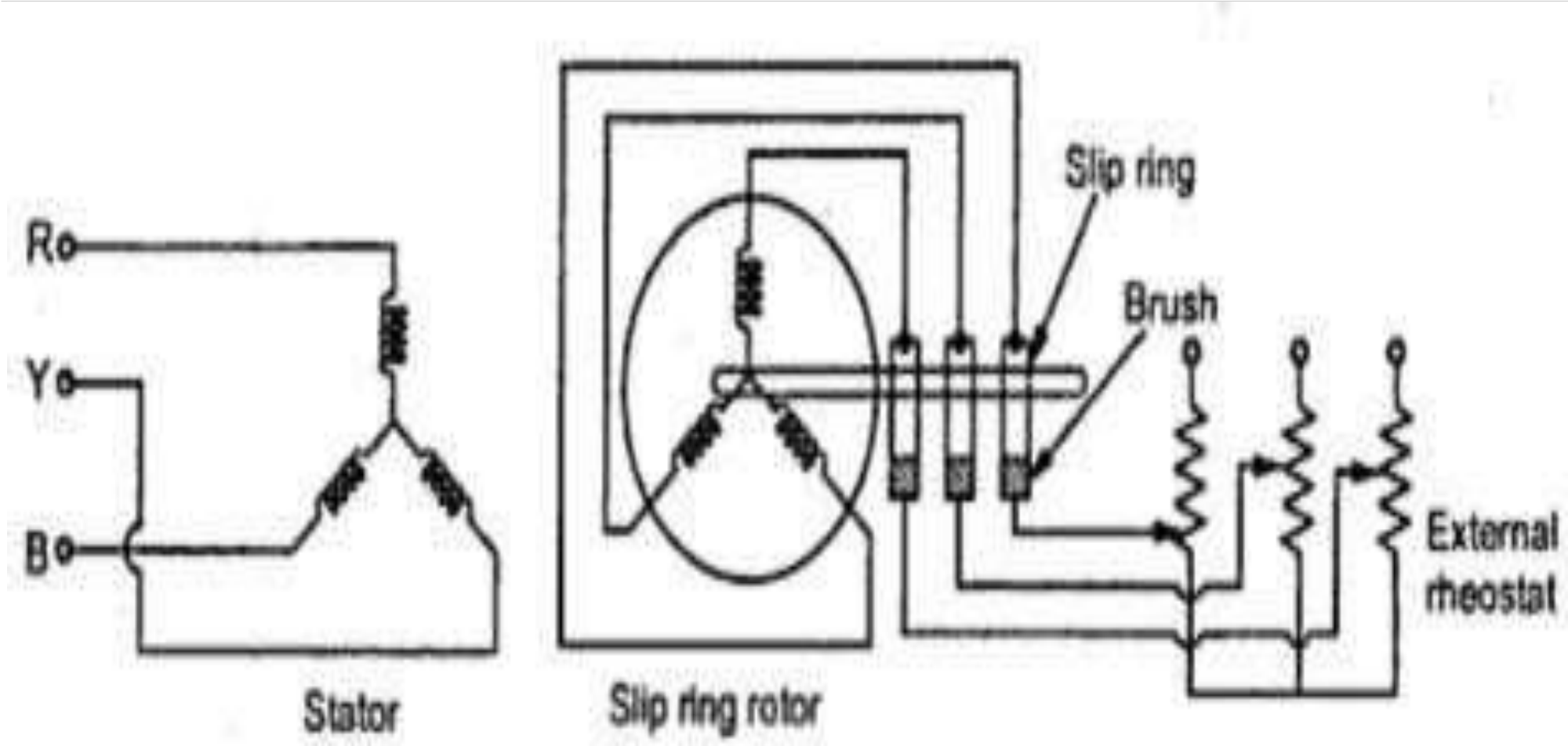


Fig.2 Use of auto-transformer to reduce voltage at start

4.Star-Delta Starter



5.Rotor resistance starter



Speed Control of Three Phase Induction Motor:

Thus speed of the induction motor can be controlled by basically two methods :

1. From stator side and
2. From rotor side

From stator side, it includes following methods :

1. Supply frequency control to control Ns, called V / f control.
2. Supply voltage control.
3. Controlling number of stator poles to control Ns.
4. Adding rheostats in stator circuit.

From rotor side, it includes following methods :

1. Adding external resistance in the rotor circuit.
2. Cascade control.
3. Injecting slip frequency voltage into the rotor circuit.

Speed Control of 3 Phase Induction Motor:

$$N_s = [120f/P] \text{----------1}$$

&

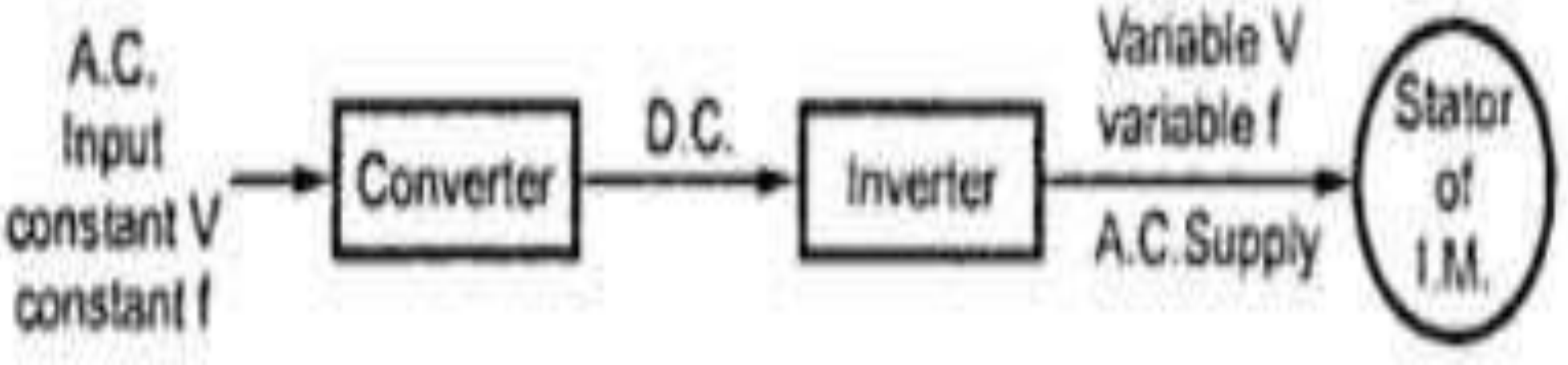
$$S = [(N_s - N)/N_s] \text{----------2}$$

$$N = N_s (1 - s) \text{----------3}$$

- From this expression it can be seen that the speed of induction motor can be changed either by changing its **synchronous speed** (Ns)or by changing the **slip s.**
- So as the parameters like **R2, E2** are changed then to keep the **torque constant** for **constant load condition**, motor reacts by change in its **slip**. Effectively its speed changes.

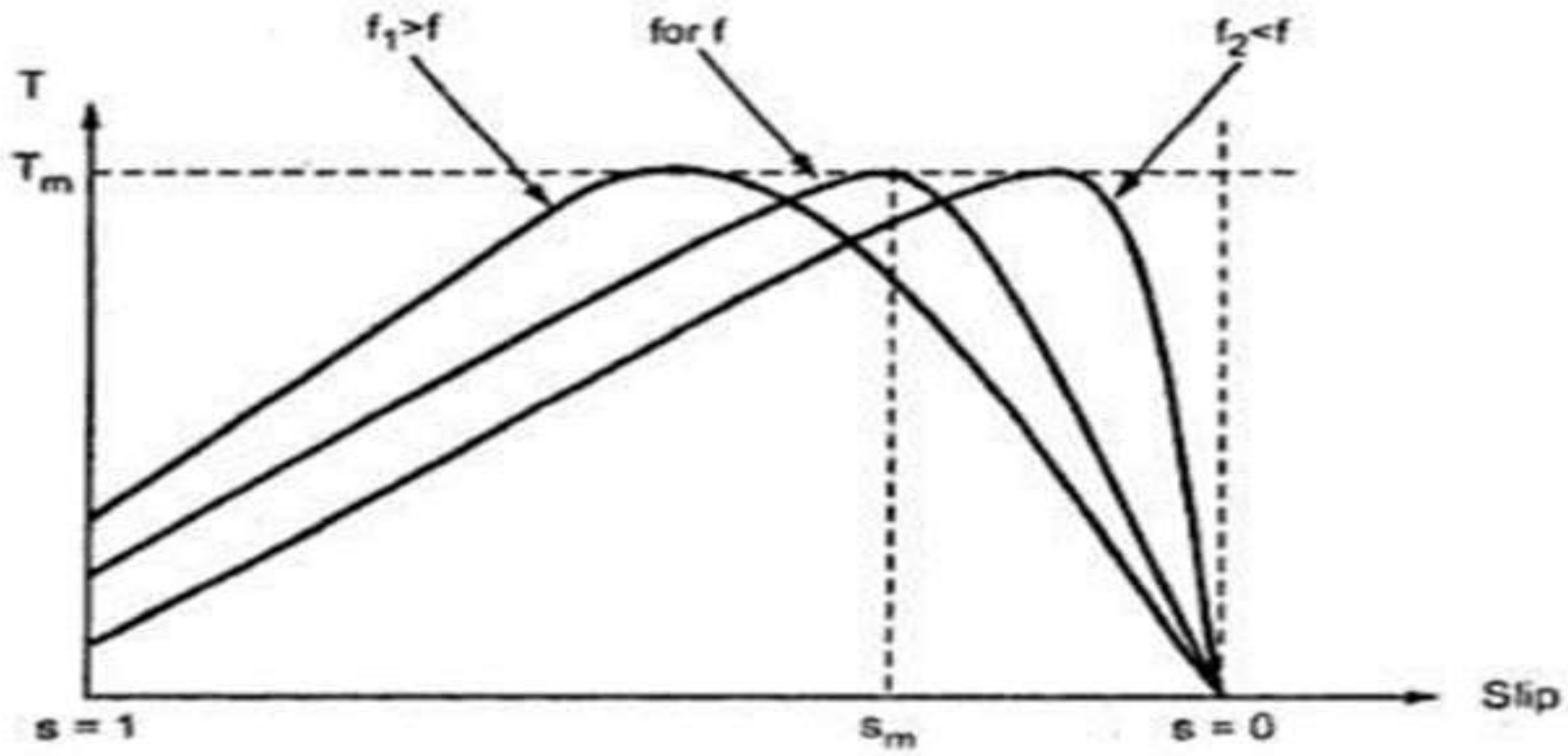
From stator side

Supply Frequency Control or V / f Control:

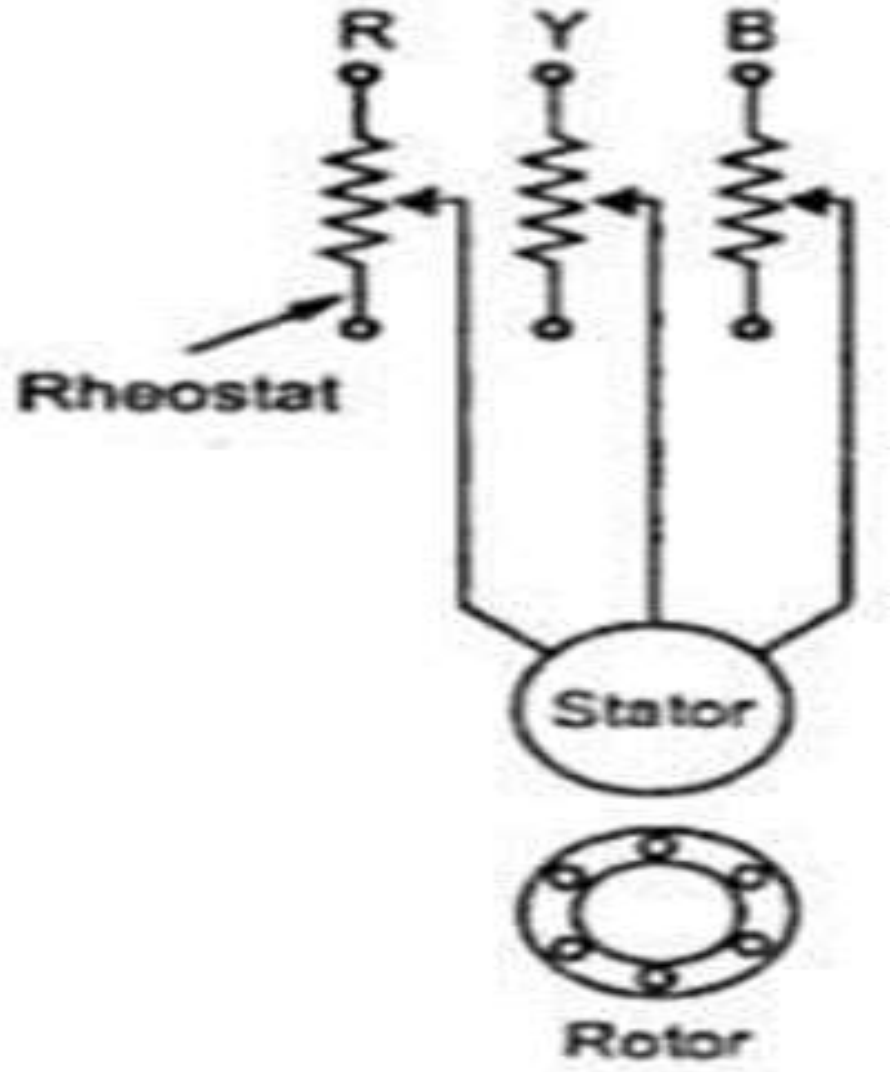


- Fig. 1 Electronic scheme for V/f control

Torque-slip characteristics with variable f and constant (V/f)



Adding Rheostats in Stator Circuit:



Cascaded control