5- Speed Control of Induction Motor

Induction motors are not good machines for applications requiring considerable speed control. The normal operating range of a typical induction motor is confined to less than 5% slip, and the speed variation is more or less proportional to the load. if slip is made higher, rotor copper losses will be high as well.

There are basically 2 general methods to control induction motor's speed:

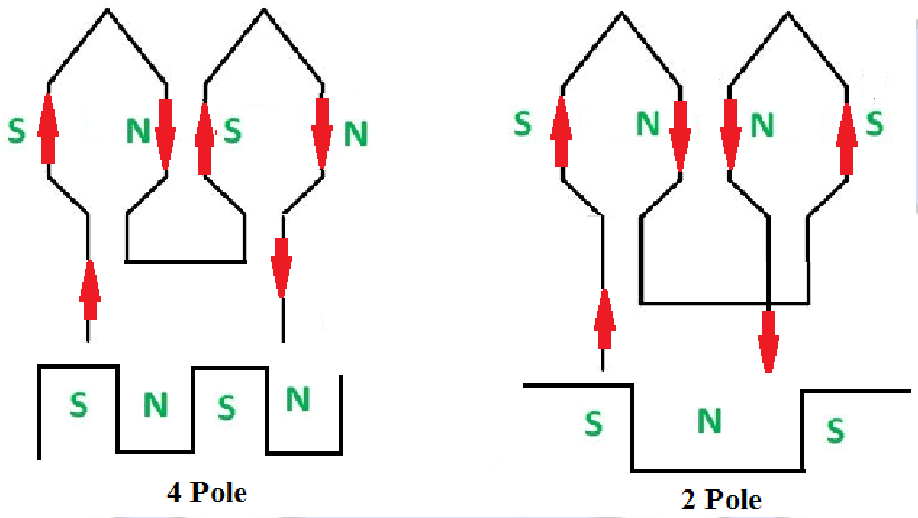
a) Varying stator and rotor magnetic field speed

b) Varying slip

Varying the magnetic field speed may be achieved by varying the **electrical frequency** or by

5-1 Changing the Number of Poles.

Varying slip may be achieved by **varying rotor resistance** or **varying the terminal voltage**. In the method of consequent poles, a single stator winding is divided into few coil groups. The terminals of all these groups are brought out. By simply changing the coil connections, the number of poles can be changed. In practice, the stator windings are divided only in two coil groups. The number of poles can be changed in the ratio of 2:1



Induction Motor Speed Control by Pole Changing

There are 2 approaches possible:

a) Method of Consequent Poles (Old Method)

b) Multiple Stator Windings Method

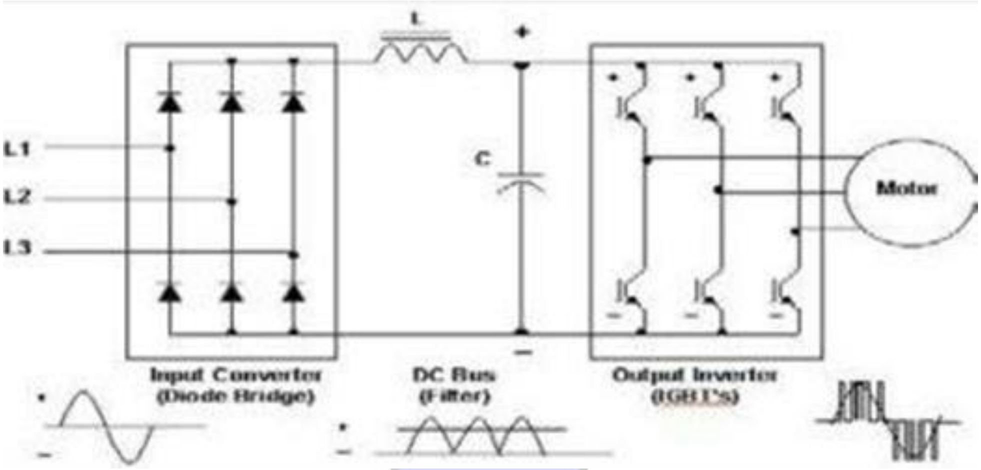
Method of Consequent Poles

General Idea:

Consider one phase winding in a stator. By changing the current flow in one portion of the stator windings as such that it is similar to the current flow in the opposite portion of the stator will automatically generate an extra pair of poles.
By applying this method, the number of poles may be maintained (no changes), doubled or halfed , hence would vary its operating speed.
In terms of torque, the maximum torque magnitude would generally be maintained.

Disadvantage:
This method will enable speed changes in terms of 2:1 ratio steps, hence to obtained variations in speed, multiple stator windings has to be applied. Multiple stator windings have extra sets of windings that may be switched in or out to obtain the required number of poles. Unfortunately this would an expensive alternative.

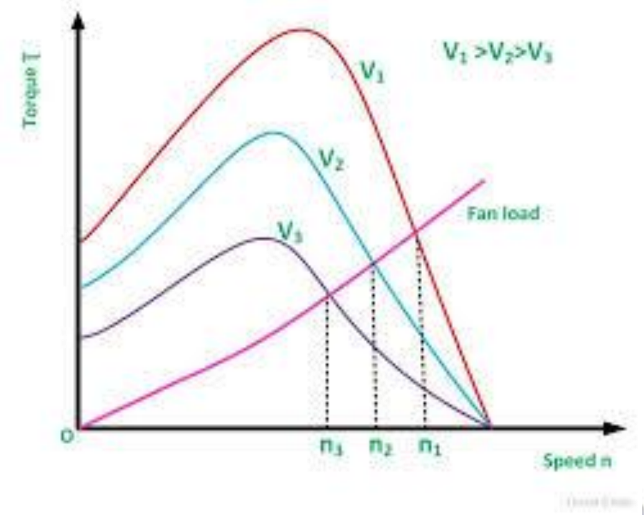
5-2 Speed Control by Changing the Line Frequency
Changing the electrical frequency will change the synchronous speed of the machine.
Changing the electrical frequency would also require an adjustment to the terminal voltage in order to maintain the same amount of flux level in the machine core. If not the machine will experience:
a) Core saturation (non linearity effects)
b) Excessive magnetization current.
Varying frequency with or without adjustment to the terminal voltage may give 2 different effects:
a) Vary frequency, stator voltage adjusted – generally vary speed and maintain operating torque.
b) Vary Frequency, stator voltage maintained – able to achieve higher speeds but a reduction of torque as speed is increased.
There may also be instances where both characteristics are needed in the motor operation; hence it may be combined to give both effects.
With the arrival of solid-state devices/power electronics, line frequency change is easy to achieved and it is more versatile to a variety of machines and application
.

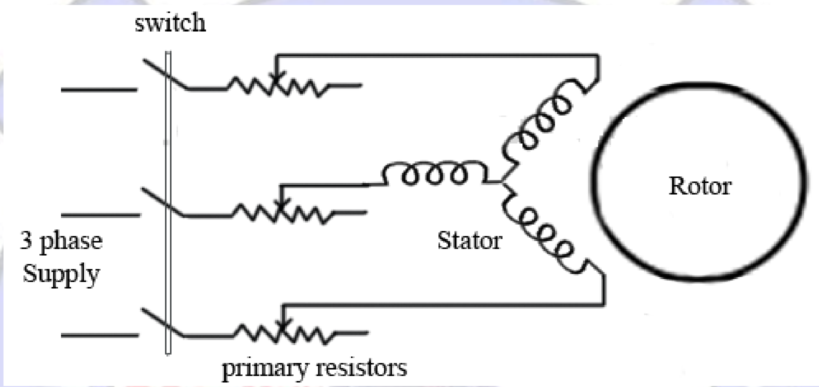


5-3 Speed Control by Changing the Line Voltage

From the torque equation of the induction machine given , we can see that the torque depends on the square of the applied voltage. The variation of speed torque curves with respect to the applied voltage is shown in fig. below. These curves show that the slip at maximum torque ˆs remains same, while the value of stall torque comes down with decrease in applied voltage. The speed range for stable operation remains the same. Further, we also note that the starting torque is also lower at lower voltages. Thus, even if a given voltage level is sufficient for achieving the running torque, the machine may not start. This method of trying to control the speed is best suited for loads that require very little starting torque, but their torque requirement may increase with speed.

Varying the terminal voltage will vary the operating speed but with also a variation of operating torque. In terms of the range of speed variations, it is not significant hence this method is only suitable for small motors only.





5-4 Speed Control by Changing the Rotor Resistance

It is only possible for wound rotor applications but with a cost of reduced motor efficiency.

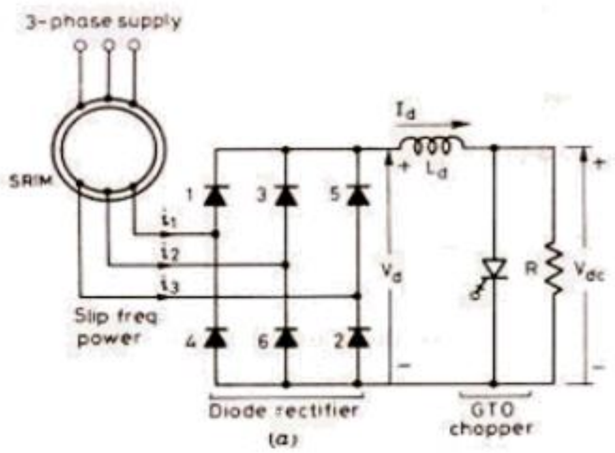
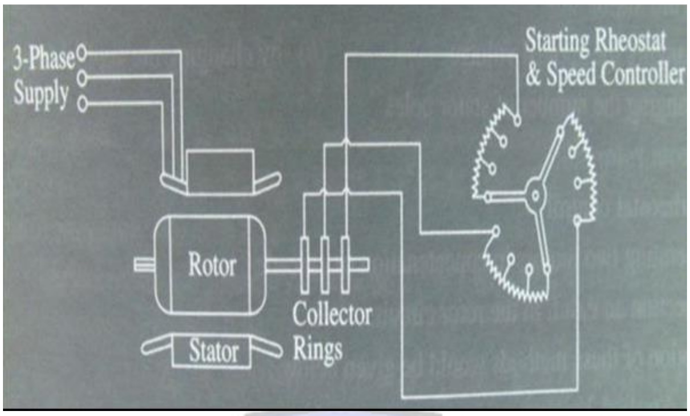
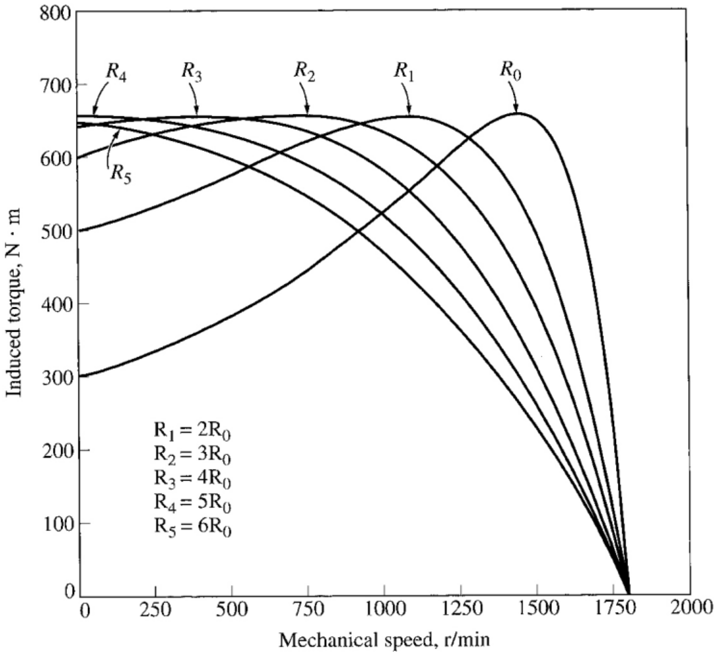


Fig. (a) SRIM control by static variation of external rotor resistance


3-Phase Supply
Starting Rheostat & Speed Controller
Rotor
Collector Rings
Stator


R_4
R_3
R_2
R_1
R_0
R_5
Induced torque, N · m
Mechanical speed, r/min
$R_1 = 2R_0$
$R_2 = 3R_0$
$R_3 = 4R_0$
$R_4 = 5R_0$
$R_5 = 6R_0$