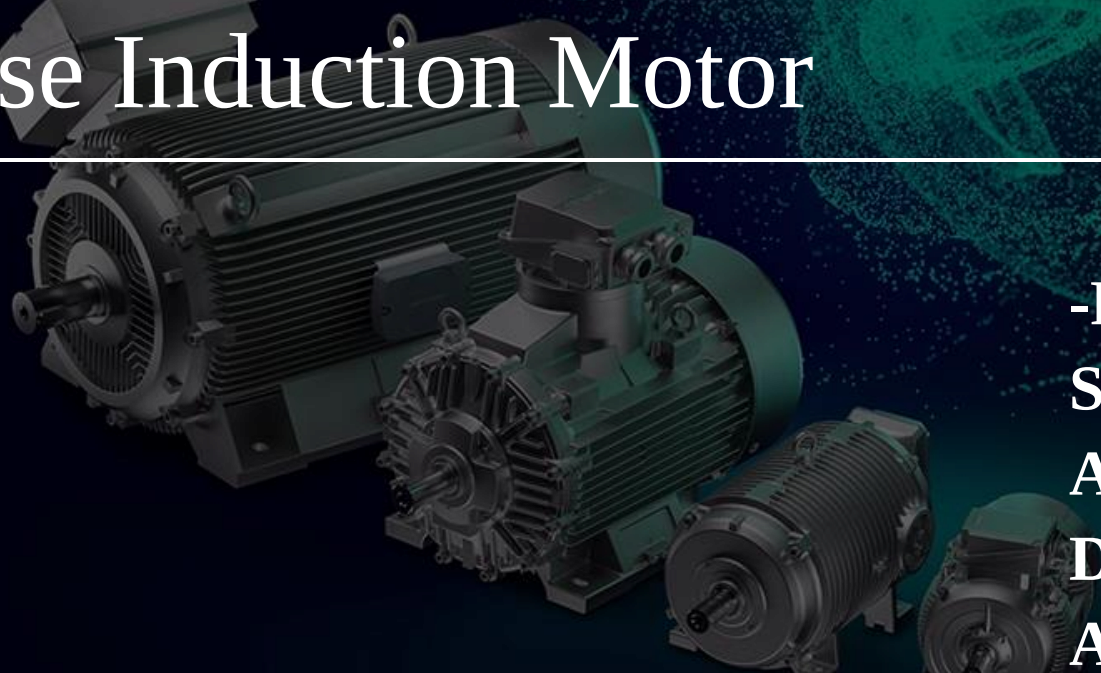
ATME College of Engineering

Electric Motors
BEE401
Module-4
a) Starting and Speed Control of Three-Phase Induction Motor
b) Single Phase Induction Motor



-Presented By
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ATMECE

Module-4

Starting and speed Control of Three-phase Induction Motors: Need for starter. Direct online, Star-Delta and autotransformer starting. Rotor resistance starting. Speed control by voltage, frequency, and rotor resistance methods.

Single-phase Induction Motor: Double revolving field theory and principle of operation. Construction and operation of split-phase, capacitor start, and capacitor run, and shaded pole motors. Comparison of single-phase motors and applications.

Need of Starter:

- Supply is connected to the stator of a three-phase induction motor rotating magnetic field is produced and the rotor starts rotating.
- At starting slip equals 1 And the starting current is very large about 5 to 8 times the full load current.
- Due to heavy inrush current at the start there is the possibility of damage to the motor winding.
- To avoid such inrush current starters are used
- starters are basically used to limit high starting current by supplying reduced voltage to the motor at the time of starting.
- Such a reduced voltage is applied only for a short period and once the rotor gets accelerated full normal rated voltage is applied.
- The starter of the motor performs two functions
- To reduce the heavy starting current
- To provide overload and under-voltage protection

Types of Starter:

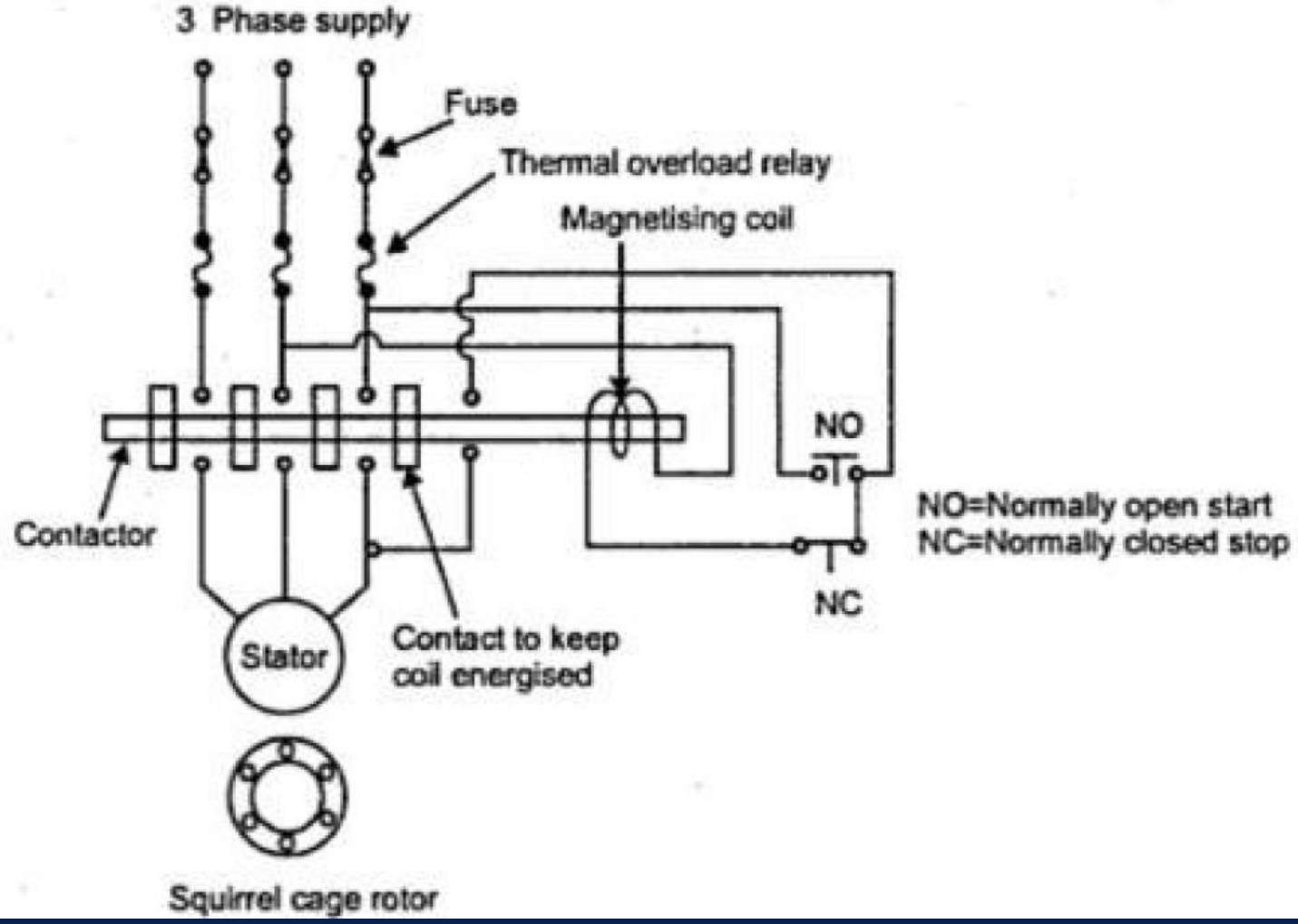
1. Starting of squirrel cage motor

- Direct online starter
- Stator resistance or reactor starting
- Autotransformer starter
- Star delta starter

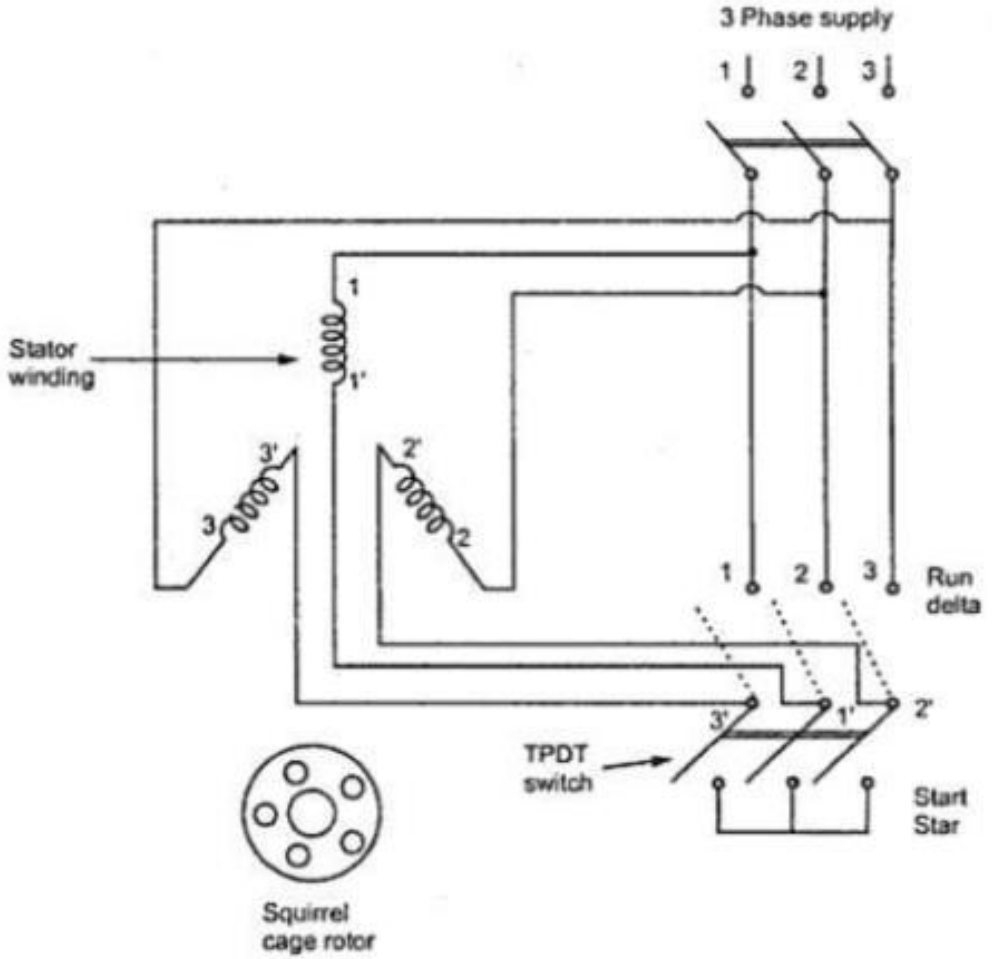
2. Starting of slip ring motor

- Rotor resistance starter

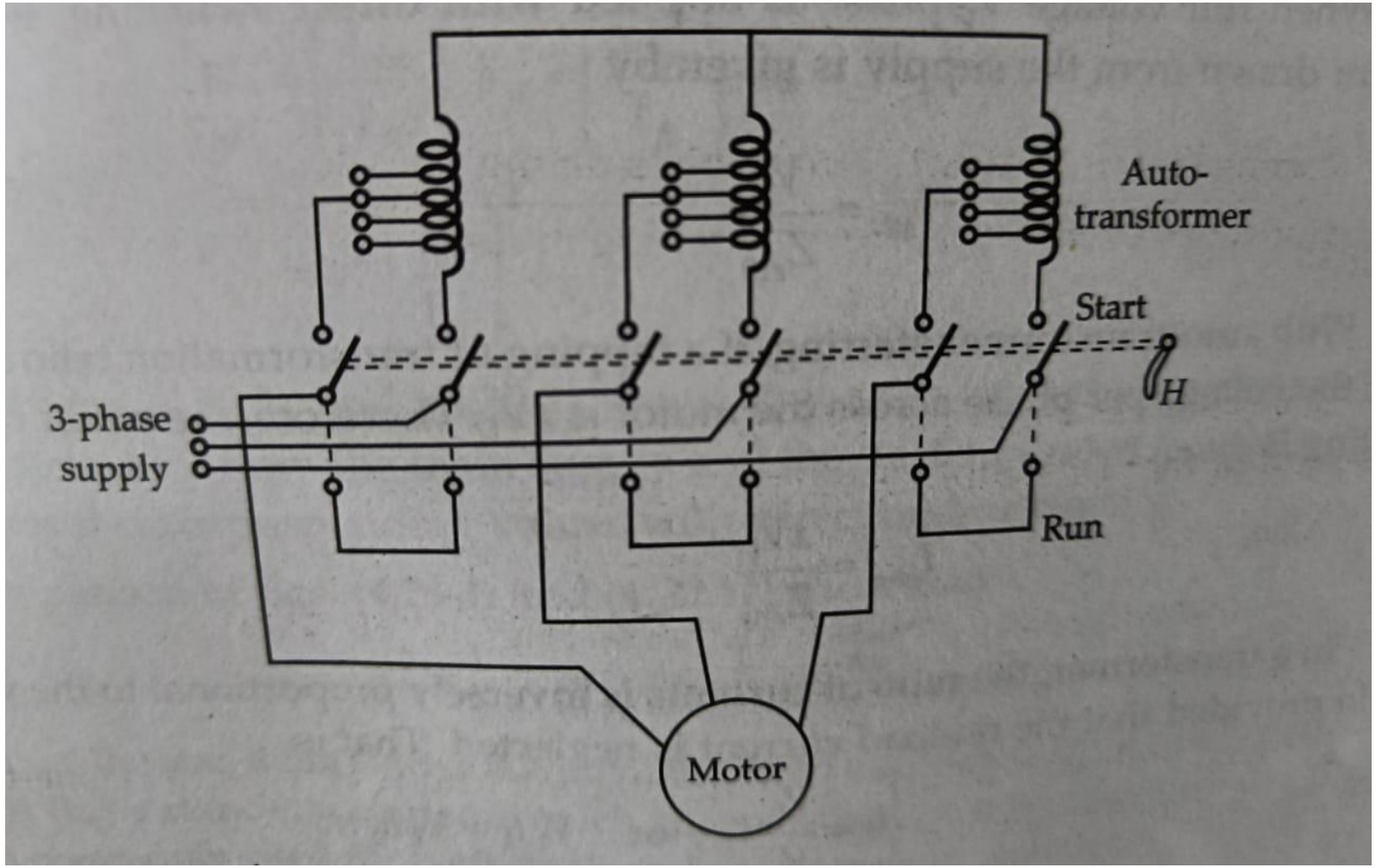
Direct Online Starter (DOL):



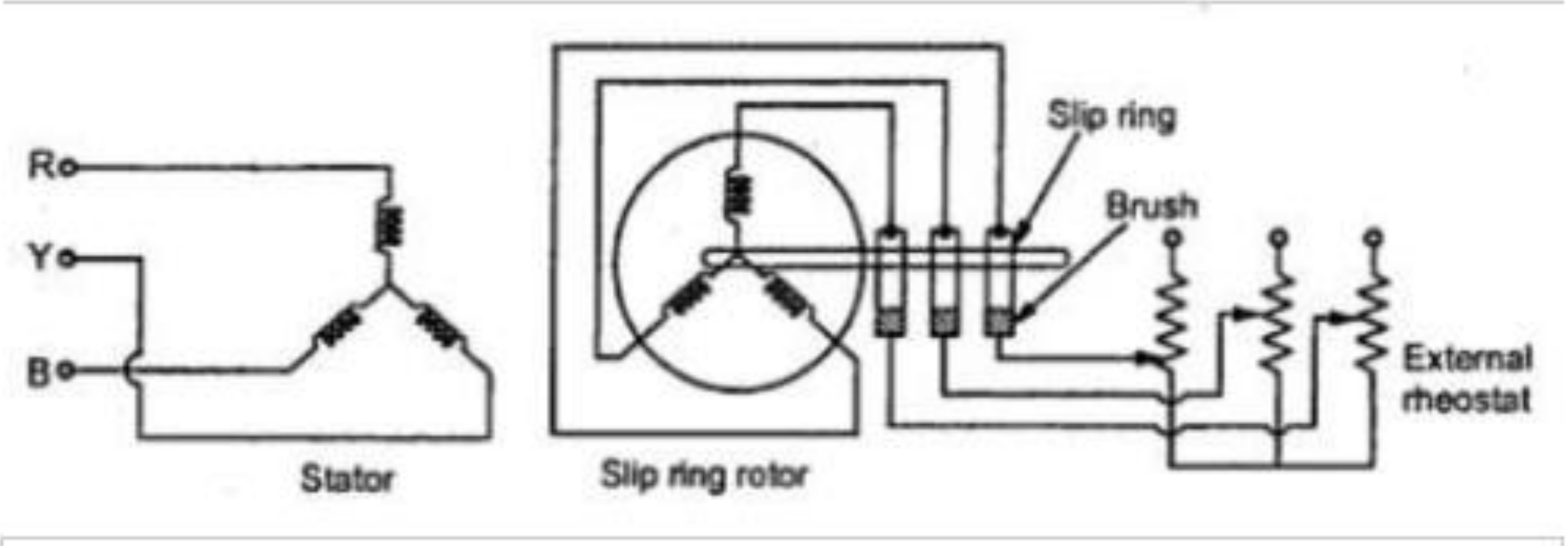
Star-Delta Starter :



Autotransformer Starter:



Rotor Resistance Starter:



Speed Control of Induction Motor:

The three phase induction motor is practically a constant speed motor like a DC shunt motor but the speed of DC shunt motor can be varied smoothly just by using simple REO strats the speed regulation and efficiency of DC shunt motor is maintained but in case of a three phase induction motor it is very difficult to achieve smooth speed control if the speed control is achieved by some means the performance of the induction motor in domes of its power factor efficiency etc gets adversely affected.

$$N = N_S (1-S)$$

$$N_S = \frac{120f}{P}$$

The speed control of the induction motor can be controlled by basically two methods

1. Control from The Stator Side

- By changing the applied voltage
- By changing the applied frequency
- By changing the number of stator poles

2. Control from the Rotar side

- Rotar Rheostat Control
- Cascade control
- By injecting an EMF in the rotor circuit

Speed Control by Changing the applied voltage:

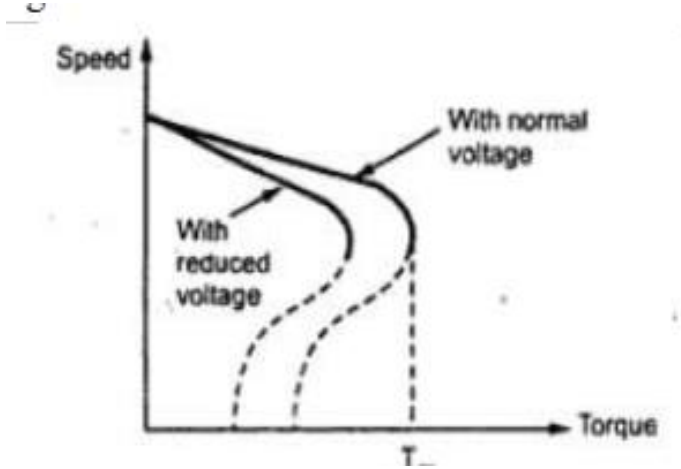
We know that, $T \alpha (k\, s\, E_2^2\, R_2)/(R_2^2 + (s\, X_2)^2)$

Now E_2, the rotor induced e.m.f. at standstill depends on the supply voltage V.

$\therefore \quad E_2 \alpha V$

Also for low slip region, which is operating region of the induction motor, $(s\, X_2)^2 << R_2$ and hence can be neglected.

$\therefore \quad T \alpha (s\, E_2^2\, R_2)/R_2^2 \alpha s V^2$ for constant R_2



Speed Control by changing the applied frequency:

The synchronous speed is given by,

$N_s = 120f / Ps$

Thus by controlling the supply frequency smoothly, the synchronous speed can be controlled over a wide range. This gives smooth speed control of an induction motor.

But the expression for the air gap flux is given by,

$$\phi_g = \frac{1}{4.44 K_1 T_{ph1}} \left(\frac{V}{f} \right)$$

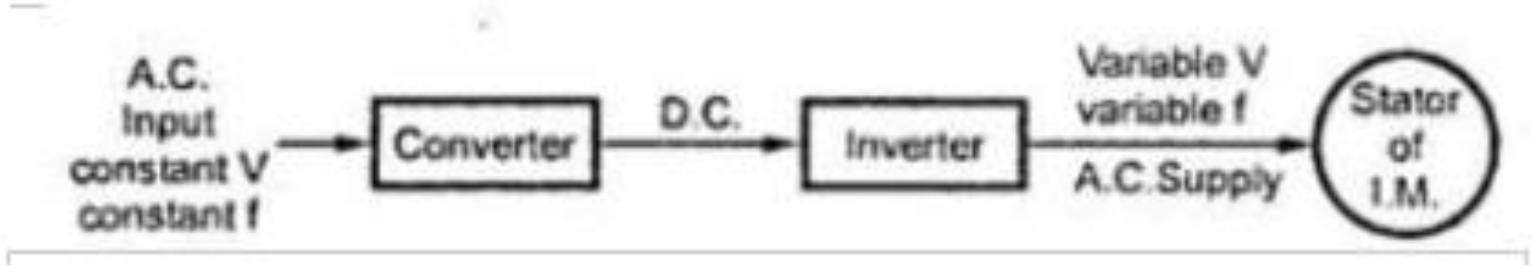
This is according to the e.m.f. equation of a transformer where,

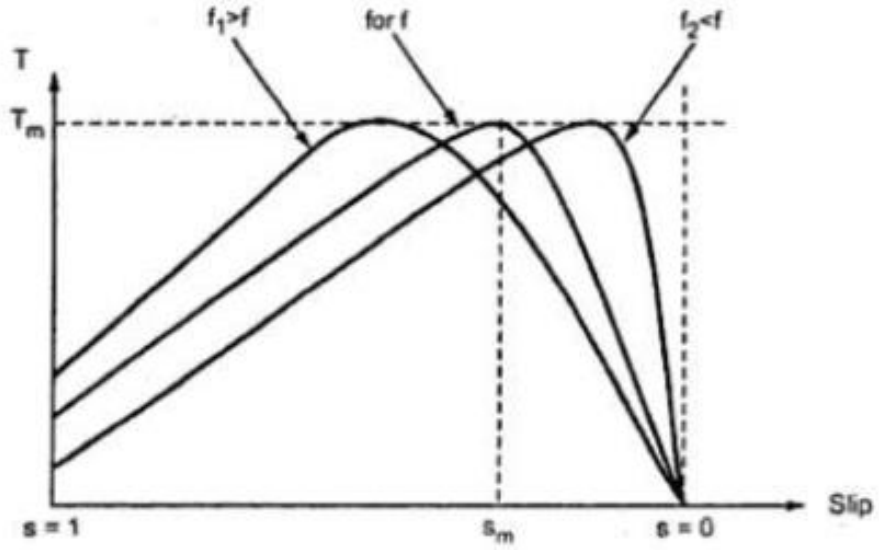
K_1 = Stator winding constant

T_{ph1} = Stator turns per phase

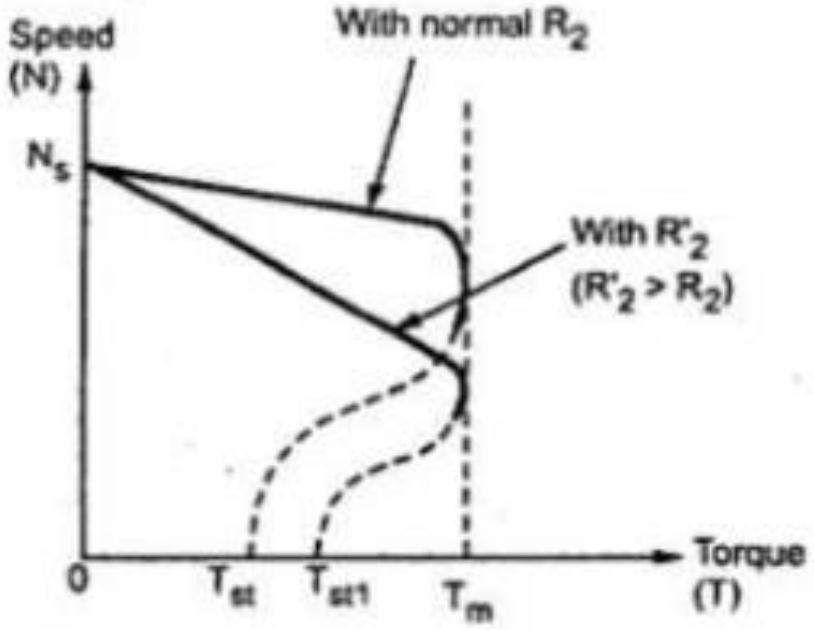
V = Supply voltage

f = Supply frequency

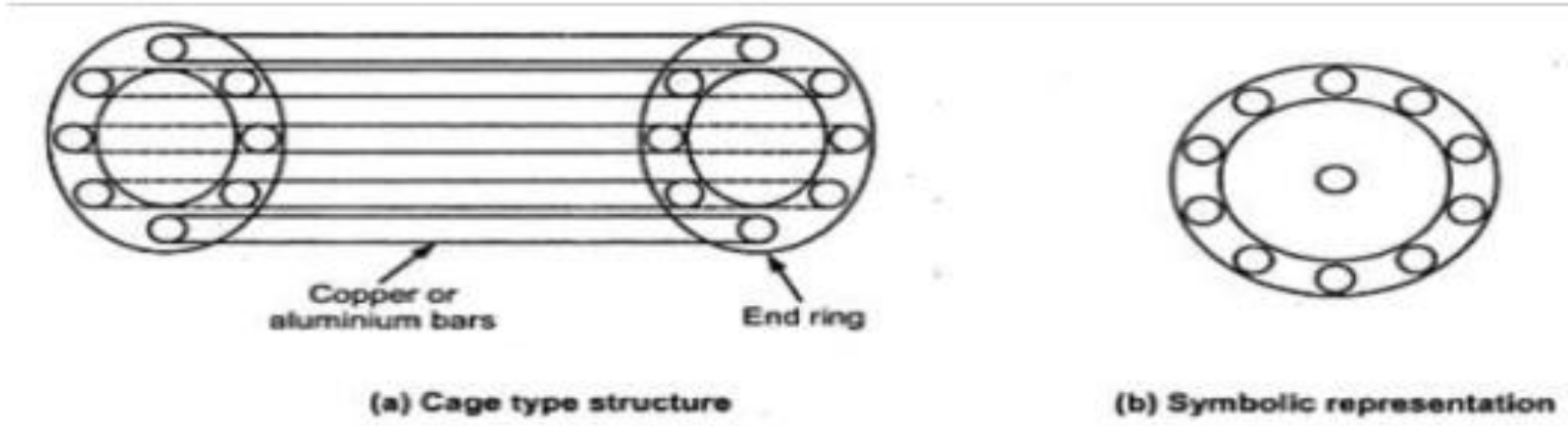

A.C.
Input
constant V
constant f
Converter
D.C.
Inverter
Variable V
variable f
A.C.Supply
Stator
of
I.M.


T
T_m
f_1>f
for f
f_2<f
Slip
s = 1
s_m
s = 0

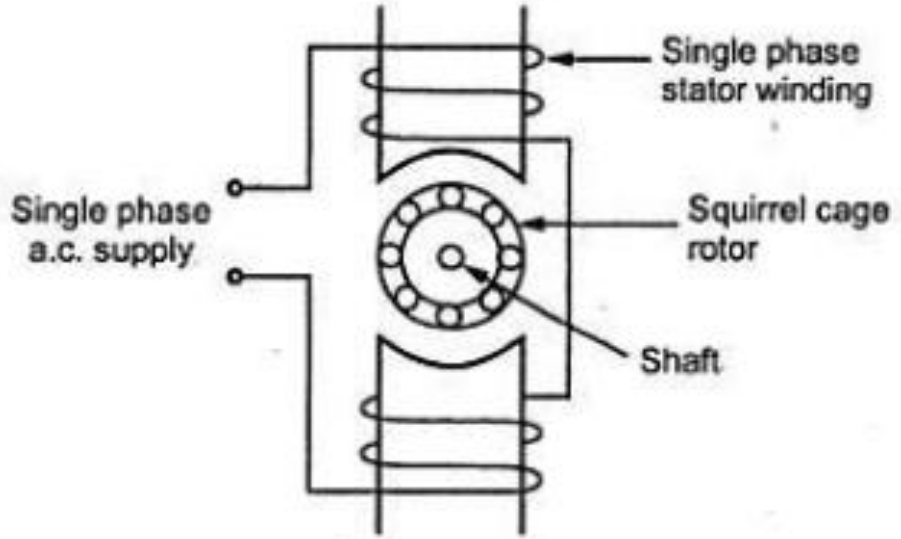
Speed Control by Rotar Rheostat Control:



Construction of Single-Phase Induction Motor:



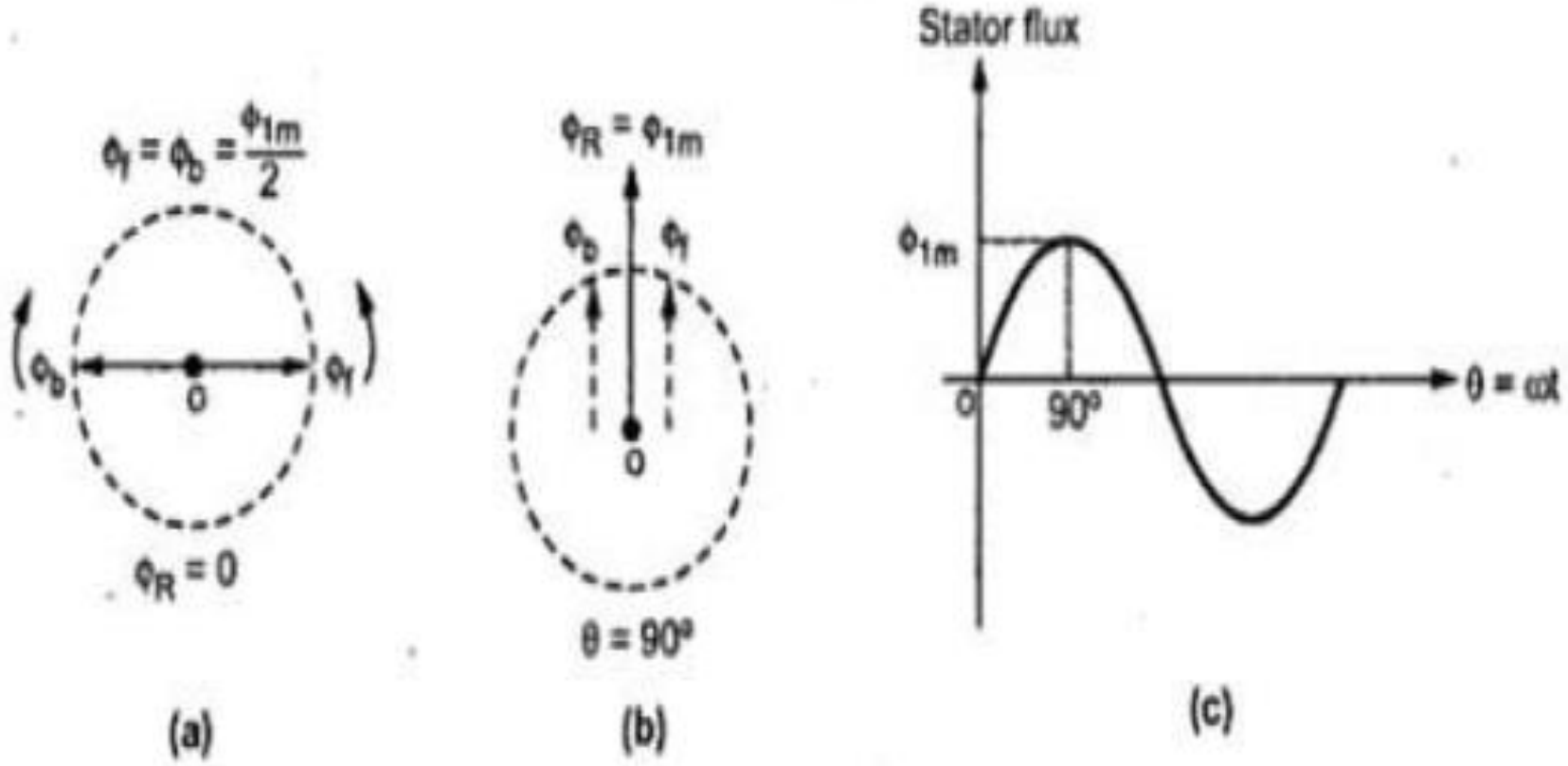
Similar to a dc- motor, single phase induction motor has basically two main parts- one rotating and other stationary The stationary part m smgle phase induction Imtors is called stator while the rotating part is called rotor-

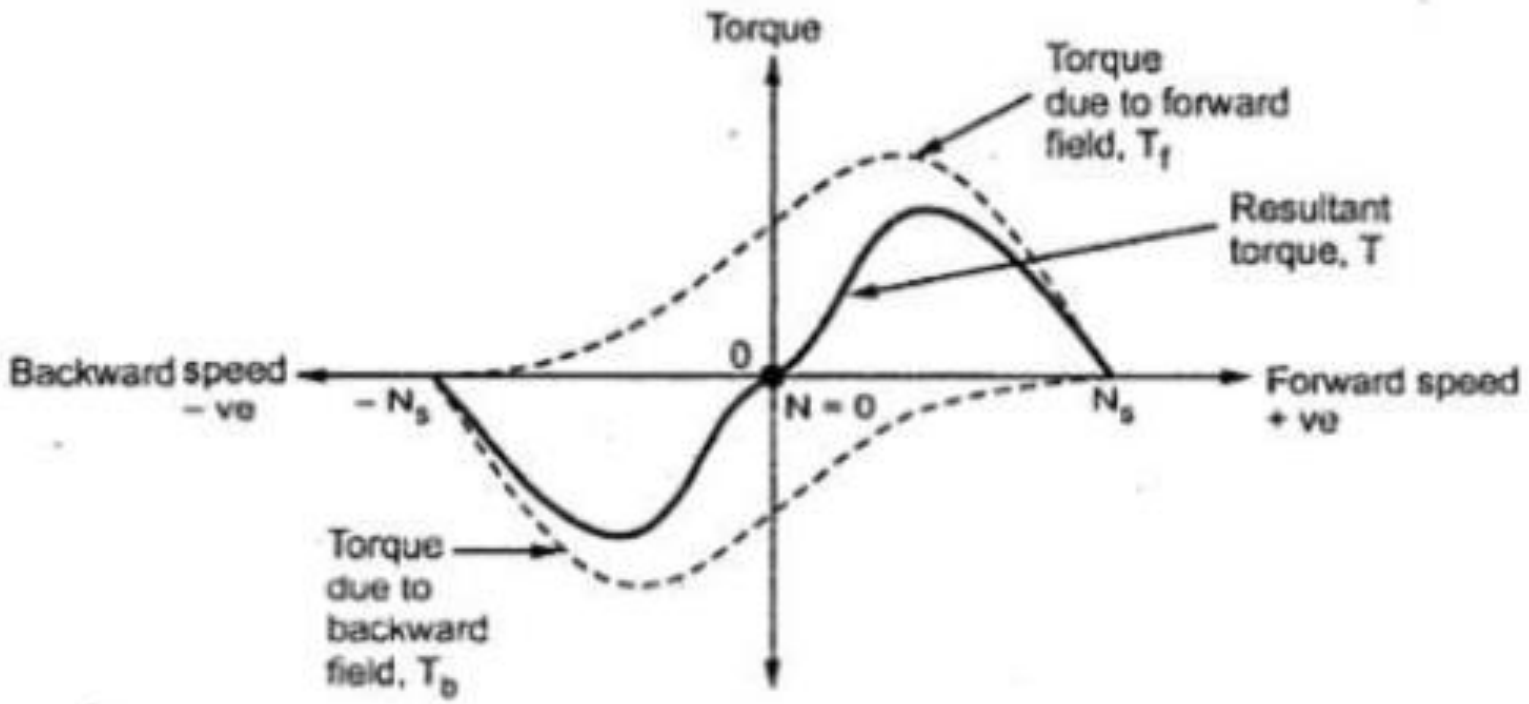


Working Principle of I-phase Induction Motor.

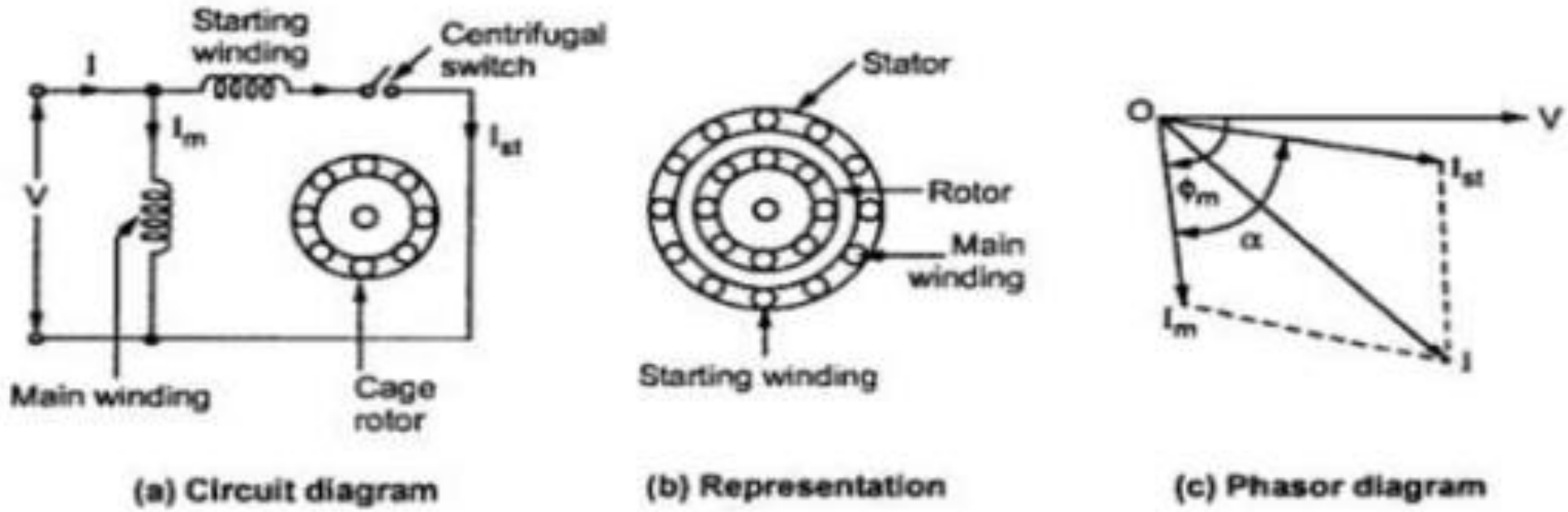
For the motoring action, there must exist two fluxes that interact with each other to produce the torque. In d.c. motors, field winding produces the main flux while d.c. supply is given to armature is responsible to produce armature flux The main flux and armature flux interact to produce the torque-

Double revolving theory:

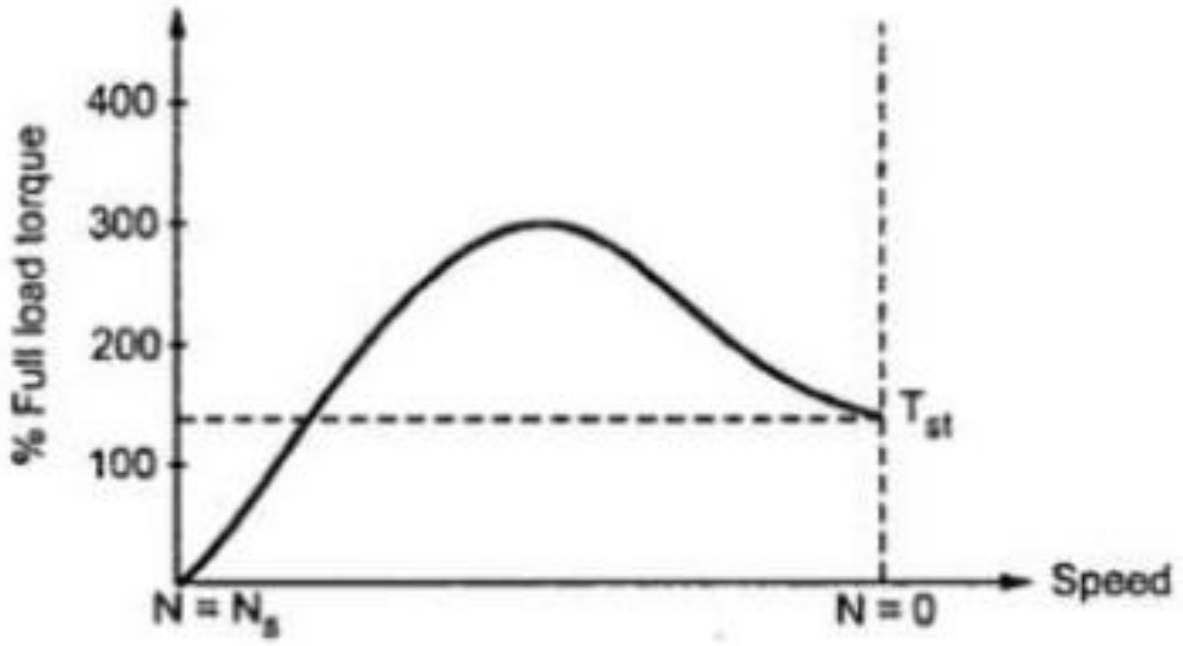



Torque
Torque due to forward field, T_f
Resultant torque, T
Backward speed – ve
– N_s
0
N = 0
N_s
Forward speed + ve
Torque due to backward field, T_b

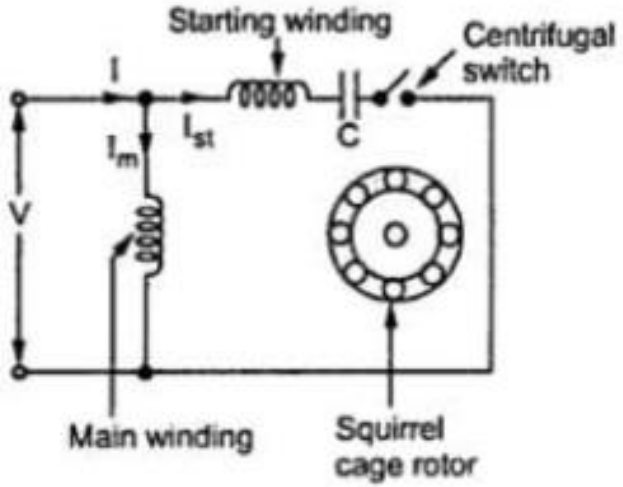
Split Phase Induction Motor:



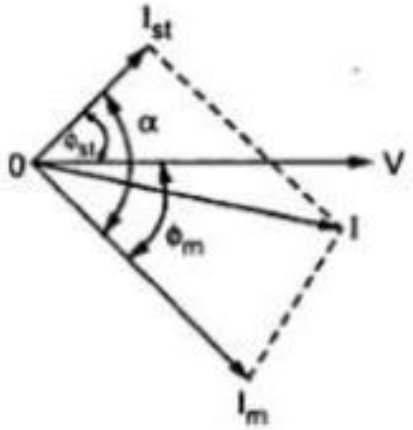
(a) Circuit diagram (b) Representation (c) Phasor diagram


400
300
200
100
% Full load torque
T_{st}
Speed
N = N_s
N = 0

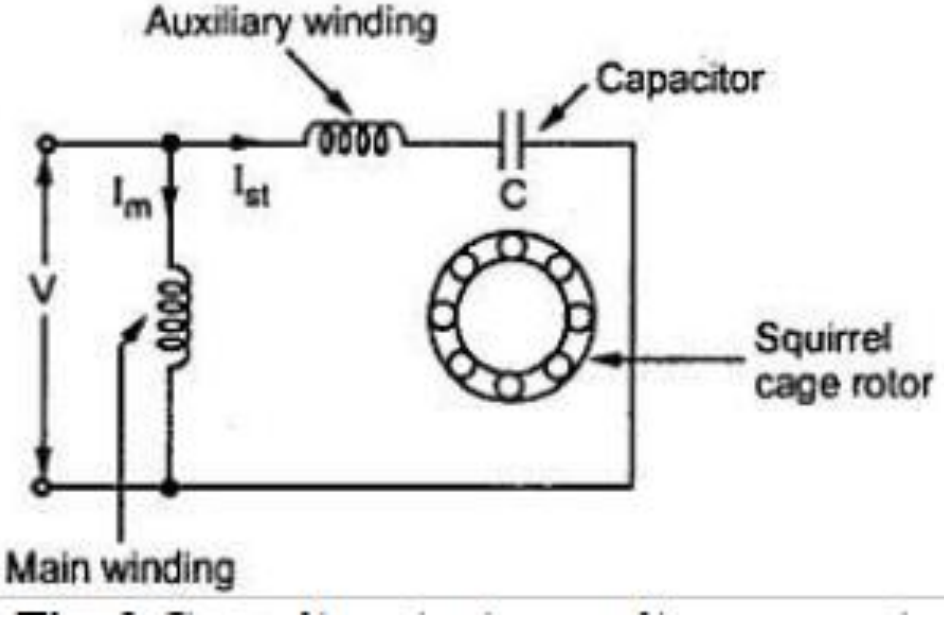
Capacitor start Induction Motor:

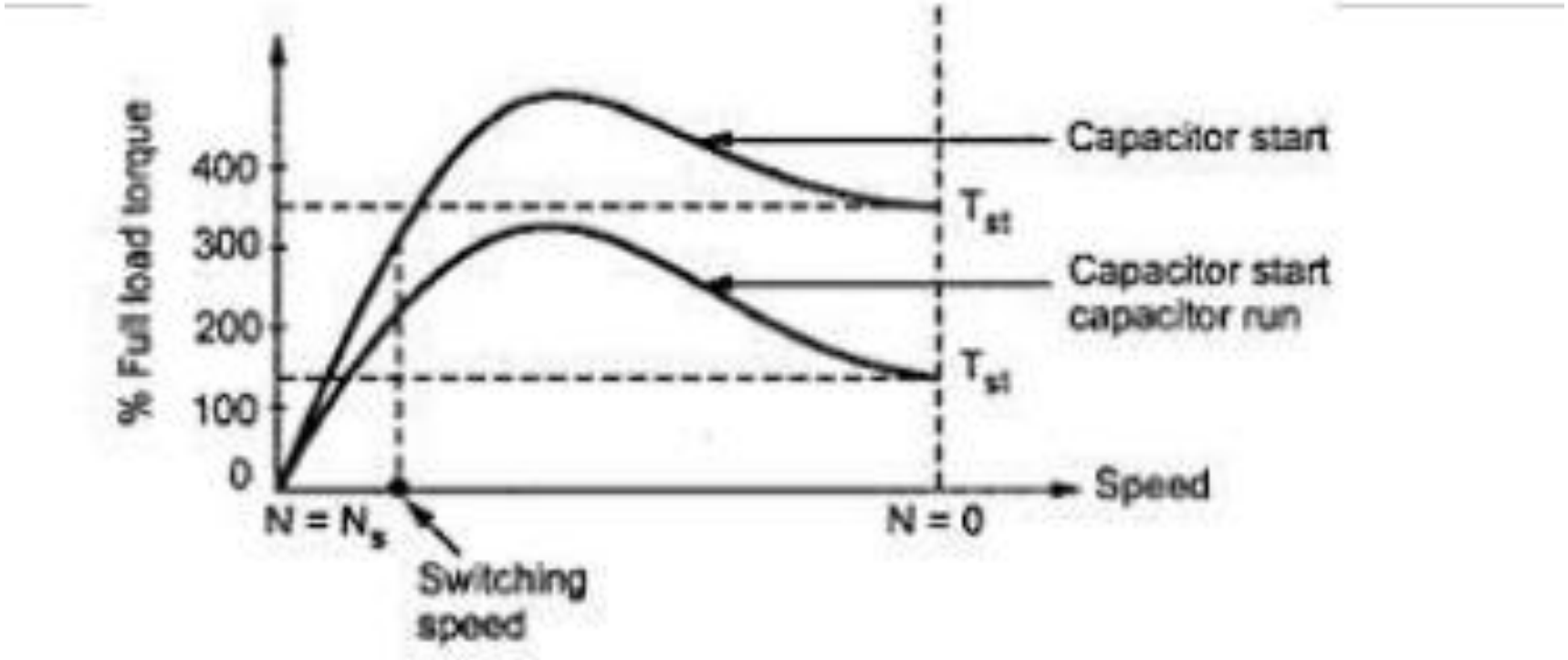


(a) Schematic representation

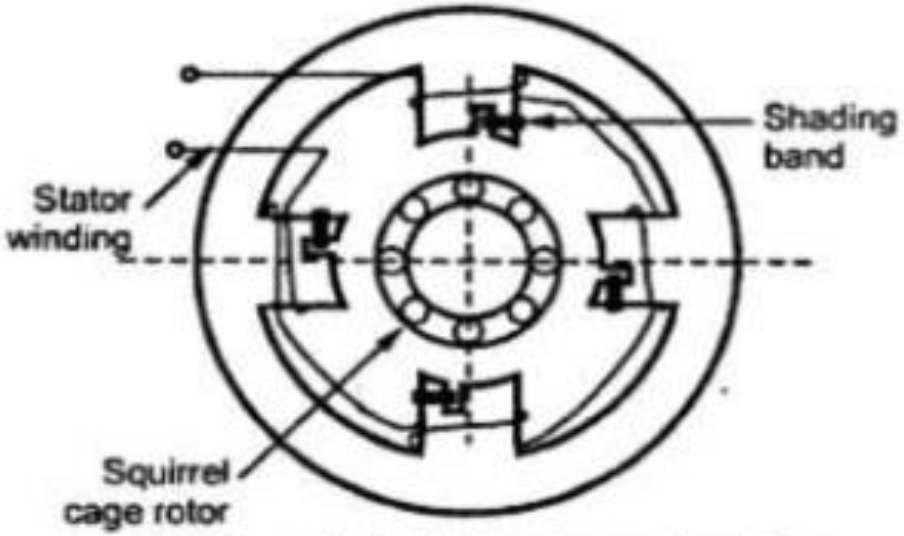


(b) Phasor diagram



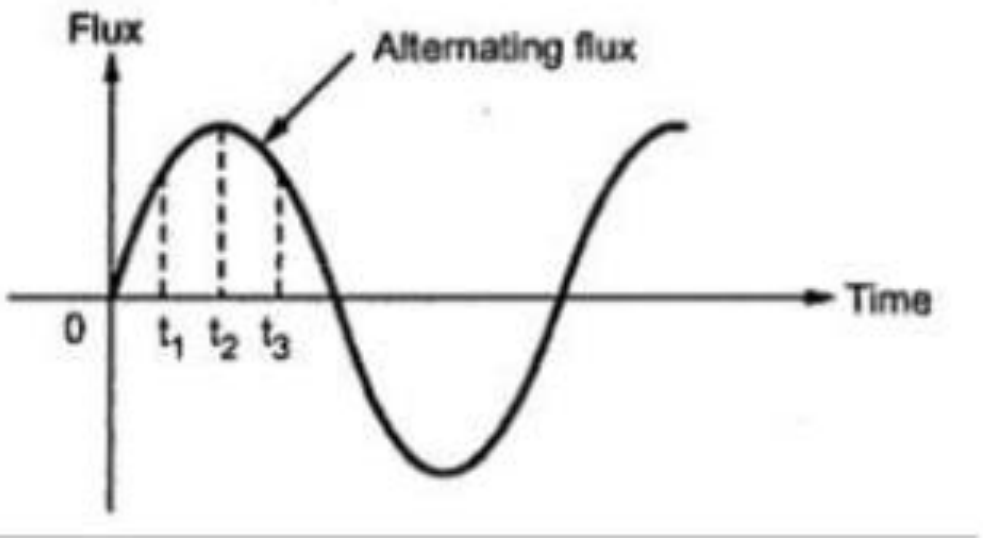

% Full load torque
400
300
200
100
0
Capacitor start
T_{st}
Capacitor start
capacitor run
T_{st}
Speed
$N = N_s$
$N = 0$
Switching
speed

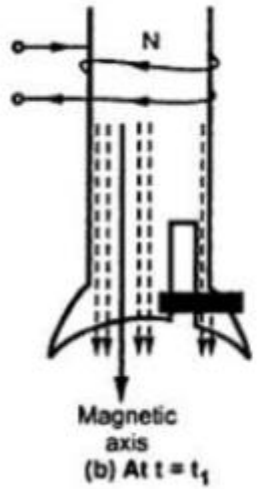
Shaded Pole Induction Motor:

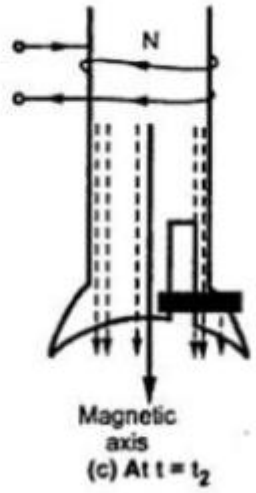


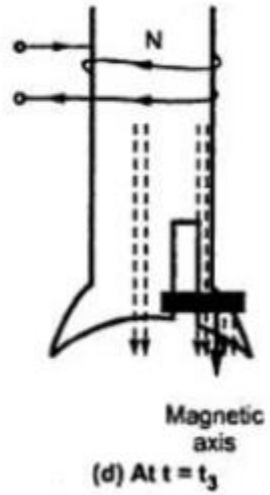
(a) 4 - pole shaded pole construction

(b) Salient pole with shading band


Flux
Alternating flux
Time
0
t_1 t_2 t_3


N
Magnetic axis
(b) At t = t_1


N
Magnetic axis
(c) At t = t_2


N
Magnetic axis
(d) At t = t_3

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