CLASSIFICATION OF SYNCHRONOUS MOTOR

- Wound field motor
  - Cylindrical rotor wound field motor
  - Salient pole rotor wound field motor
- Permanent magnet motor
  - Surface mounted PM motor
  - Interior or buried PM motor
- Synchronous reluctance motor
- Hysteresis motor

SEPARATE CONTROLLED SYNCHRONOUS MOTOR

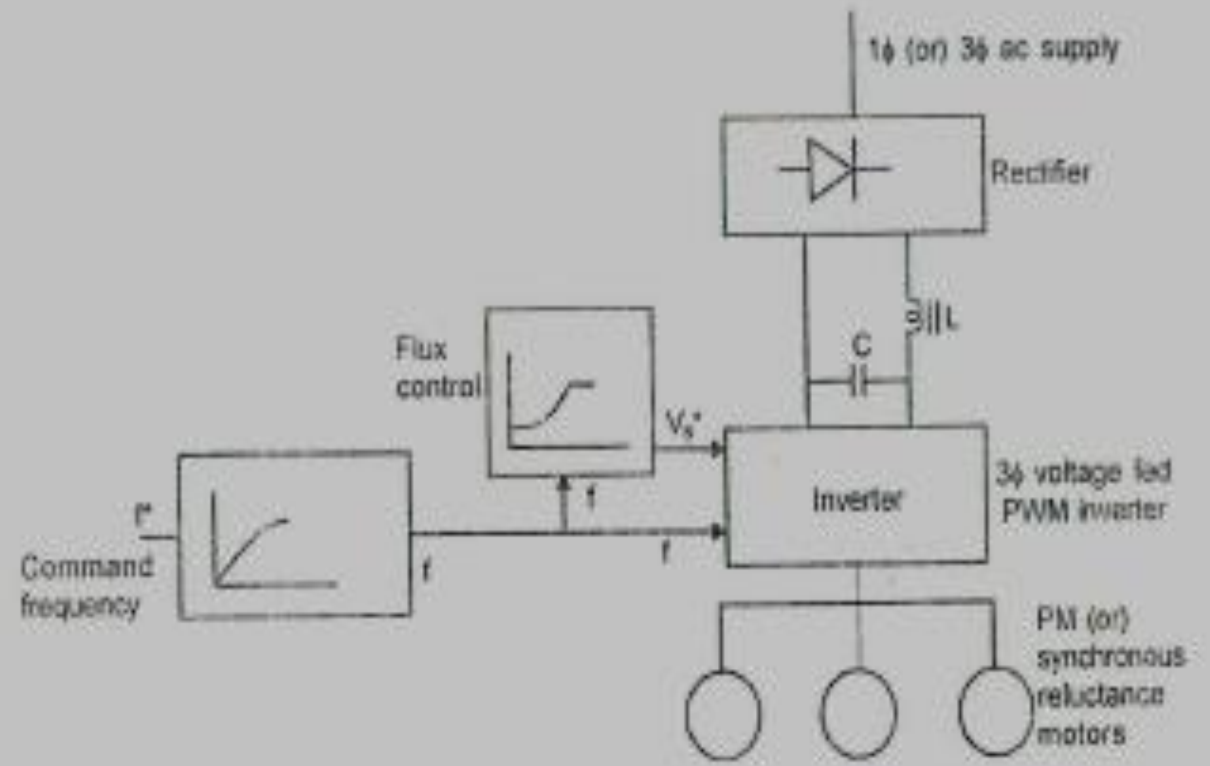


Figure 7.9: Open loop voltage/Hz speed control of multiple PM synchronous motor

SELF CONTROLLED SYNCHRONOUS MOTOR

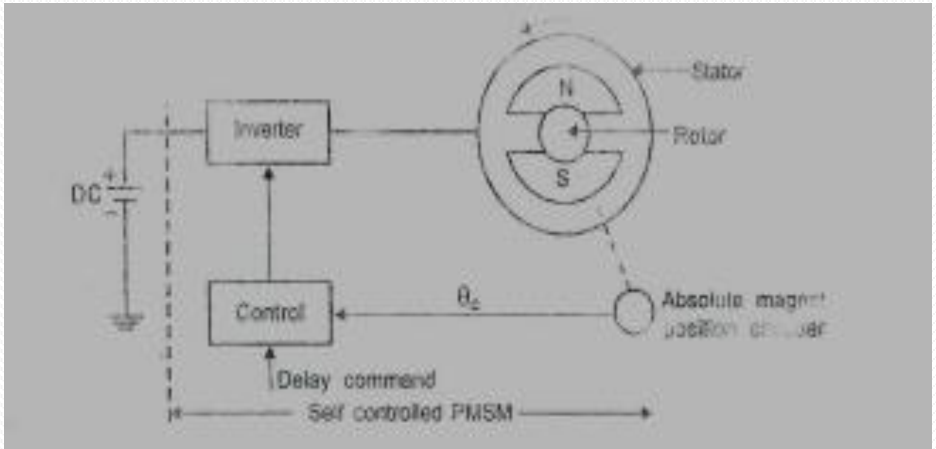
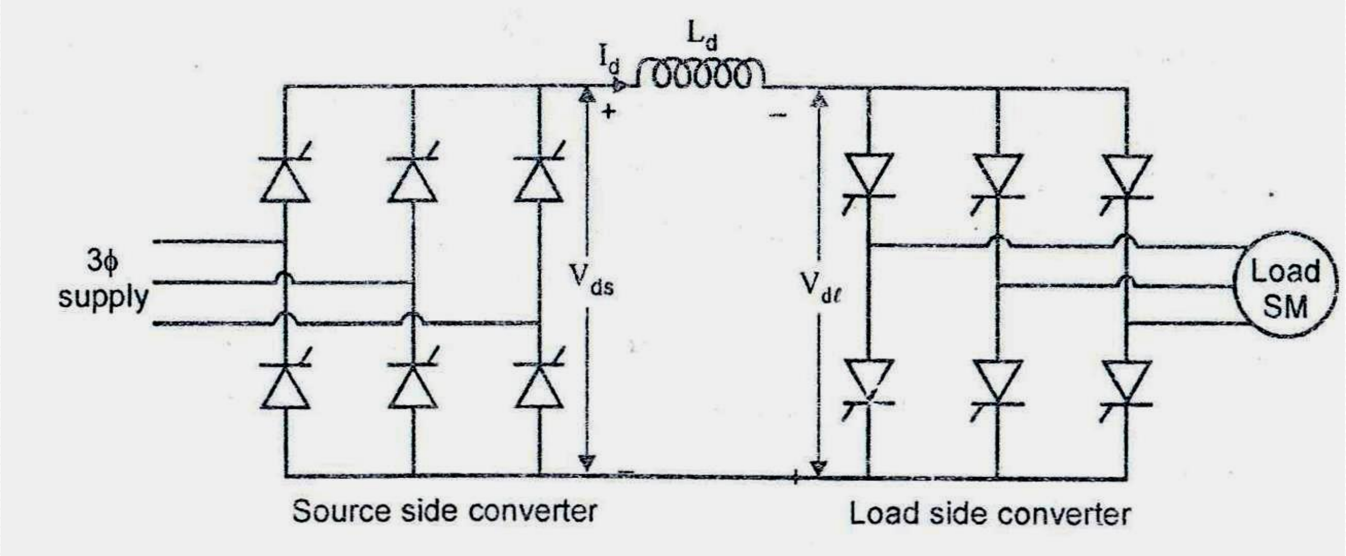


Figure 7.10: Self controlled synchronous motor

Comparison between self & separately controlled synchronous Motor drives

Sl. No.	Separate control	Self control
1.	Hunting oscillations are present	Hunting is eliminated
2.	Damper winding is required	No need of a damper winding
3.	Stator supply frequency is controlled from an independent oscillator	No need of independent oscillator for frequency adjustment.
4.	Multiple no. of machines can be controlled.	Single machine is controlled.

SELF CONTROLLED SM DRIVE EMPLOYING LOAD COMMUTATED THYRISTOR INVERTER



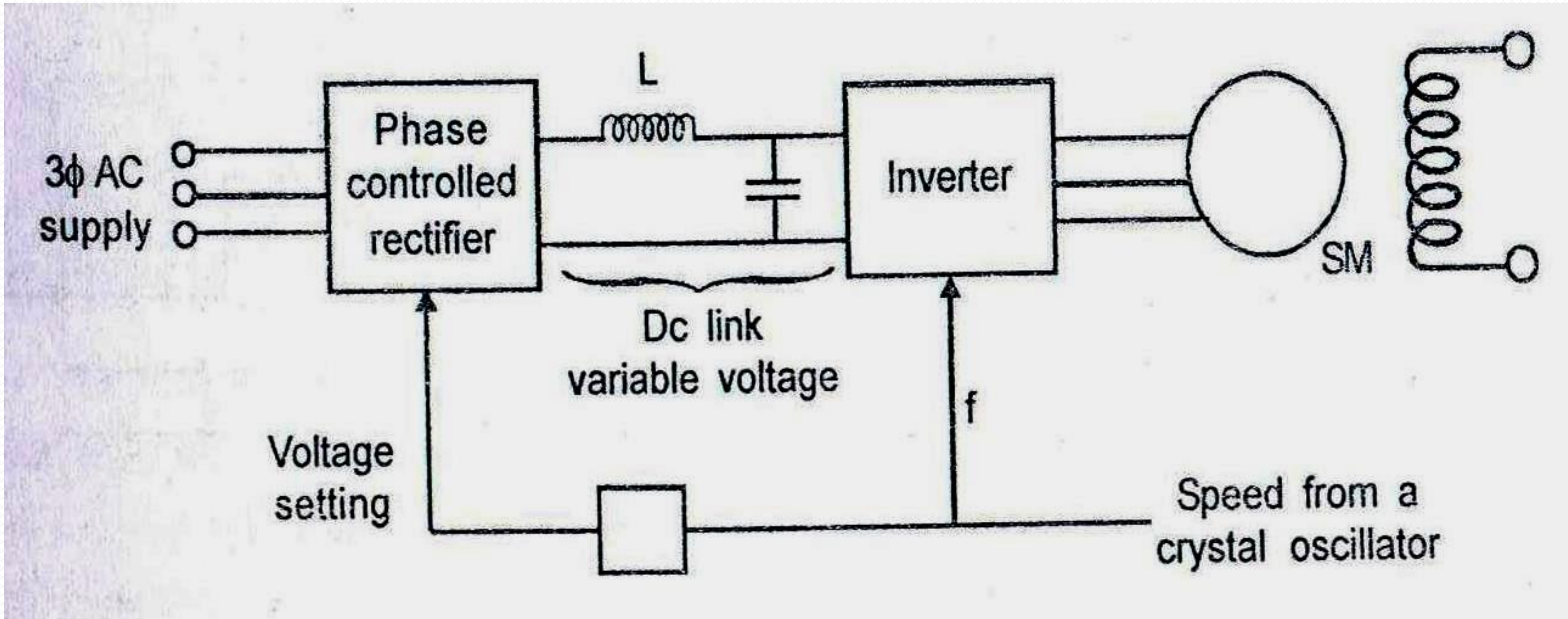
VOLTAGE SOURCE INVERTER (VSI) FED SM

- Three ways of producing VVVF supply using VSI:

1. Square wave inverters
2. PWM inverters
3. Chopper with square wave inverters

In all the cases the SM can be operated either in self or separate controlled mode

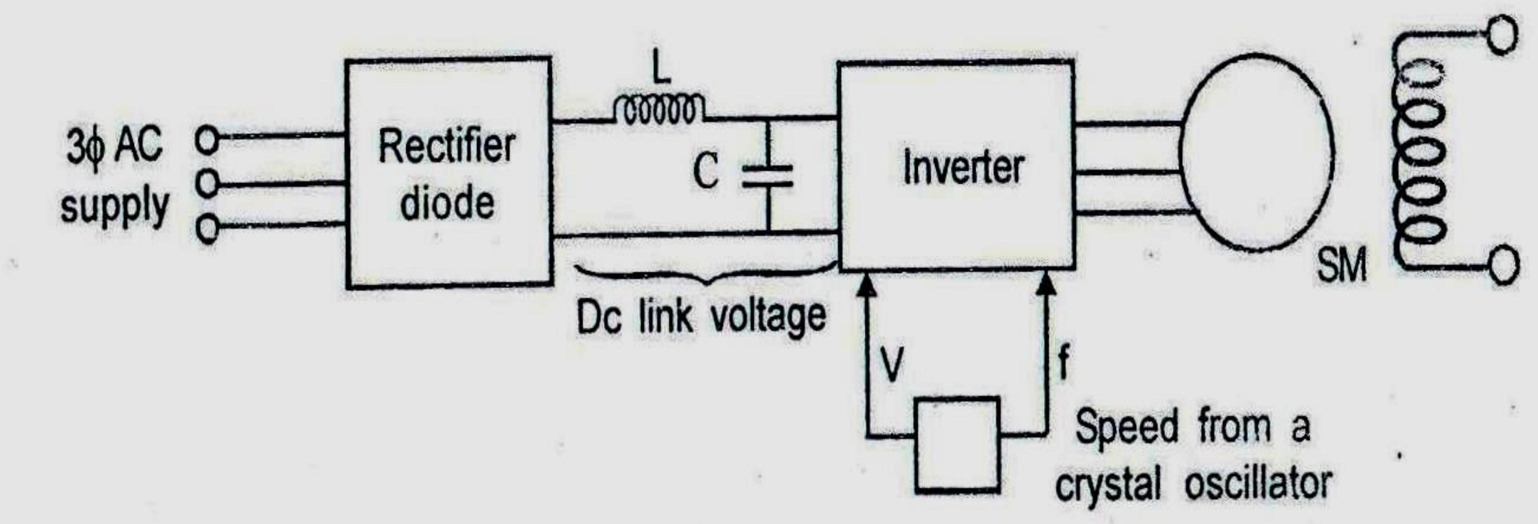
SEPARATE CONTROL OF SM FED FROM SQUARE WAVE INVERTER



(a) Separate control of SM fed from square wave inverter

- Medium to high speed applications.
- Output is a square wave
- Variable DC link voltage
- Commutation is difficult at low speeds

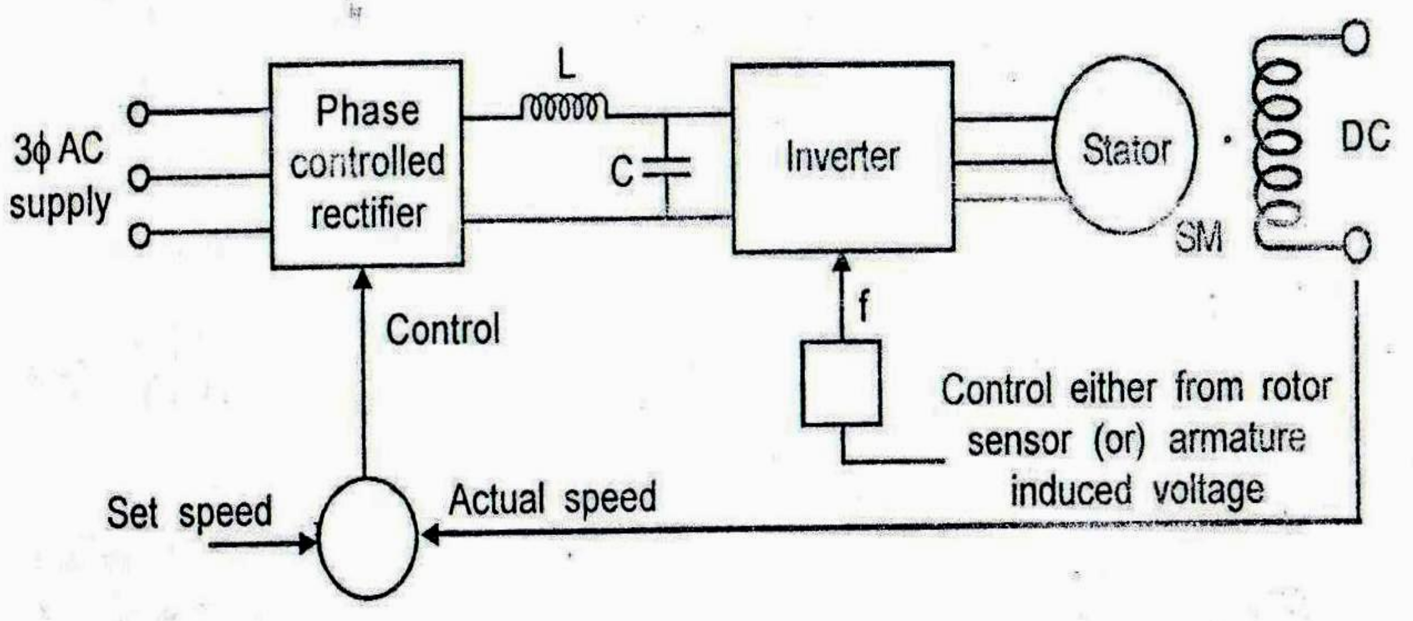
SEPARATE CONTROL OF SM FED FROM PWM INVERTER



(b) Separate control of SM fed from PWM inverter

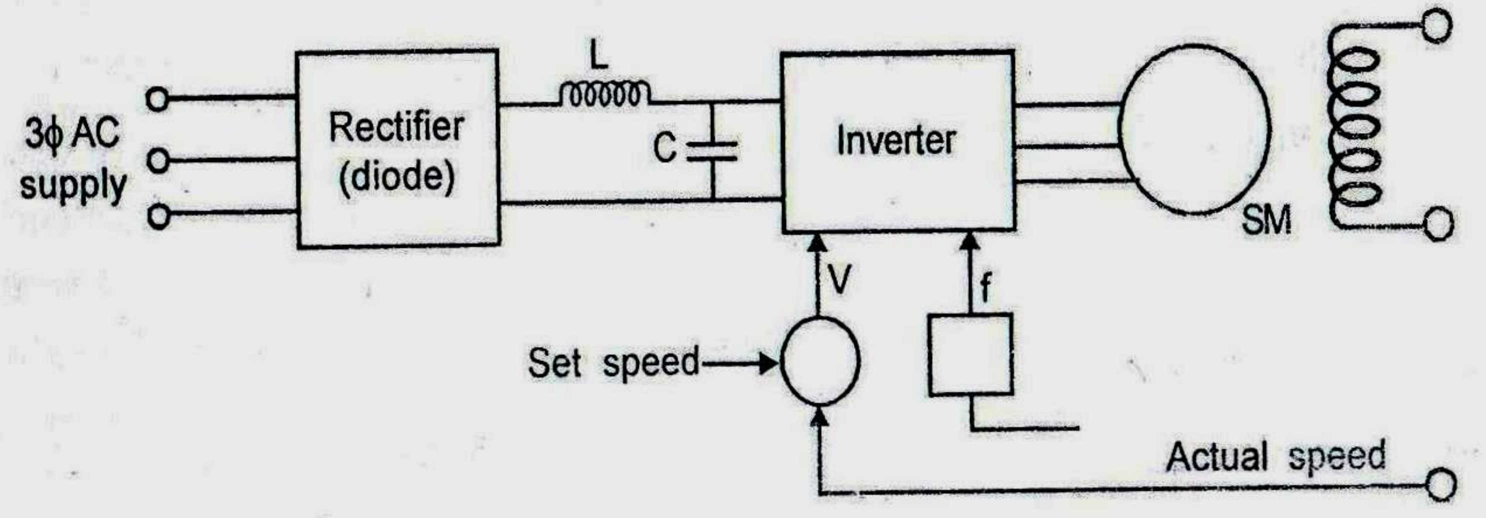
- Voltage control within the inverter
- DC link voltage is constant
- Wide range of speed applications

SELF CONTROL OF SM FED FROM SQUARE WAVE INVERTER



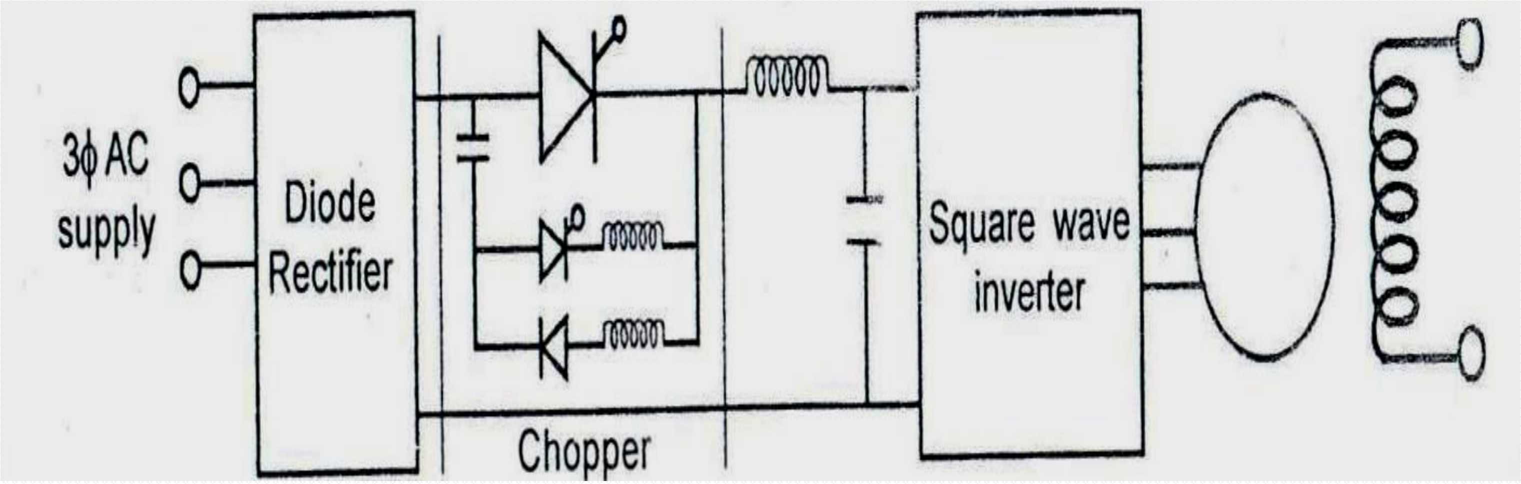
(c) Self control of SM fed from square wave inverter

SELF CONTROL OF SM FED FROM PWM INVERTER



(d) Self control of synchronous motor fed from a PWM inverter

SM FED BY CHOPPER WITH INVERTER

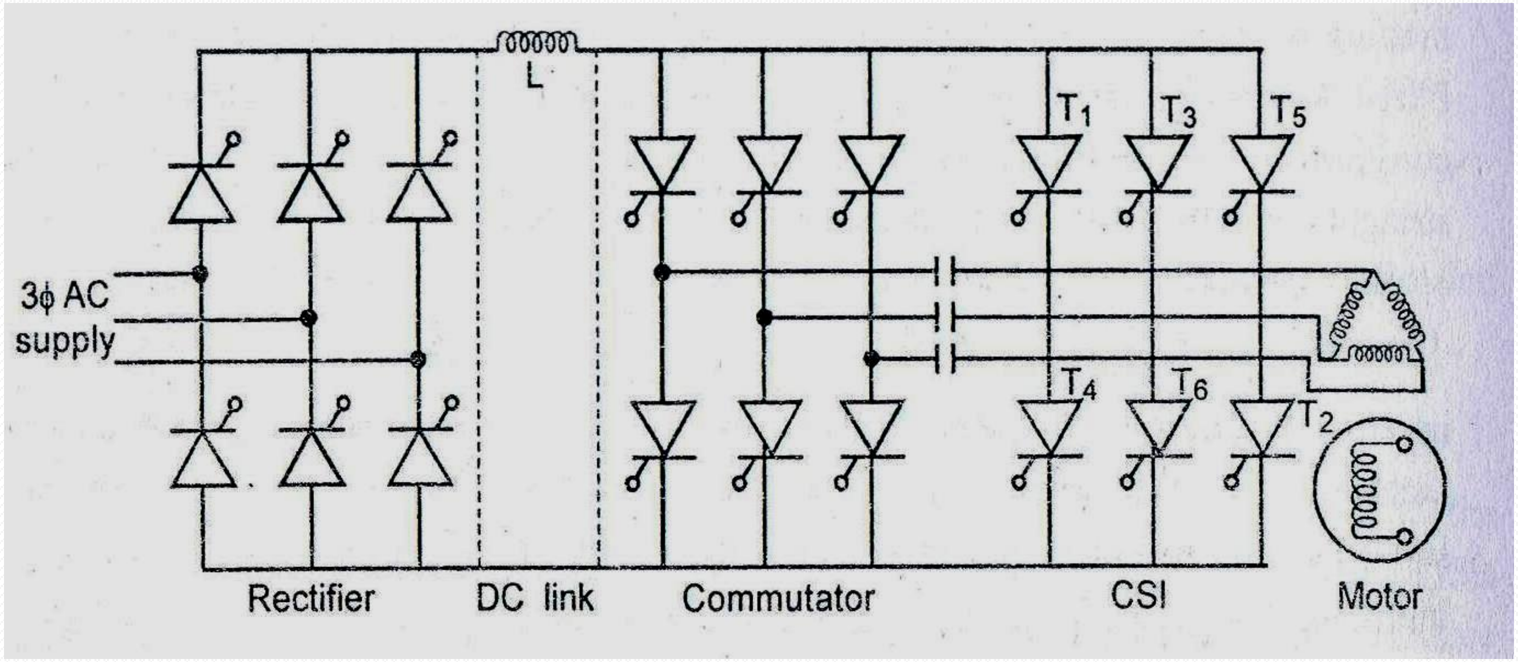


- Non sinusoidal output voltage
- Stator current has sharp peaks and is rich in harmonic content
- Pulsating torque
- Additional heating

CURRENT SOURCE INVERTER (CSI) FED SM

- The flux and torque of SM can be controlled by stator current control
- CSI SM can be operated in leading pf and hence machine voltage can be used for commutation (load commutation)
- Voltage spikes in terminal voltage at the instant of commutation
- Voltage spikes limited by damper winding and hence CSI fed SM always provided with damper winding
- Four quadrant operation is simple
- Speed range - above 10% of base speed for load commutated
  - zero t max speed for forced commutation

CSI WITH INDIVIDUAL COMMUTATION



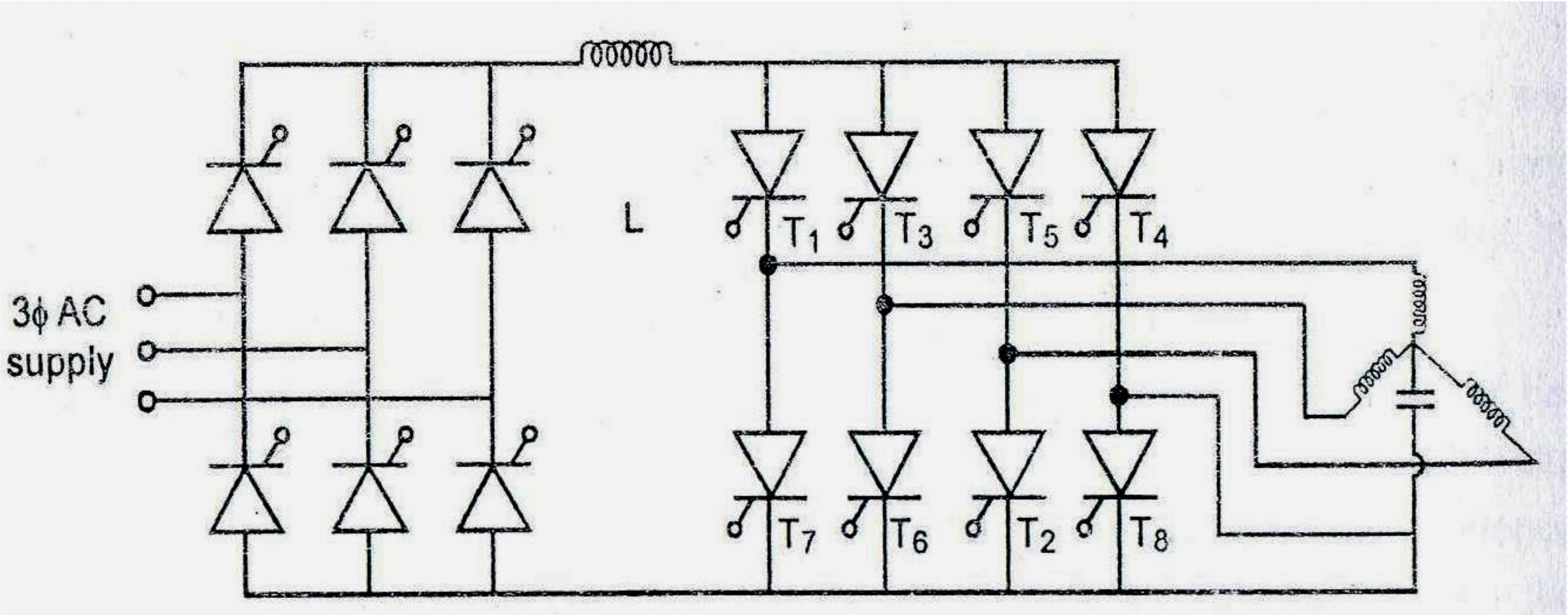
•Forced commutation circuitry is required only for the low speed(0 t0 10 %)

•Motor operated at UPF

•Large inductance in DC link makes source current fed to inverter a constant

•Each main thyristor has an auxiliary thyristor for commutation

THIRD HARMONIC COMMUTATED ASCSI

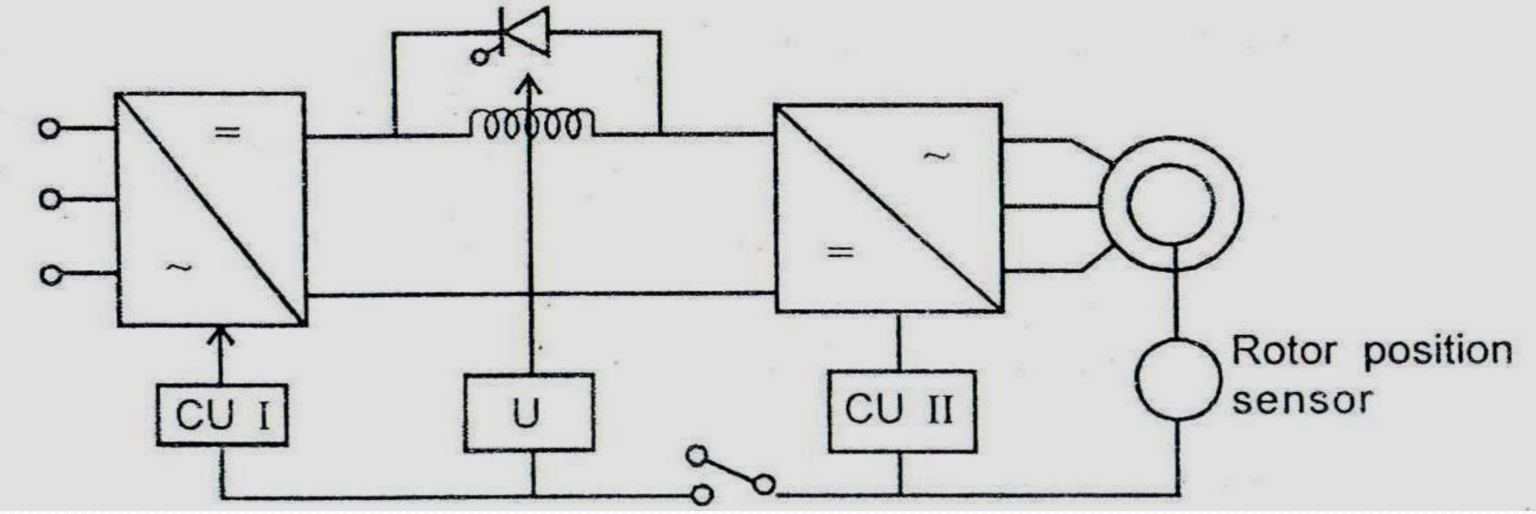


•T7 and T8 are aux. thyristors and C is the commutation capacitor

•At low speed, voltage across the Capacitor is used to commutate the main thyristor

•When the machine achieves the speed where load commutation is applicale, the fourth leg is cut off.

DC LINK CONTROL CURRENT INTERRUPTION



At low speeds the DC link current is interrupted at the instant of commutation

During commutation :

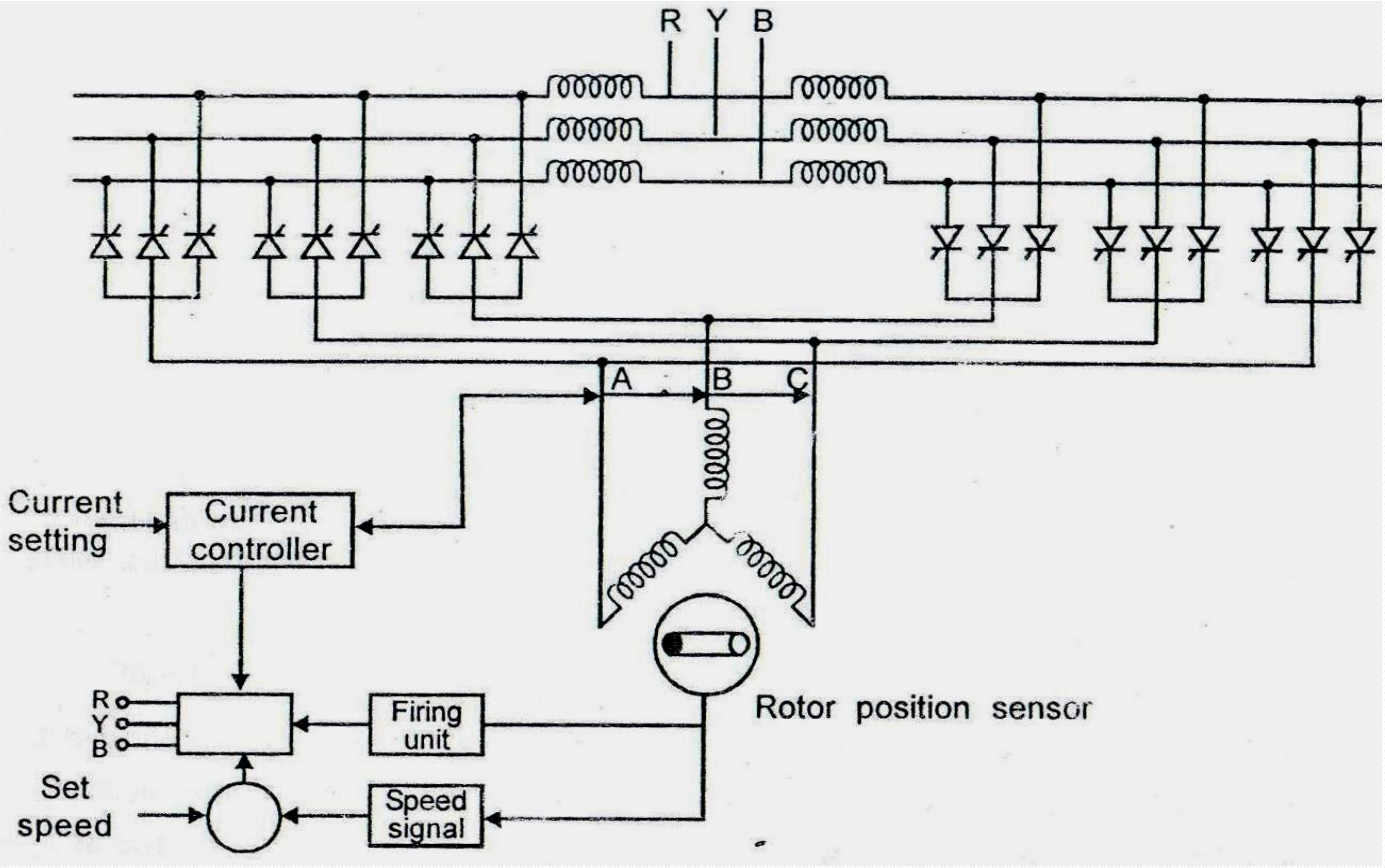
•The line side converter operates in inversion mode

•The RPS sends control signal to load side converter to block firing pulses to outgoing SCRs and to provide pulses to incoming SCRs

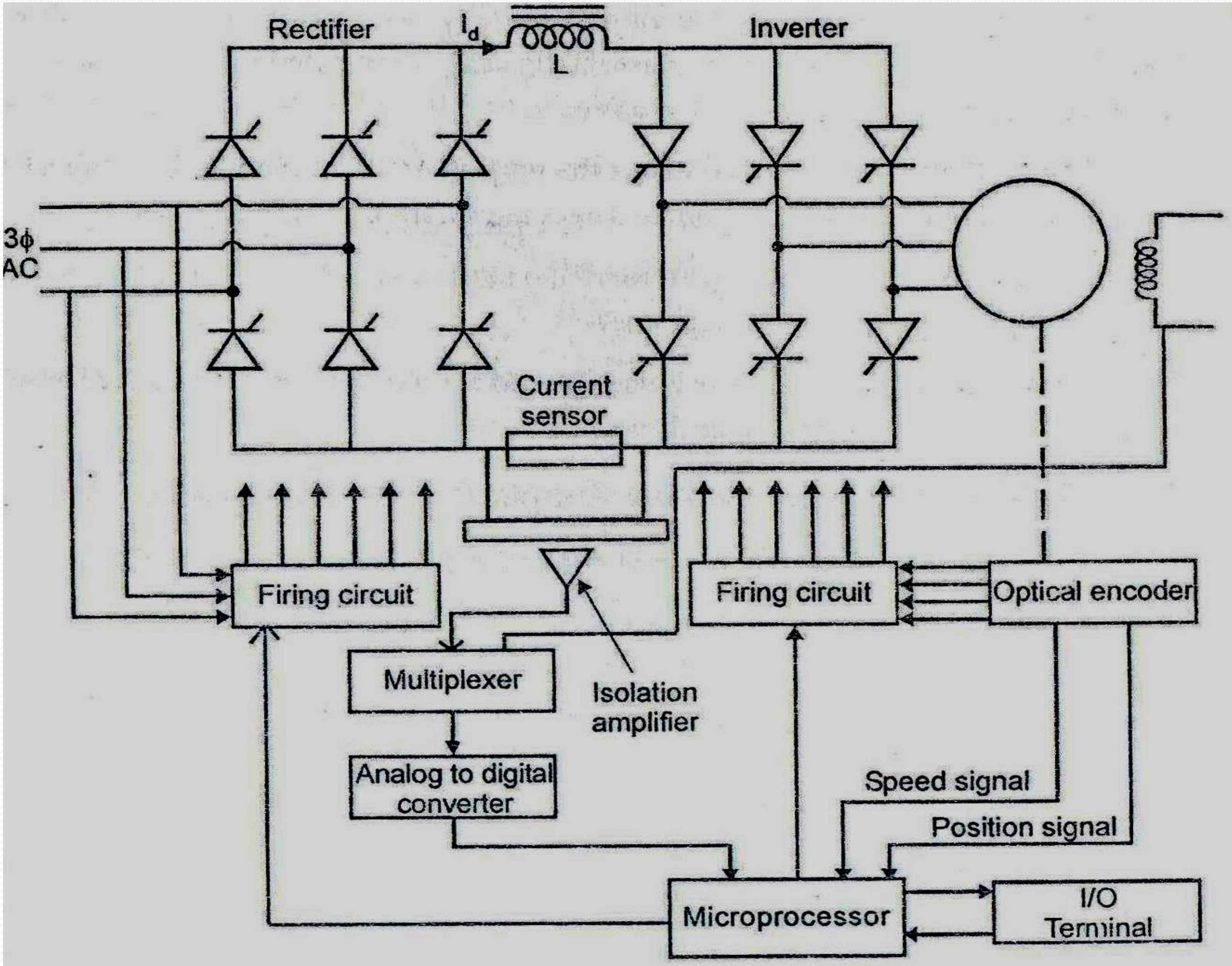
•Polarity of DC link voltage changes and hence current decays to zero and is maintained for a time greater than the turn off time of SCR

•Again the line side converter is operated in conversion mode and the sequence is repeated.

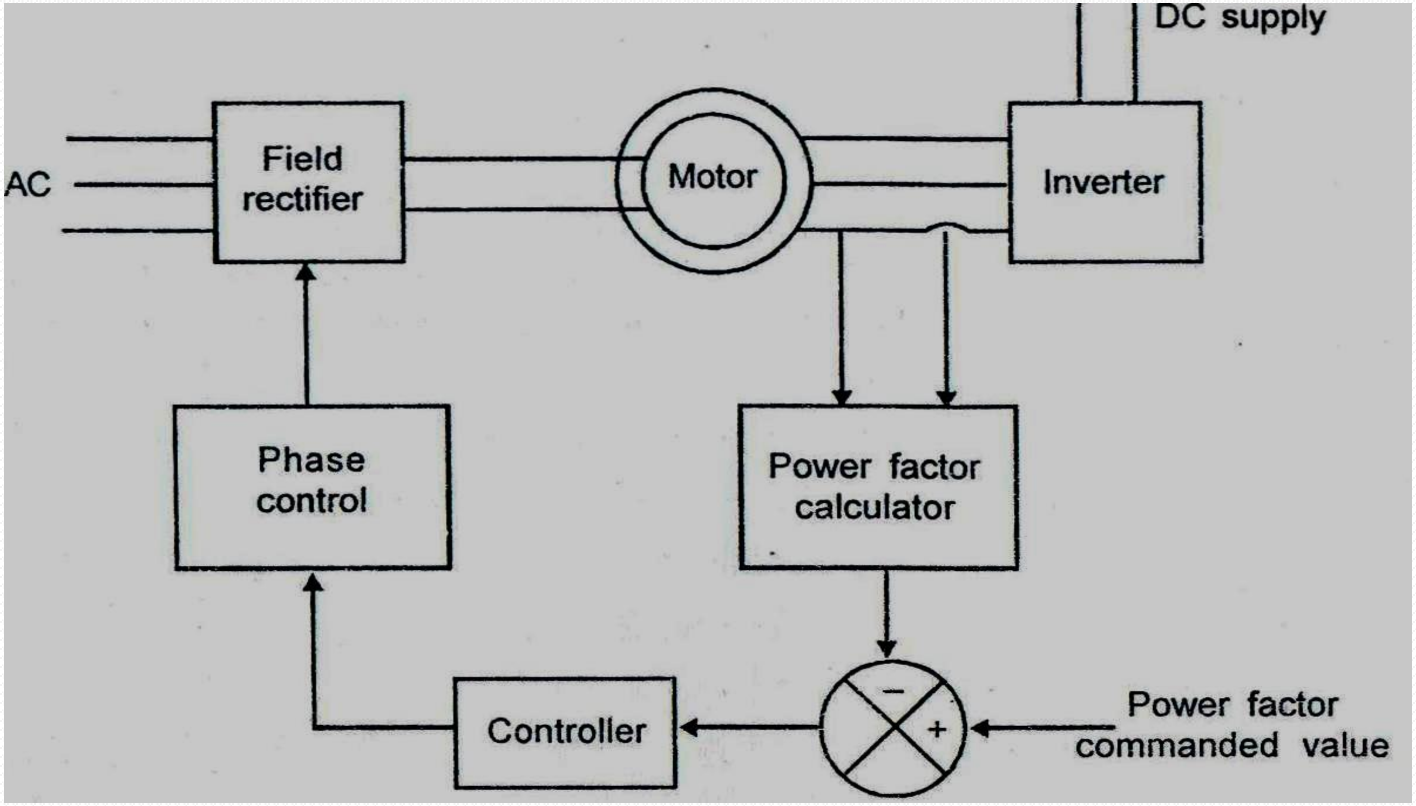
CYCLOCONVERTER FED SM (SELF CONTROL)



MICROPROCESSOR BASED CONTROL OF SYNCHRONOUS MOTOR



MOTOR POWER FACTOR CONTROL

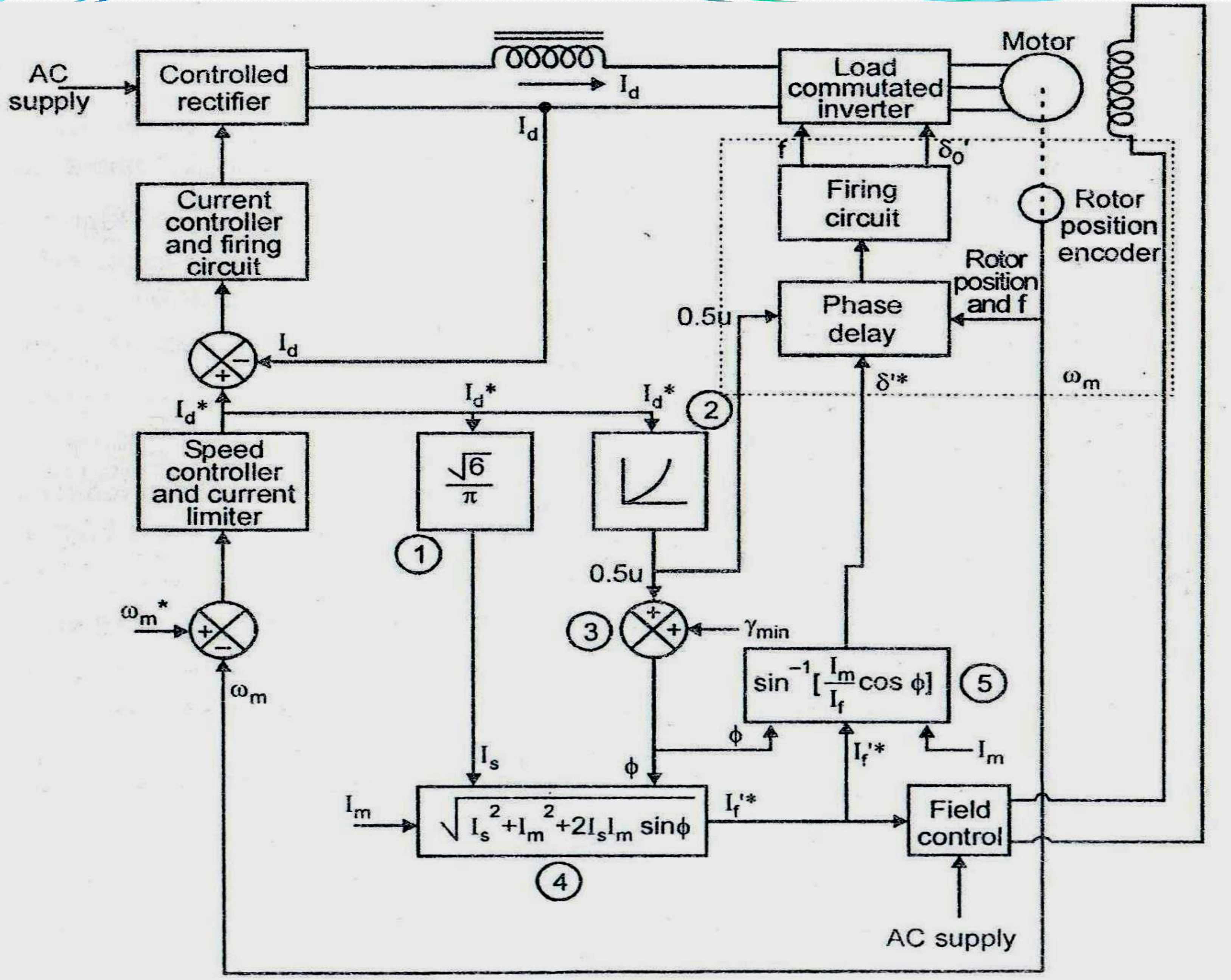


❖Motor must have wound field rotor

❖By varying field current motor power factor can be varied

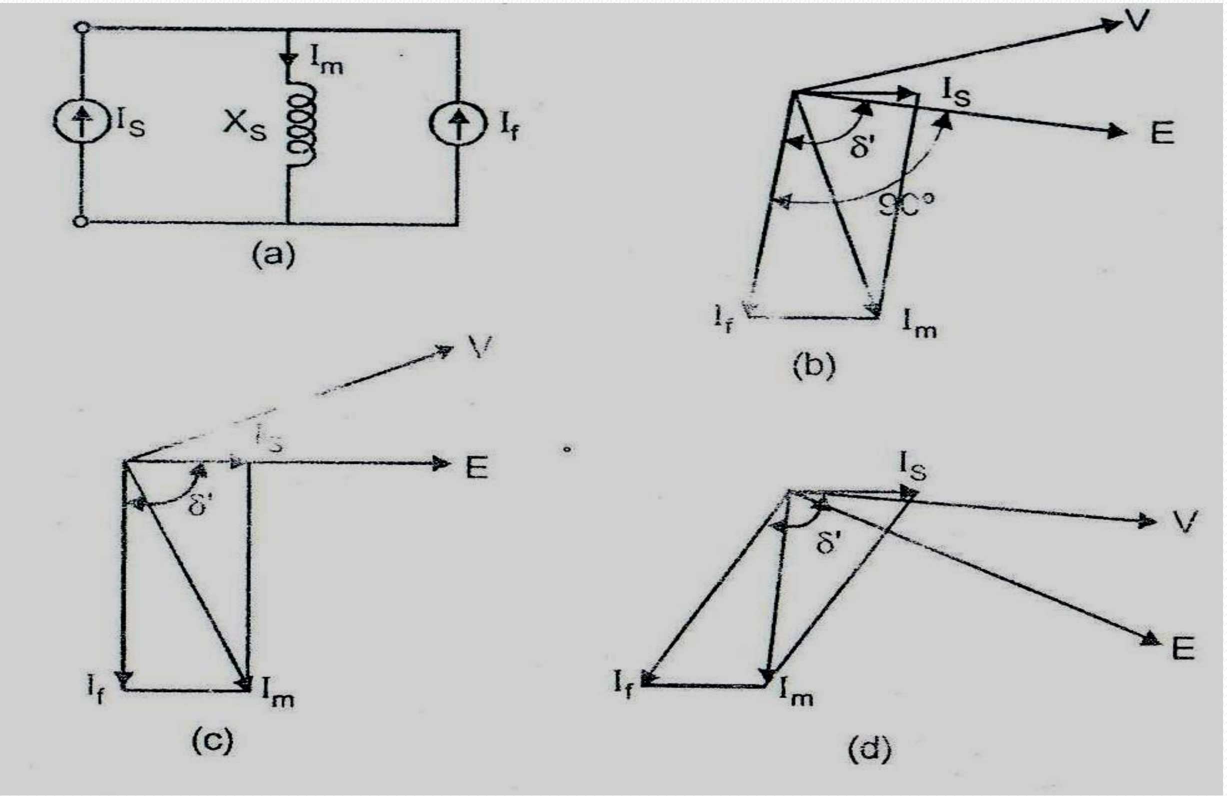
❖Power factor calculator receives voltage and current feedback signals and calculates pf of motor.

CONSTANT MARGINAL ANGLE CONTROL

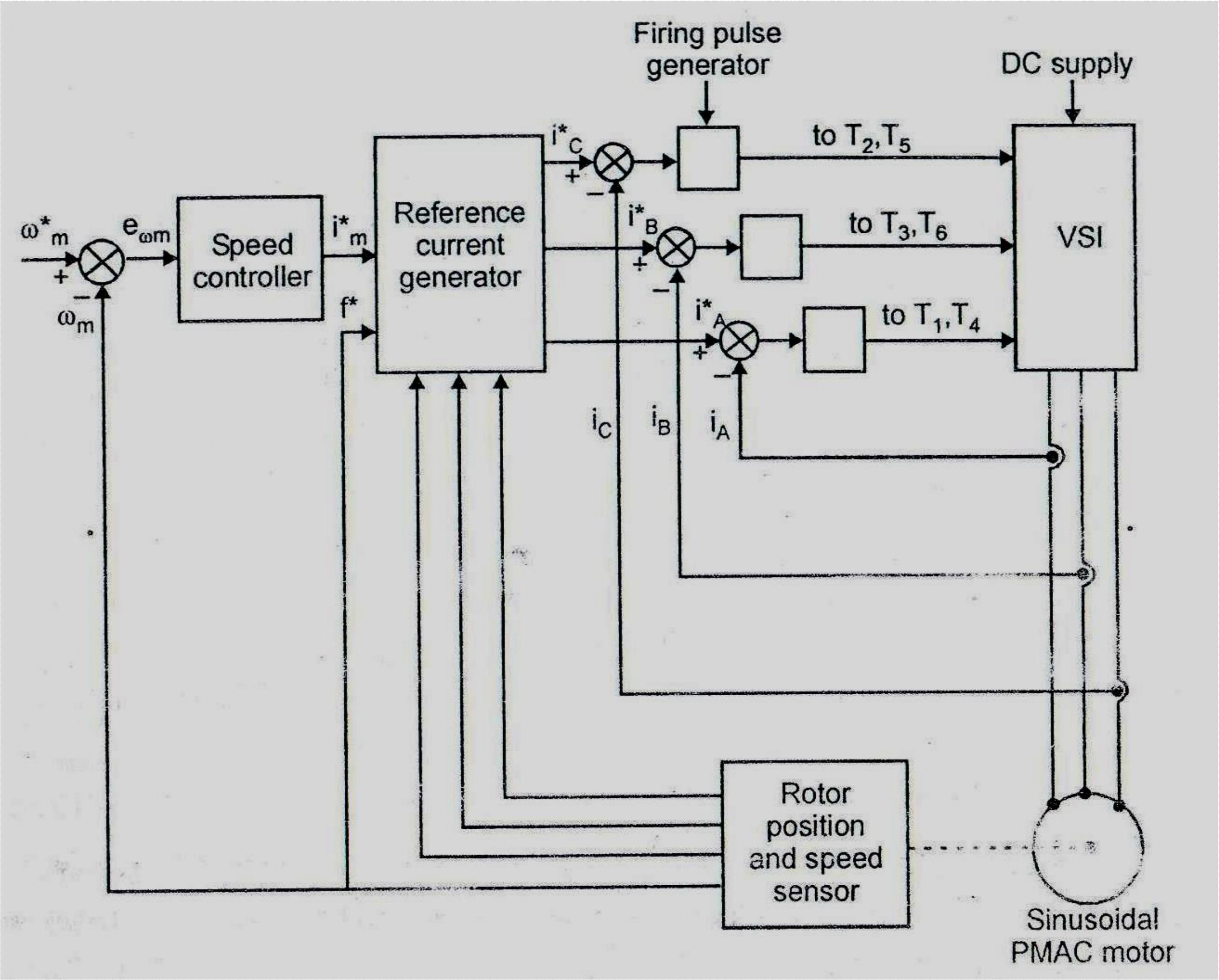


PERMANENT MAGNET SYNCHRONOUS MOTOR DRIVES

EQUIVALENT CIRCUIT AND VECTOR DIAGRAMS:

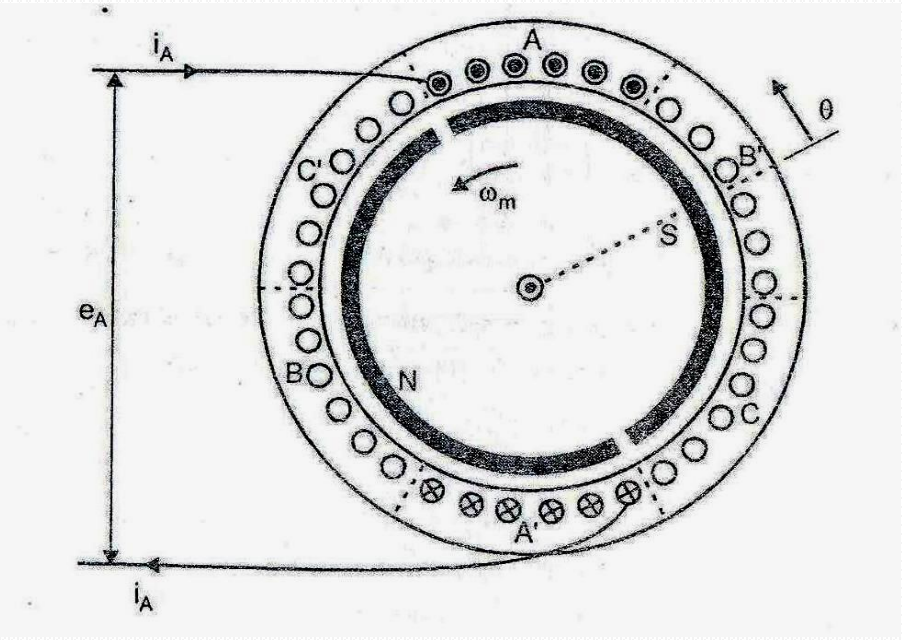


VSI FED SINUSOIDAL PMAC MOTOR DRIVE

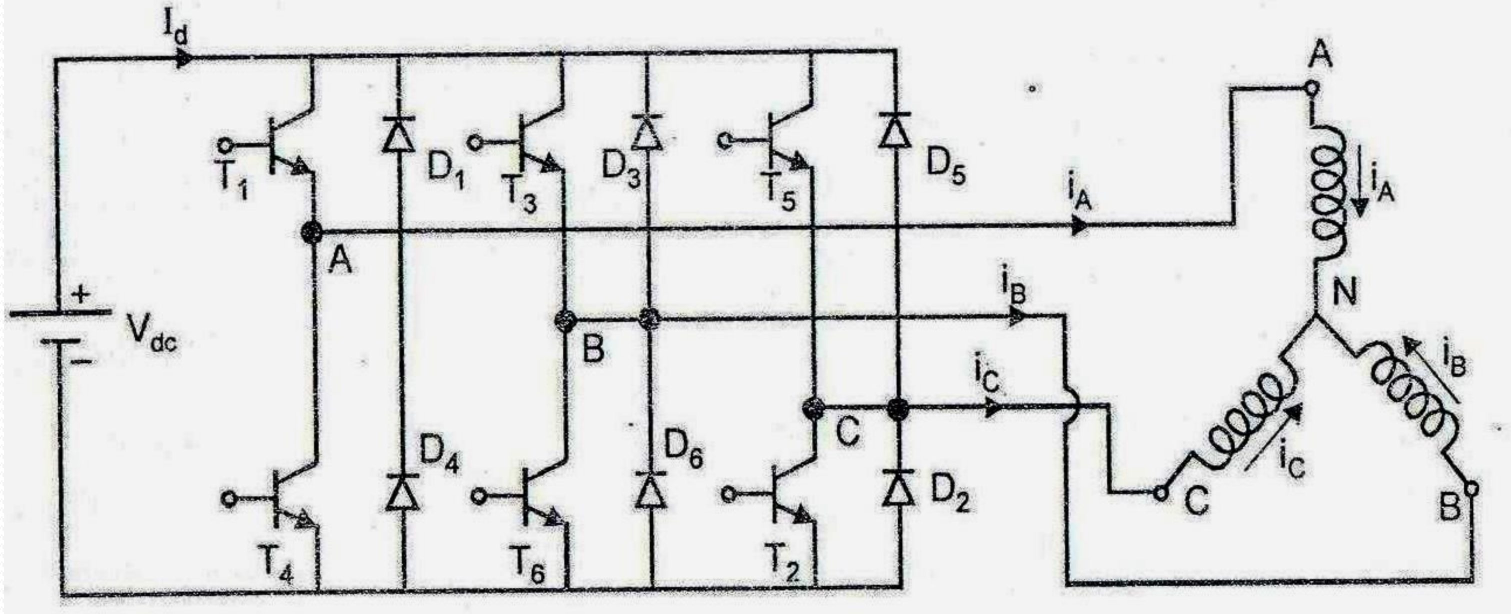


TRAPEZOIDAL PMAC MOTOR DRIVE

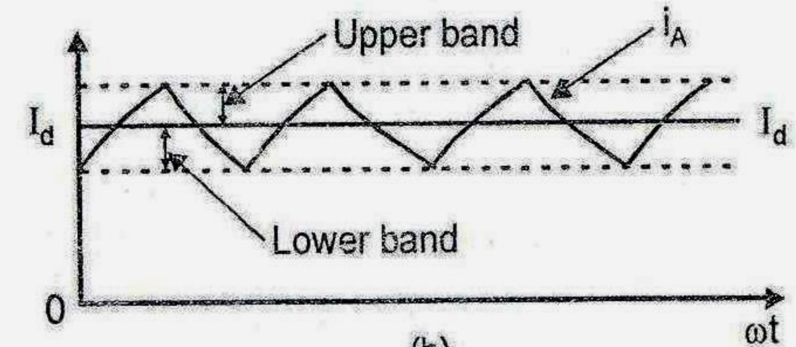
Cross sectional view:



VSI FED TRAPEZOIDAL PMAC MOTOR DRIVE

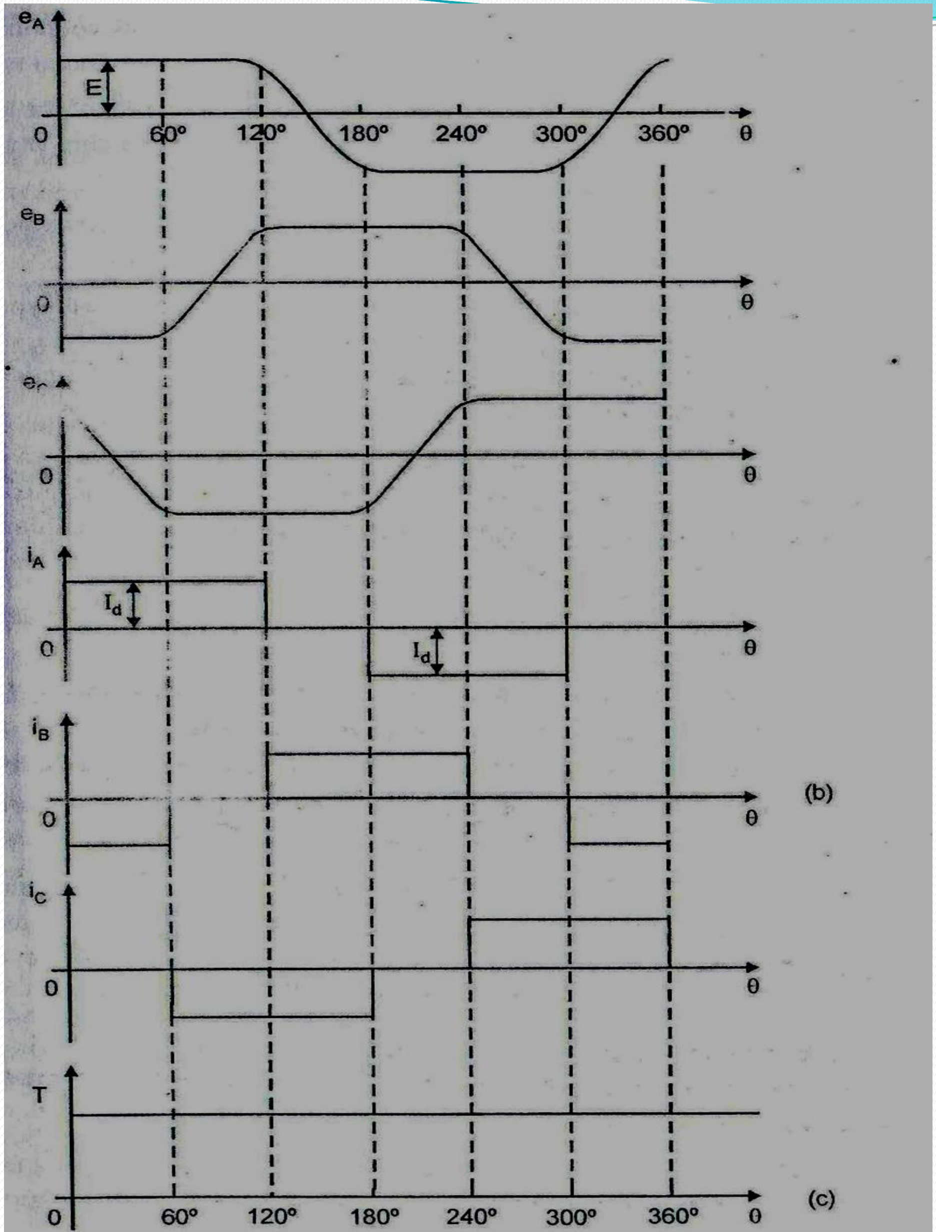


(a)



(b)

VSI FED TRAPEZOIDAL PMAC MOTOR DRIVE (Cont..)



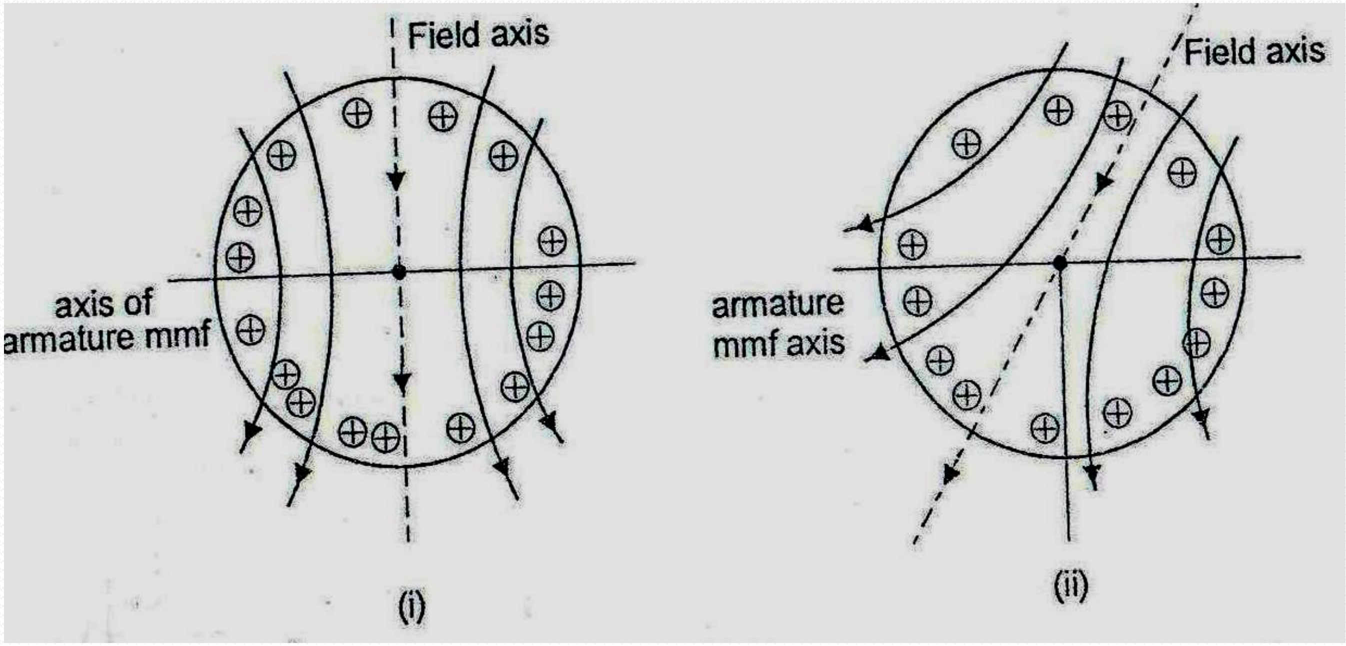
e 7.24: Induced voltage, phase current and torque waveforms of a trapezoidal PMAC motor

Effect of Harmonics on the performance of AC motors

The following effects are occured due to the harmonics.

1. Core loss and copper loss increases.
2. Motor efficiency decreases.
3. Thermal loading of the motor is increases.
4. Torque pulsations are occur.
5. Due to torque pulsations, motor speed will be fluctuating.
6. Due to harmonics, lead to appreciable derating of the motor.

VECTOR CONTROL OF SYNCHRONOUS MOTOR



VECTOR CONTROL OF SYNCHRONOUS MOTOR (Cont.)

$$\dot{I} = \dot{I}_d + \dot{I}_q$$

where

$\dot{I}_d \rightarrow$ Direct axis current

$\dot{I}_q \rightarrow$ Quadrature axis current

Desired operating point of current is such that $\dot{I}_d = 0$

$\therefore$ I is along the 'q' axis

BLOCK DIAGRAM OF VECTOR CONTROL OF BLPM SNW MOTOR (Cont.)