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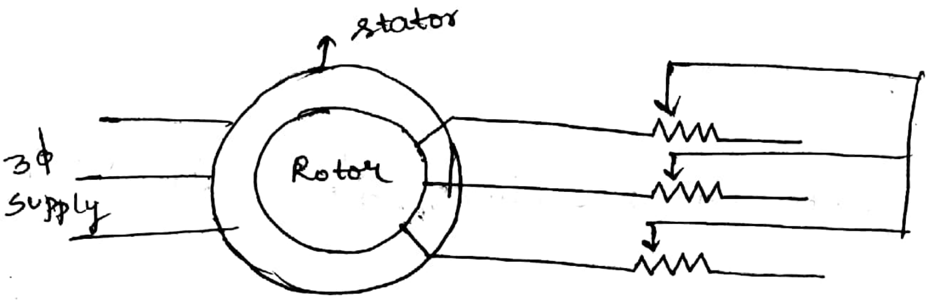
UNIT - 5 - CONTROL OF INDUCTION MOTOR FROM ROTOR SIDE

→ **Conventional Rotor Resistance control :-**



$$T = \frac{3}{\omega_s}\left[\frac{V^2}{\left(R_1+\frac{R_2'}{s}\right)^2+(X_1+X_2')^2}\right]\frac{R_2'}{S}$$

$$T_{st} = \frac{3}{\omega_s}\left[\frac{V^2}{(R_1+R_2')^2+(X_1+X_2')^2}\right]R_2'$$

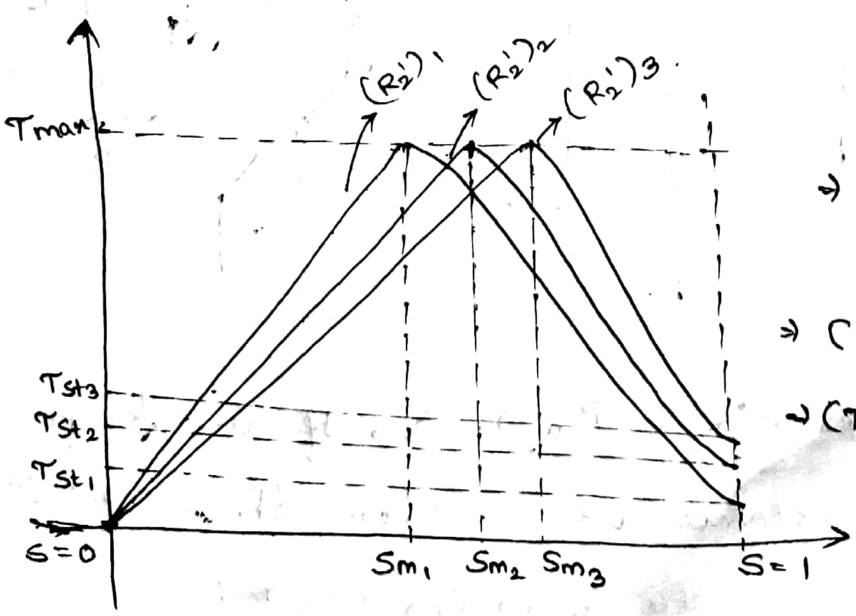
$$T_{max} = \frac{3}{2\omega_s}\left[\frac{V^2}{R_1 \pm \sqrt{R_1^2+(X_1+X_2')^2}}\right]$$

$$\boxed{T_{max} = \text{constant}}$$

$$S_m = \frac{R_2'}{\sqrt{R_1'^2+(X_1+X_2')^2}}$$

$R_2' - \uparrow$, $S_m \uparrow$

$R_2' - \downarrow$, $S_m \downarrow$



→ $(R_2')_1 < (R_2')_2 < (R_2')_3$

→ $(S_{m1}) < (S_{m2}) < (S_{m3})$

→ $(T_{st})_1 < (T_{st})_2 < (T_{st})_3$

Advantages :-

1) The starting torque increases as resistance increases.

2) (T_{max}) ⇒ Maximum torque is constant.

Disadvantages :-

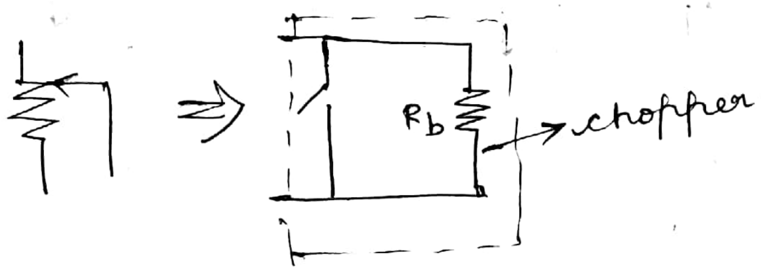
1) Due to the external resistance slip power is getting wasted.

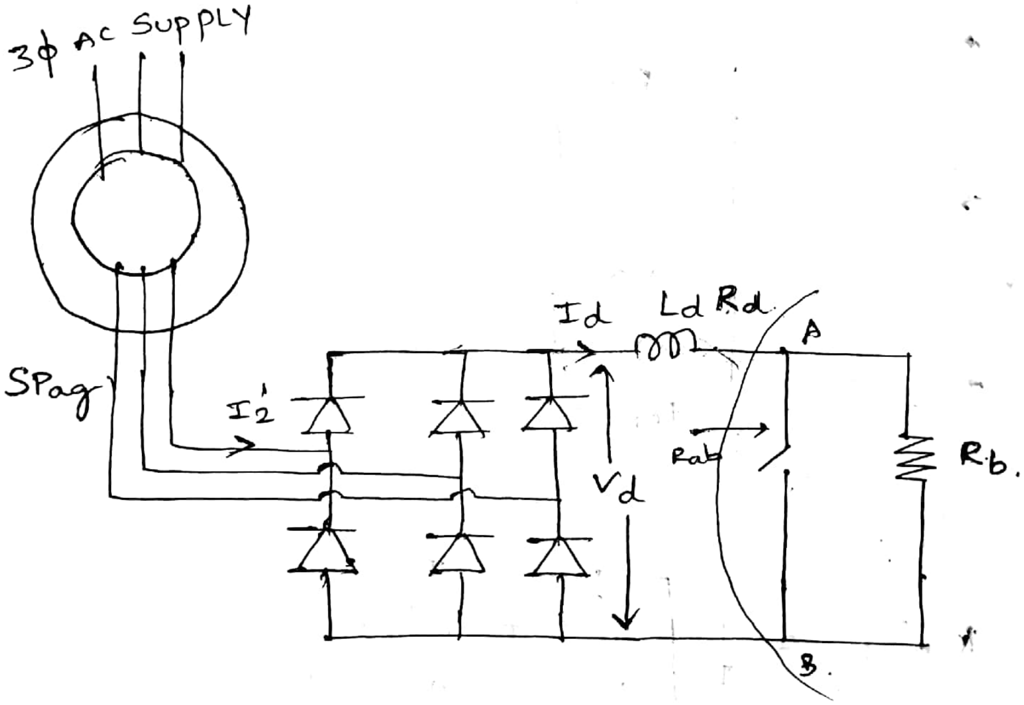
2) It has mechanical control of Rotor resistance.

* STATIC ROTOR RESISTANCE CONTROL:-

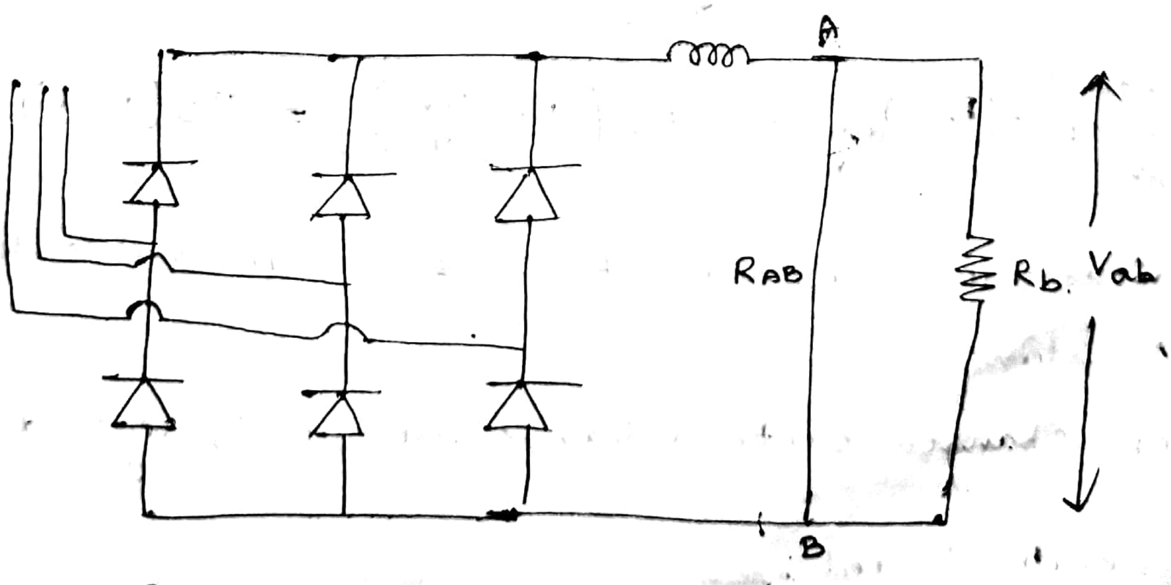
In power electronics,

A variable Resistance is replaced with a switch and a constant resistance.





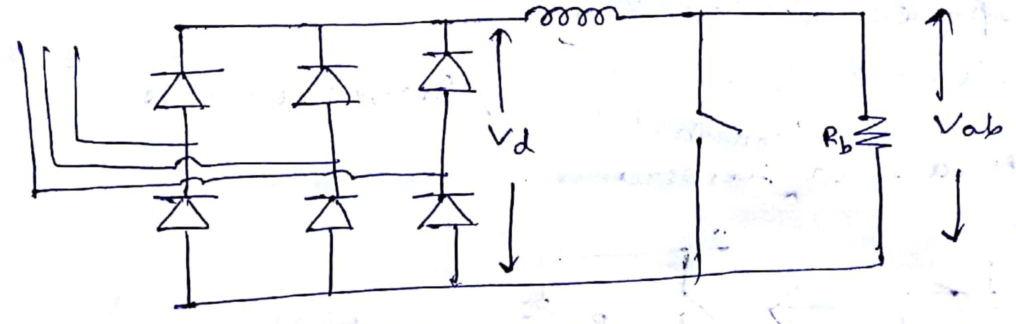
(i) Switch is closed.



$R_{AB} = 0$

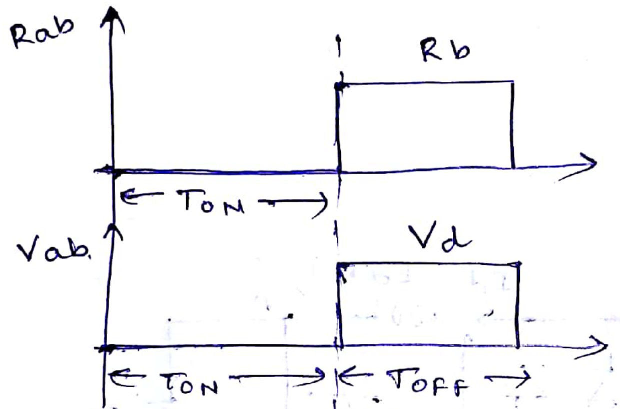
$V_{ab} = 0$

(ii) Sw ⇒ off



$R_{ab} = R_b$.

$V_{ab} = V_d$.



Average Value :-

$$(R_{ab})_{avg} = \frac{1}{T}\left[\int_0^{T_{on}} 0 + \int_{T_{on}}^{T} R_b\right]$$

$$= \frac{R_b}{T}\left[T - T_{on}\right]$$

Resistance across 'AB' $R_{AB} = (R_{ab})_{avg} = \left[R_b\left(1 - \frac{T_{on}}{T}\right)\right] = R_b(1-d)$

Constant resistance R_b has become variable resistance.

R_b changes with change in duty cycle d.

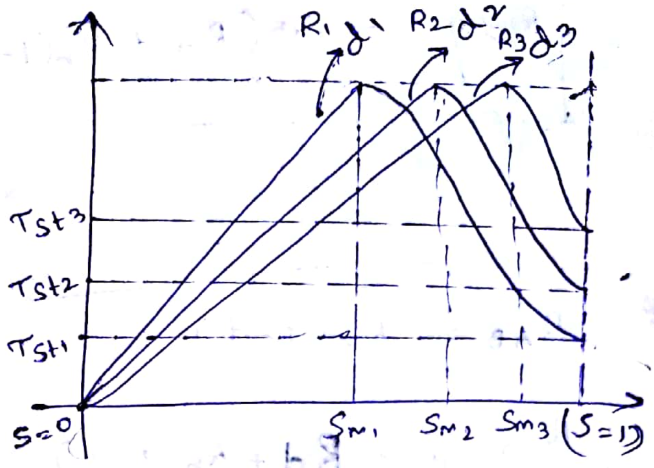
Power dissipated :-

$$P_{AB} = (I_d)^2 \cdot R_b(1-d)$$

As duty cycle ↑, Resistance ↓, P_{avg} ↓ :

$(d_1) < (d_2) < (d_3)$

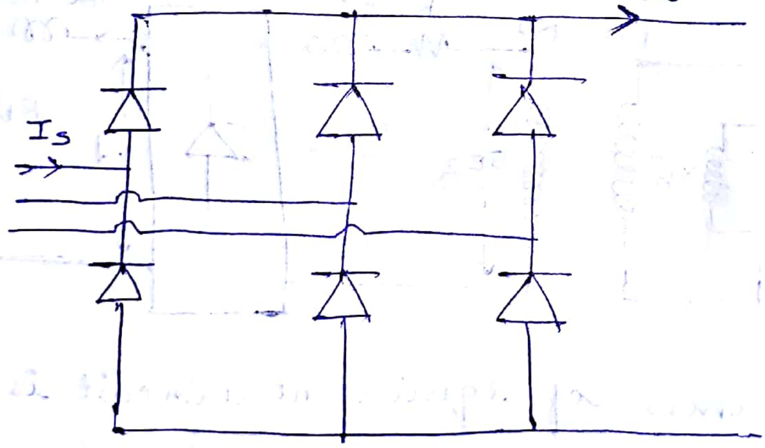
$(R_1) > (R_2) > (R_3)$.



→ Resistance across the bridge $= R_d + R_b(1-d)$

→ Power dissipated ⇒ $I_d^2 (R_d + R_b(1-d))$

→ Per phase slip power (slip rings) $= \frac{I_d^2 (R_d + R_b(1-d))}{3}$



$(I_s)_{rms} = I_o\sqrt{\frac{2}{3}}$

⇒ $(I_2) = (I_d)\sqrt{\frac{2}{3}}$

$$I_d = I_2\sqrt{\frac{3}{2}}$$

⇒ Per phase slip power $= I_2^2 \left(\frac{3}{2}\right) \cdot \frac{(R_d + R_b(1-d))}{3}$

$= 0.5 I_2^2 (R_d + R_b(1-d))$

$$P_{avg} = I_2^2 \left[0.5(R_d + R_b(1-d))\right]$$

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Per phase resistance across slip rings :

$$R_{slip} = 0.5(R_d + R_b(1-d))$$

*

$$R_{AB} = R_b(1-d)$$

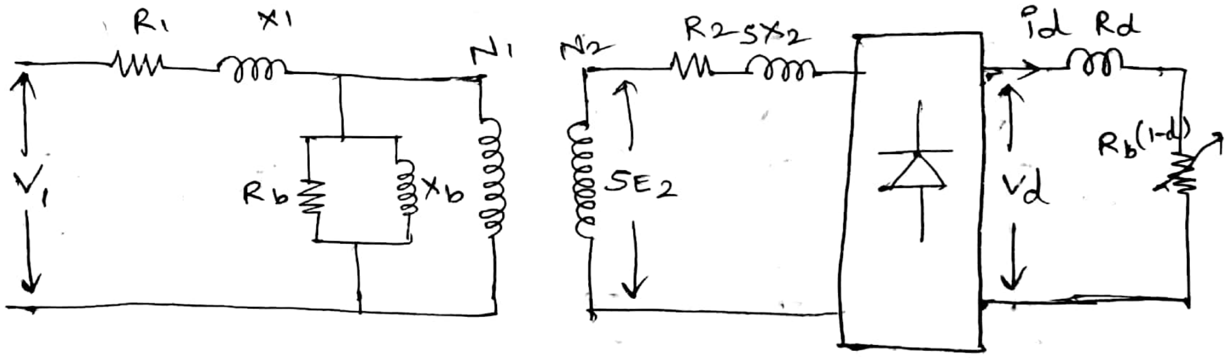
$$R_{bridge} = R_d + R_b(1-d)$$

$$R_{slip} = 0.5(R_d + R_b(1-d))$$

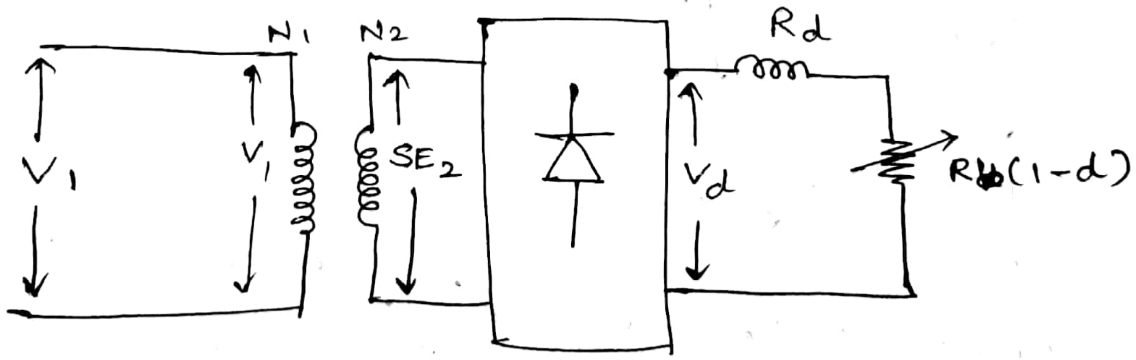
*

* ANALYSIS OF STATIC RESISTANCE CONTROL :-

Equivalent circuit :-



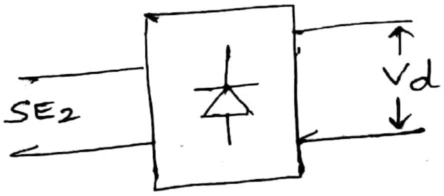
⇒ All the Impedances of equivalent circuit is neglected.



$$\text{Turns Ratio} = \frac{N_2}{N_1} = a = \frac{E_2}{V_1}$$

$$E_2 = aV_1$$

Expression for V_d :-



$$V_d = \frac{3V_{ml}}{\pi} = \frac{3\times\sqrt{2}\times V_{LL}}{\pi}$$

$$V_d = \frac{3\times\sqrt{2}\times\sqrt{3}\times V_{ph}}{\pi}$$

$$V_d = \frac{3\times\sqrt{6}\, V_{ph}}{\pi}$$

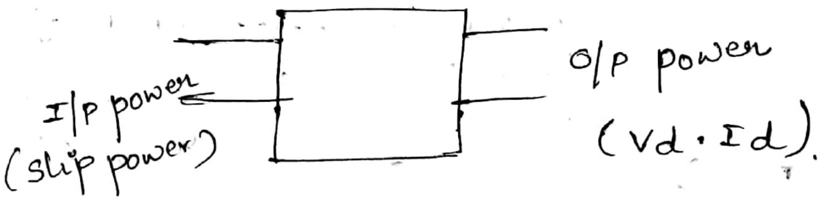
$$V_d = \frac{3\sqrt{6}\cdot SE_2}{\pi}$$

$$V_d = 2.33\, SE_2.$$

$$\boxed{V_d = 2.33\, S(a)V_1}$$

Expression for I_d :-

- Neglecting ~~R~~ Power loss in the rectifier.



$$SP_{ag} = V_d \cdot I_d.$$

$$S\times T\times \omega_s = V_d \cdot I_d.$$

$$I_d = \frac{S\times T\times \omega_s}{V_d} = \frac{S\times T\times \omega_s}{2.33(S)aV_1}$$

$$\boxed{I_d = \frac{T\cdot \omega_s}{2.33aV_1}}$$

Expression for slip :-

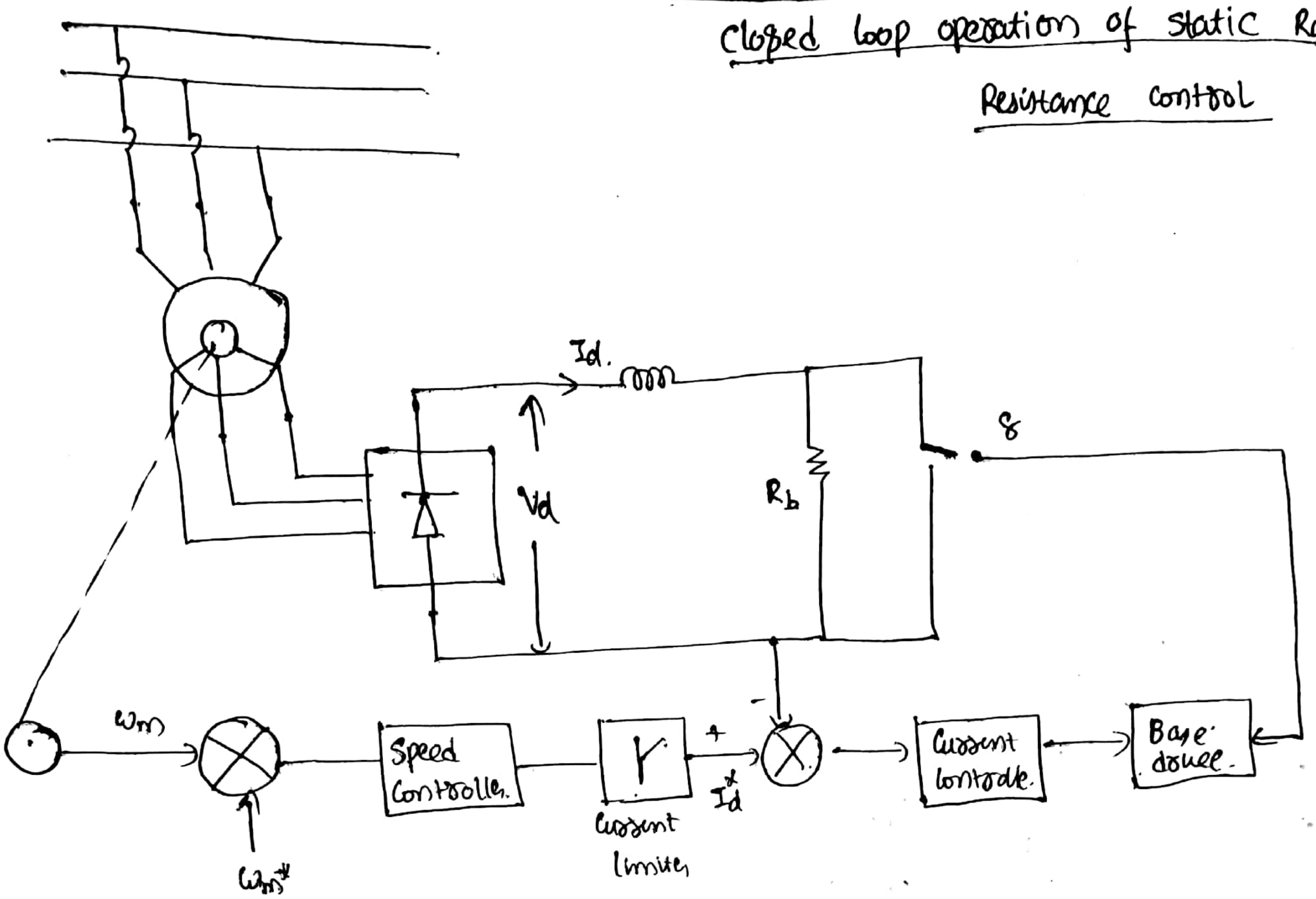
$$V_d = I_d(R_d) + I_d(R_b(1-d))$$

$$V_d = I_d(R_b(1-d))$$

$$\Rightarrow 2.33\, SaV_1 = I_d(R_b(1-d))$$

$$\boxed{S = \frac{I_d(R_b(1-d))}{2.33aV_1}}$$

Closed loop operation of Static Rotor Resistance control



→ It consist of a closed loop speed control arrangement with Inner current loop

→ The variation in the resistance can be acheived by controlling the switch.

→ The closed loop controls the on and off of the switch (chopper) which Indeed control the (vary) the Resistance.

→ In this the shaft of the Induction motor is coupled with tacho-generator which senses the actual speed of the machine

→ This speed is compared with the present speed of the machine and the error is given to speed controller & current limiter which will set the Id (ref) for corresponding to the error

→ This Id (ref) is compared with actual current and the error is given to current controller which will adjust the (on & off of the switch)

→ Hence the rotor Resistance will change & the speed of the machine changes untill the speed is equal to the reference speed.

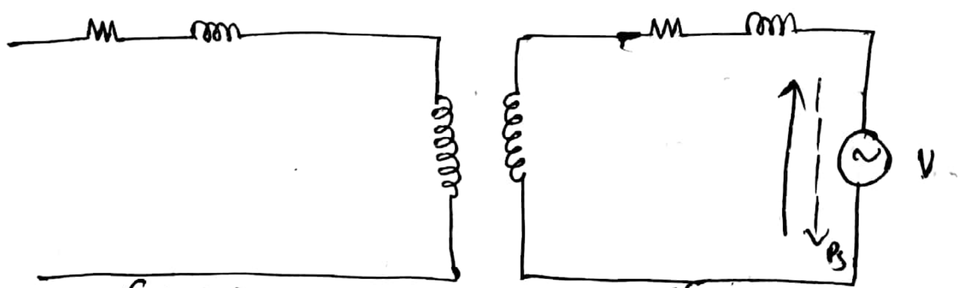
Advantages:

- ↳ Smooth variation of resistance
- ↳ Simplicity in operation using closed loop control.
- ↳ Quick response of system.

Dis advantages: ↳ slip power is getting wasted in the system

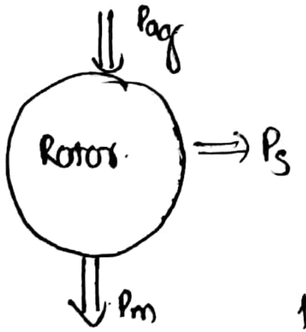
Slip power Recovery:

In this scheme instead of wasting the power in the sliprings we will send it to the source. A voltage source is injected at a sliprings which have a capability of taking (absorbing) the power from slip rings (a) can pump the power in to the slip rings which is controlled by controlling the magnitude & phase of V_r



(Stata) (Rota)

⇒



⇒ $P_{ag} = P_s + P_m$

⇒ $P_m = P_{ag} - P_s$

⇒ The Gross mech power in the machine will change when the P_s (slip Power) varies

Case(i): If power absorbed by the source

$P_m = P_{ag} - P_s$

As $P_s \uparrow$ $P_m \downarrow$

means the machine will run below synchronous speed

Case(ii): If the source is supplying (injects the power in to slip rings)

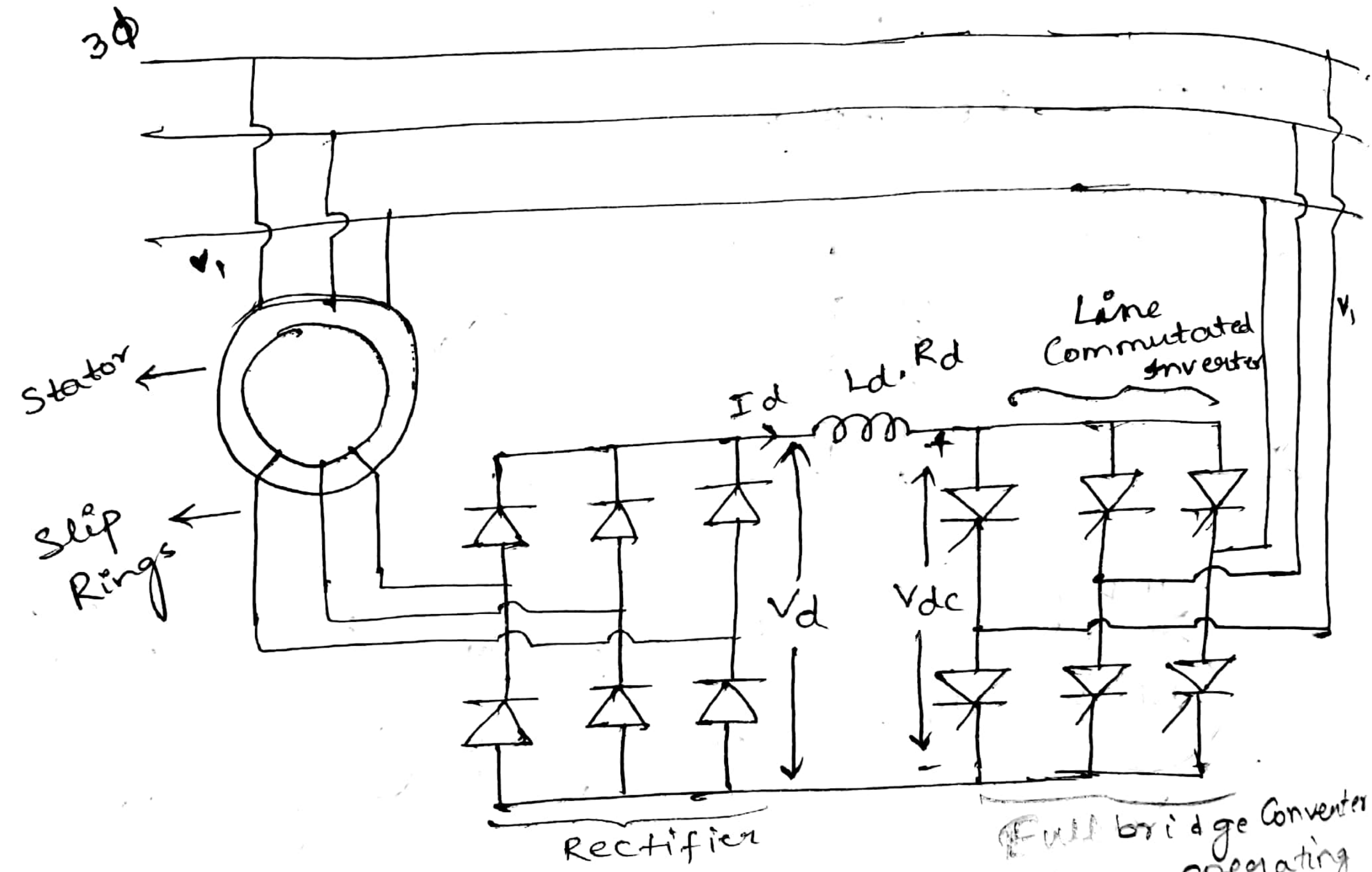
$P_s \Rightarrow -ve$

$P_m = P_{ag} + P_s$

As $P_s \uparrow$, $P_m \uparrow$

means Machine will run above synchronous speed.

* STATIC SCHERBIUS DRIVE :-

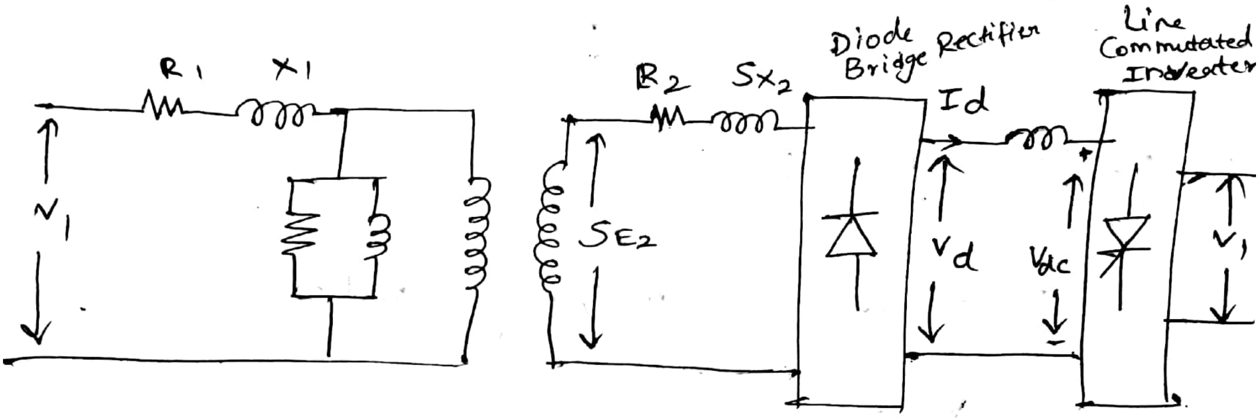


- Line commutated Inverter operates in $90 < \alpha < 180°$.
- It is capable of ~~giving~~ receiving the power.
- Load is capable of giving power.
- So, power is -ve. The operation is (L → S).
- The power is fed back to source with same frequency.
- Here the Inverter is in Receiving mode and operate at below Synchronous speed. So, it is Subsynchronous operation

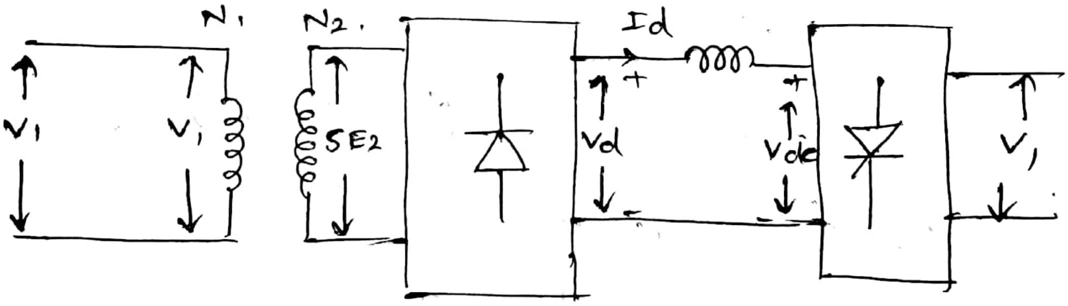
Assumptions :-

- The converters are loss less
- Transformer is loss less.
- Current I_d is ripple free.

ANALYSIS USING EQUIVALENT CIRCUIT :-



All the Impedances are neglected.



$$a = \frac{N_2}{N_1} = \frac{E_2}{V_1}.$$

$$\boxed{E_2 = aV_1}$$

- Expression for V_d.

$$V_d = \frac{3V_{ml}}{\pi}.$$

$$= \frac{3 \times \sqrt{2} \times \sqrt{3} \times (SE_2)}{\pi}.$$

$$= 2.33\,(SE_2)$$

$$\boxed{V_d = 2.33\,SaV_1} \rightarrow (1)$$

Expression for V_{dc} -

$$V_{dc} = \frac{-3V_{ml}}{\pi} \cos\alpha \quad (90 < \alpha < 180)$$

$$= \frac{-3 \times \sqrt{2} \times \sqrt{3} \times V_1}{\pi} \cos\alpha .$$

$$\boxed{V_{dc} = -2.33 V_1 \cos\alpha} \rightarrow (2)$$

→ <u>No load operation</u> -

I_d = less, $(I_d R_d)$ neglected.

$$V_d = V_{dc}.$$

$$\Rightarrow 2.33\, s a V_1 = -2.33 V_1 \cos\alpha .$$

slip ← $\boxed{S = -\frac{1}{a} \cos\alpha .}$

$$S \propto -\cos\alpha . \quad (90 < \alpha < 180)$$

$\alpha = 90°$	$\alpha = 180$
$S = 0.$	$S = 1.$
$N_r = N_s$	$N_r = 0.$

Machine operates at less than synchronous speed. (i.e) sub synchronous operation.

<u>TORQUE EQUATION</u> :- (As we Assumed Converter is lossless).

Input = output.

$$S \cdot P_{ag} = V_{dc} \cdot I_d$$

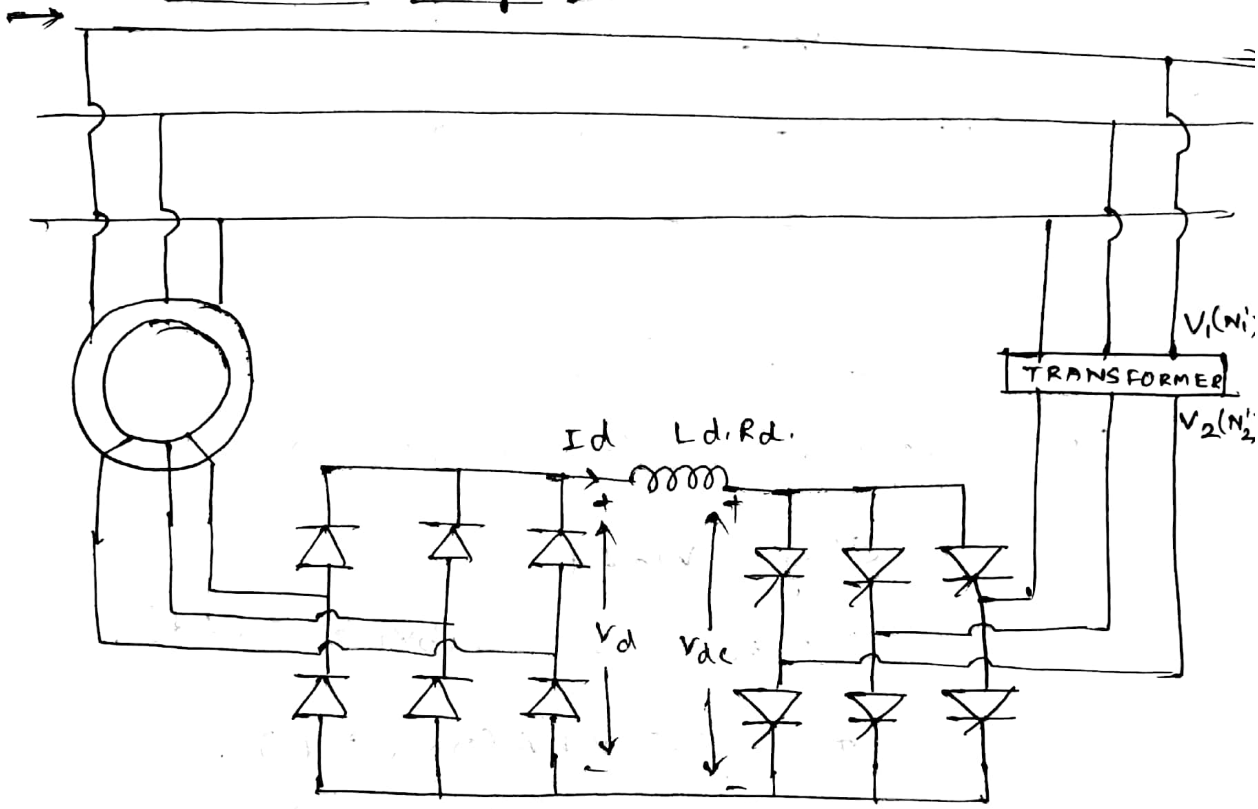
$$S \cdot T \times \omega_s = V_{dc} \cdot I_d$$

$$T = \frac{V_{dc} \cdot I_d}{S \omega_s}$$

$$T = \frac{\not{+} 2.33 V_1 \not{\cos\alpha} I_d}{\not{+} \frac{1}{a} \not{\cos\alpha} \times \omega_s}$$

$$\boxed{T = \frac{2.33 V_1 a I_d}{\omega_s}}$$

Scherbius drive Analysis with Transformer:

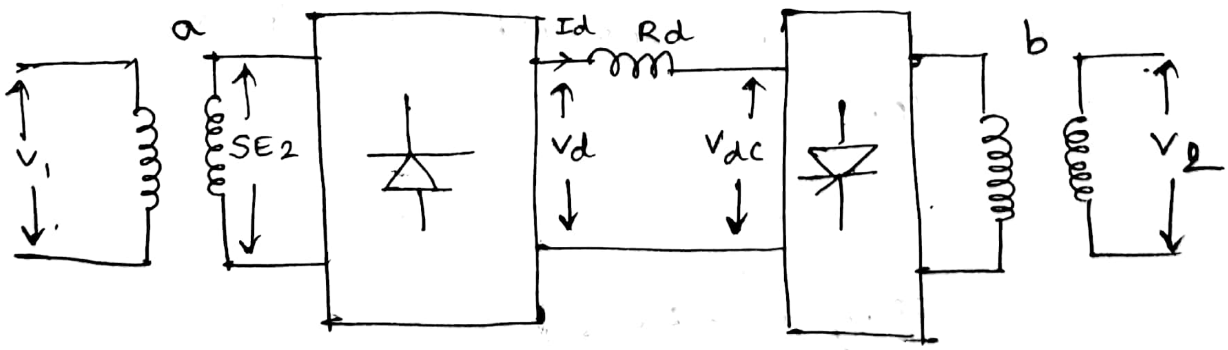


For IM ⇒ $a = \frac{E_2}{V_1}$.

$E_2 = a V_1$

For T/F ⇒ $b = \frac{N_2'}{N_1'} = \frac{V_2}{V_1}$

$V_2 = b V_1$



$$V_d = \frac{3V_{ml}}{\pi}$$

$$= \frac{3 \times \sqrt{6} \times V_{ph}}{\pi}$$

$$V_d = \frac{3\sqrt{6}\, SE_2}{\pi} \Rightarrow \boxed{V_d = 2.33\, S a V_1}$$

$$V_{dc} = -\frac{3V_{ml}}{\pi} \cos\alpha.$$

$$= -\frac{3 \times \sqrt{6} \times V_2}{\pi} \cos\alpha.$$

$$\boxed{V_{dc} = -2.33 \times bV_1 \cos\alpha}$$

$$V_d = V_{dc}$$

$$2.33aV_1S = -2.33\,bV_1 \cos\alpha.$$

$$S = -\frac{b}{a} \cos\alpha.$$

$$\boxed{S \propto -\cos\alpha}$$

Torque operation (loss less conv.)

$$SP_{ag} = V_{dc} I_d.$$

$$S \times T \times \omega_s = -2.33 \times bV_1 \cos\alpha\,(I_d).$$

$$T = \frac{-2.33 \times bV_1 \cos\alpha\,(I_d)}{\omega_s\left(-\frac{b}{a}\cos\alpha\right)}.$$

$$\boxed{T = \frac{2.33aV_1 I_d}{\omega_s}}$$ ⇒ with T/F.

Torque remains same for both with T/F and without T/F.

- Expression for I_d (considering R_d):-

$$SP_{ag} = V_d I_d$$

$$\boxed{I_d = \frac{SP_{ag}}{V_d} = \frac{-\frac{b}{a}\cos\alpha \cdot T_e \times \omega_s}{2.33aV_1S}}$$

- Expression for slip:

$$V_d = I_d R_d + V_{dc}$$

$$2.33 a V_1 s = I_d R_d - 2.33 b V_1 \cos\alpha$$

$$S = \frac{I_d (R_d - 2.33 b V_1 \cos\alpha)}{2.33 a V_1}$$

- Expression for rotor speed:

$$\omega_m = \omega_s (1 - s)$$

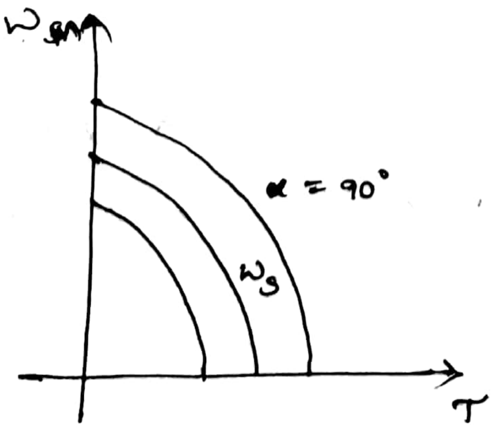
$$= \omega_s \left(1 - \frac{I_d (R_d - 2.33 b V_1 \cos\alpha)}{2.33 a V_1}\right)$$

$$\omega_m = \omega_s \left(1 - \frac{I_d R_d}{2.33 a V_1} + \frac{b \cos\alpha}{a}\right)$$

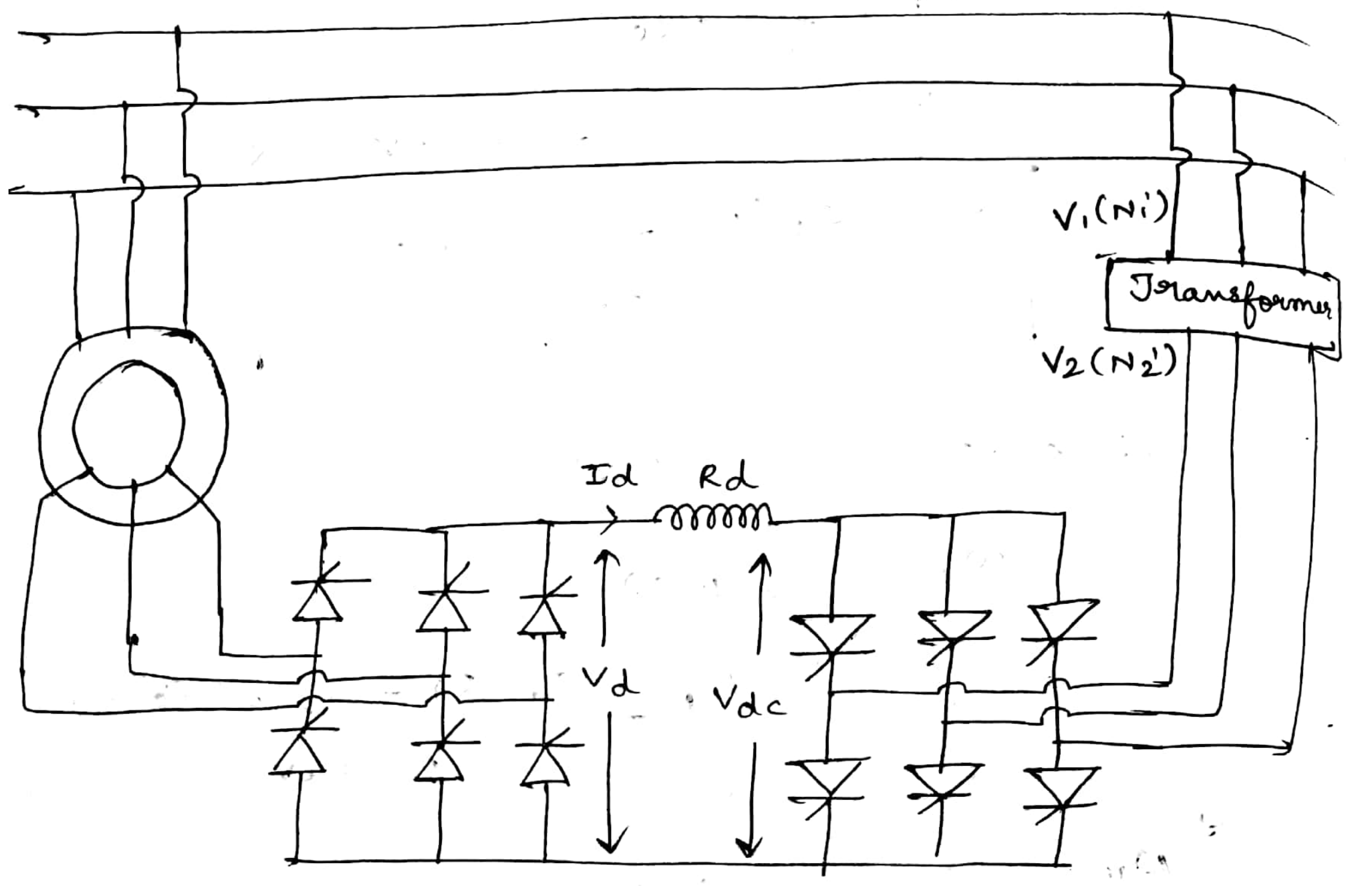
$$\omega_m = \omega_s \left(1 - \frac{T_e \omega_s}{(2.33 a V_1)^2} \cdot R_d + \frac{b \cos\alpha}{a}\right)$$

$$\omega_m = \omega_s \left(1 + \frac{b \cos\alpha}{a} - k T_e\right)$$

where $k = \frac{\omega_s}{(2.33 a V_1)^2} R_d$.



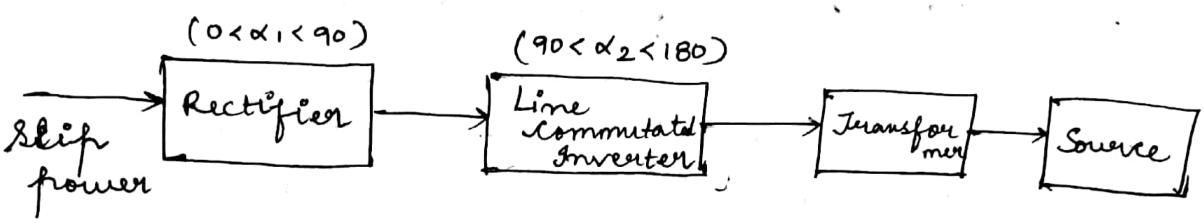
* DC LINK SCHERBIUS DRIVE :-



- In static scherbius drive from slip rings it will come to diode bridge rectifier. This operates in subsynchronous speed.
- By using diode bridge rectifier we cannot make it to operate in super synchronous speed.
- So, to overcome this problem we use a controlled rectifier in place of Diode bridge rectifier. Then we can operate in both sub synchronous and super synchronous speed
- when controlled rectifier is used based on operation it acts as rectifier and line commutated Inverter.

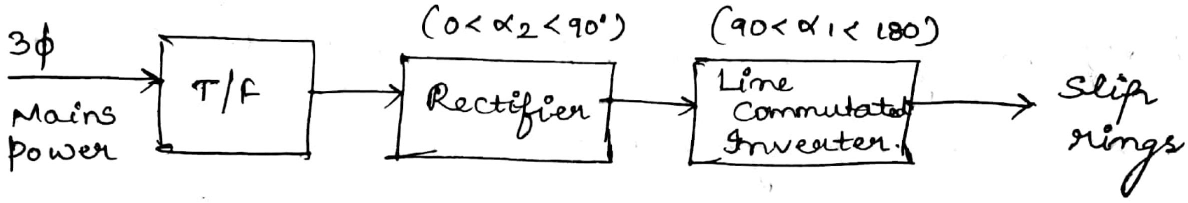
Sub synchronous operation :-

slip power is taken and given back to source.



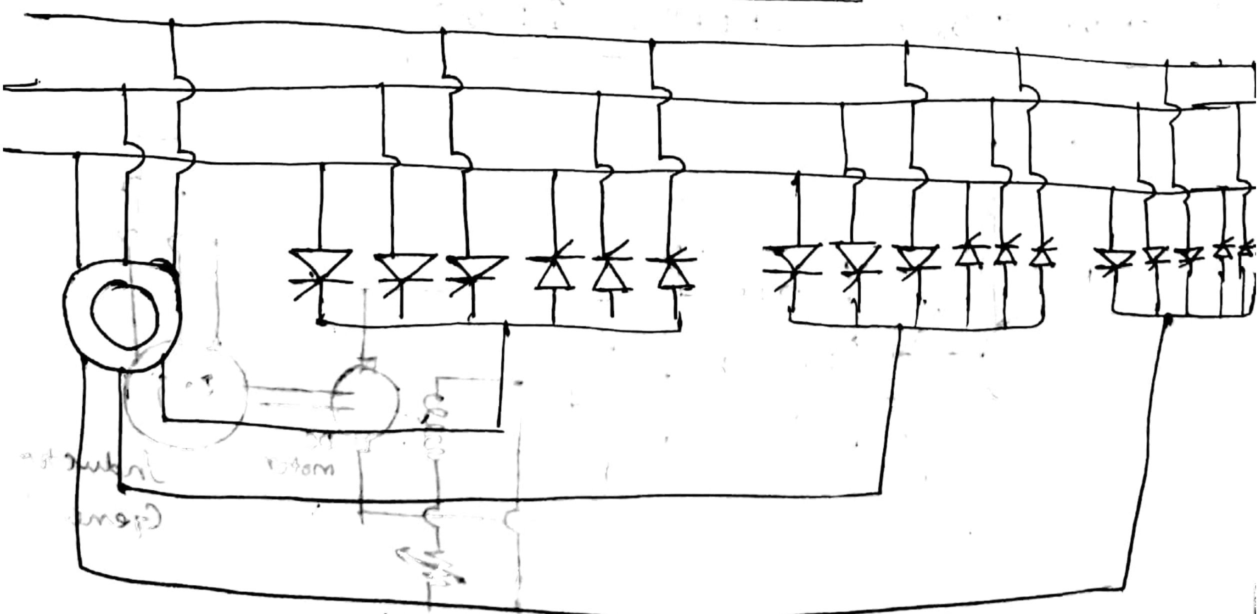
Super Synchronous operation :-

Power need to be injected into slip rings from source.



- Near synchronous speeds slip frequency emf's are insufficient for natural commutation of thyristors and this difficulty can overcome by forced commutation.

* CYCLOCONVERTER SCHERBIUS DRIVE :-



± SPag.

\+ → Subsynchronous − → Supersynchronous

1) If we give suppey from source it is known as rectifier.

2) If we take power from load is called as inverter.

3) cycloconverter can take power on both sides. So it can be done in both Sub & Super Synchrorous Speed

ADVANTAGES :-

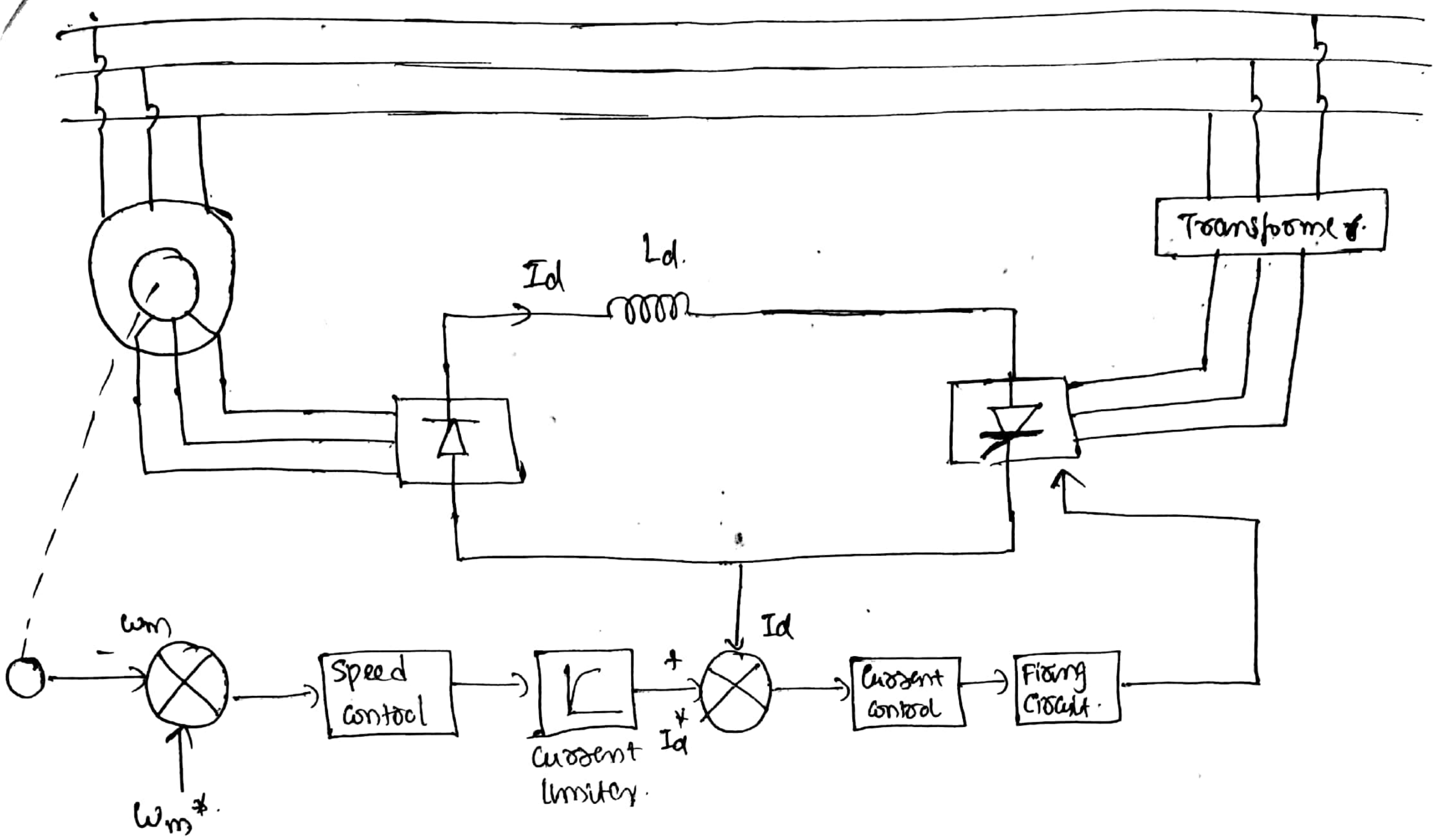
1) The line commutated cyclo converter works with minimum harmonics if the frequency ratio is less than 1/3 of your supply frequency.

2) By using this drive speed range is of 67% to 133%. of synchronous speed.

DISADVANTAGE :-

The main disadvantage of system is it is expensive and control circuit is complex. So this drive are suitable for large capacity machines.

Closed loop operation of static Scherbius Drive:



→ It consist of a closed loop speed control arrangement with Inner current loop.

→ The variation in the speed can be achived by controlling the firing angle of line commutated Inverter (conv-2)

→ This speed control is achived by controlling the slip power from the slip rings and sent it back to the source.

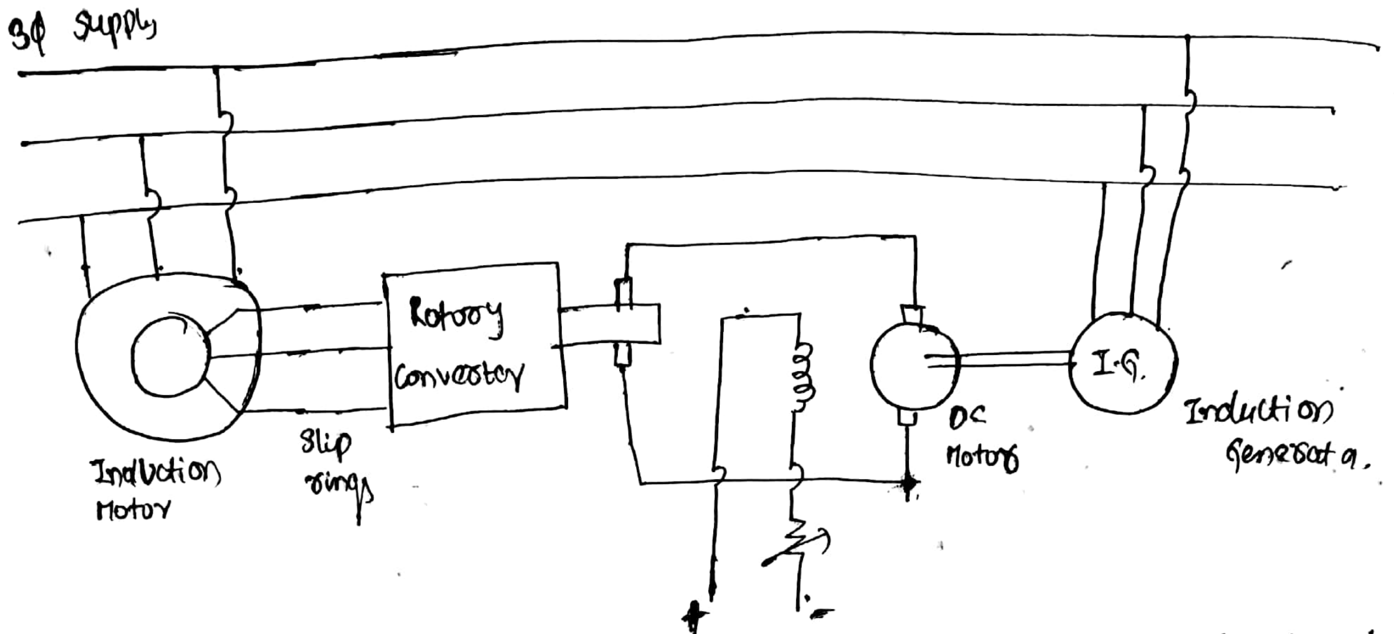
→ In this the shaft of Induction motor is coupled with tacho generator which senses the actual speed of the machine

→ This speed is compared with the present speed of the machine and error is given to speed controller & current limiter which will set the (Id)ref For corresponding error

→ This Id (ref) is compared with actual Id and error is given to current control which will set (change) the firing angle of the converter

→ Hence the speed of the machine changes & power is fed back to source.

Conventional Scherbius drive:



→ In this control the slip power is taken out from slip rings and given to rotatary converter

→ This Rotory converter will convert this AC supply (slip power) to DC voltage (DC power)

~~→ This is connected to the Input to the DC Motor and the shaft of the DC motor is coupled to the Induction Generator~~

→ This DC power is Given as Input to the DC Motor and converted to mechanical power

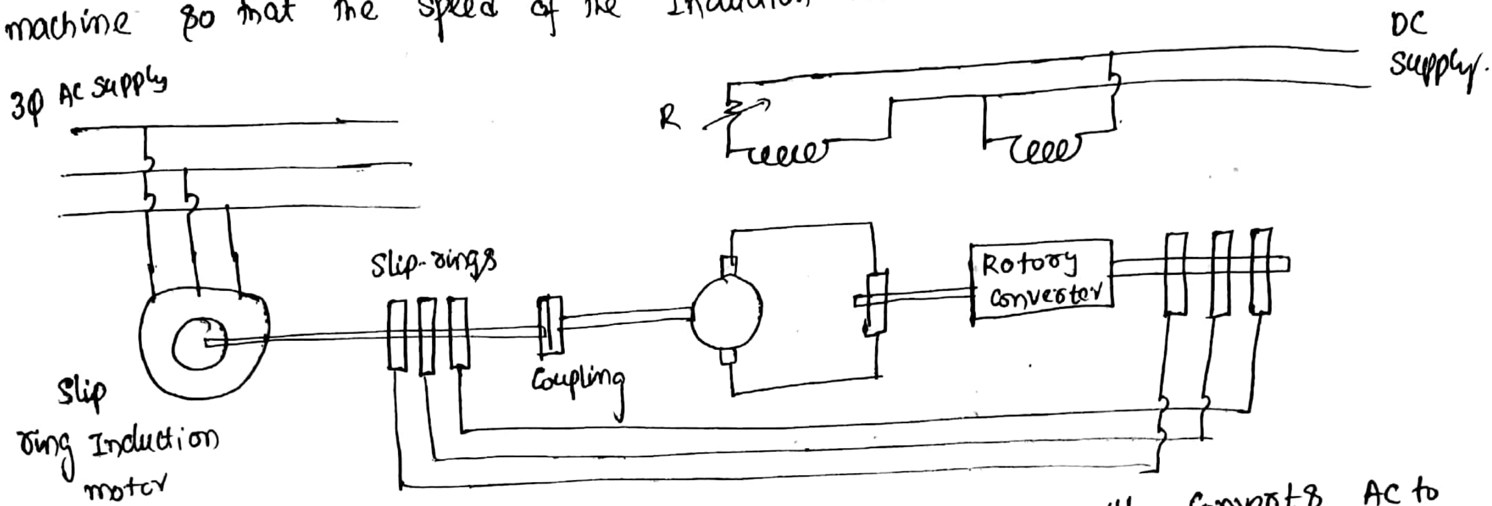
→ This mechanical energy is given to Induction generator which will convert this mechanical energy to electrical power and give back to the source.

→ As the field rheost changes the speed of the DC machine varies (means the power taken by DC Motor changes) then the speed of the Induction changes.

→ This is how the speed of the Induction Motor is varied by varying the field resistance and ultimately fed the slip power to the source.

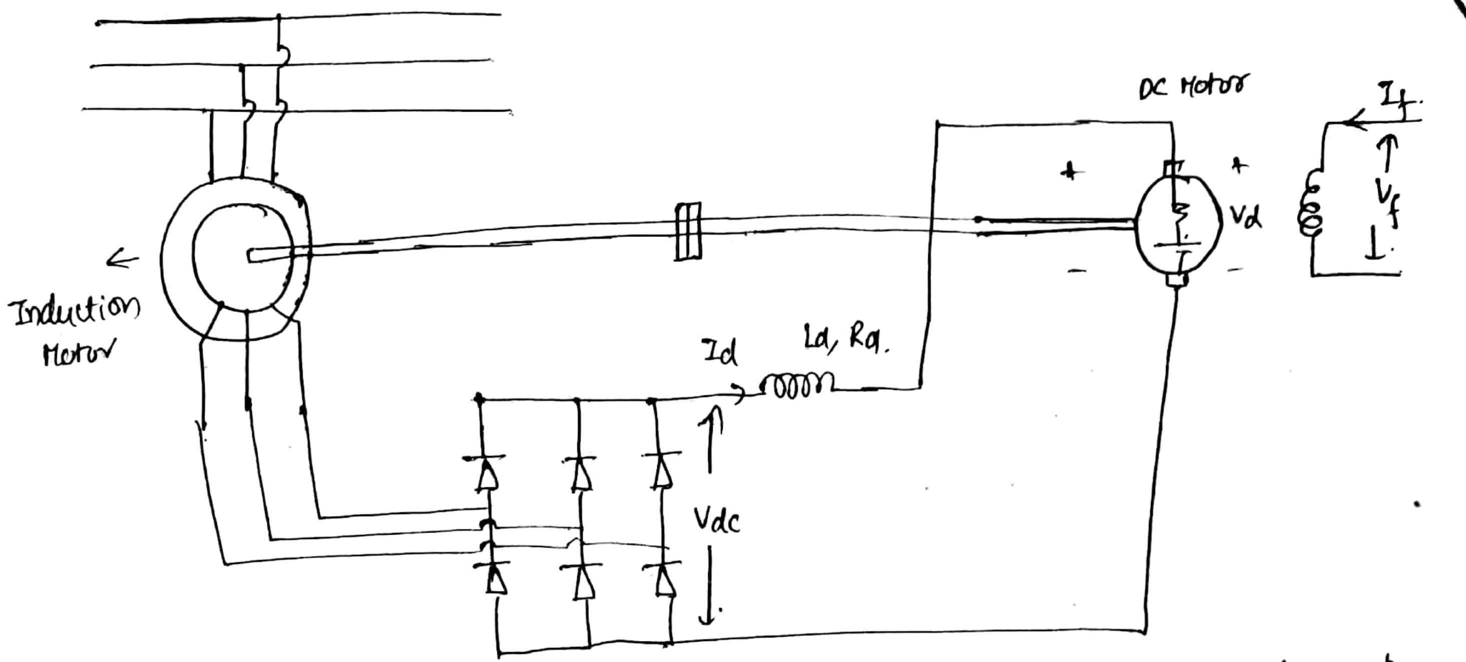
Conventional Kramer System:

The Basic Idea of the Kramers drive is to take out the slip power & convert in to mechanical energy and give back to Induction machine so that the speed of the Induction machine will be controlled.



* Rotory converter is a synchronous machine which will convert AC to DC voltage (power) to AC power and DC power to AC power
* In this power is Extracted from the rotor slip rings of Induction machine and given to Rotory converter which converts it to DC and given to the DC Motor (DC machine).
* This will now operate the DC motor and it will provide additional torque on the Induction machine (Now the developed torque is sum of DC Motor & Induction motor Torque)
* This is how the machine will be running below synchronous speeds by taking out the power from the slip rings of Induction machine.
* Changing the Exitation of Rotory converter which will Improve the p.f of the main Induction motor
* For super synchronous operation: The DC Exitation (Field) of DC Motor is increased which will reduce the speed of DC Machine
* So the main Induction motor will be driving the DC Motor so the DC Motor acts as a DC Generator.
* This DC power Generated will now converted to AC By ~~Synchronous~~ Rotory converter and fed to slip rings (which make the Induction machine to run at super synchronous speeds.

Static Kramers Drive:



- In this the slip power is converted in to mechanical power which will drive the Induction machine.

→ The diode Bridge converter is connected across the slip rings which will convert the ac voltage of rotor to DC (V_{dc}).

→ The o/p of the rectifier is connected to the armature of seperately Excited dc motor

→ The armature of this dc motor is connected to the shaft of Induction Machine

→ let the voltage across motor is V_d.

Rectifier side:

$$V_{dc} = \frac{3V_{mL}}{\pi}$$

$$V_{dc} = \frac{3 \times \sqrt{6} \times V_{ph}}{\pi}$$

$$V_{dc} = \frac{3 \times \sqrt{6} \times SE_2}{\pi}$$

$$\boxed{V_{dc} \propto S}$$

DC Motor side.

$$V_d = I_d R_d + E_b$$

(neglecting drop in Resistance) $I_d R_a = 0$

$$V_d \propto E_b$$

$$V_d \propto K_e \cdot \phi \cdot \omega_m$$

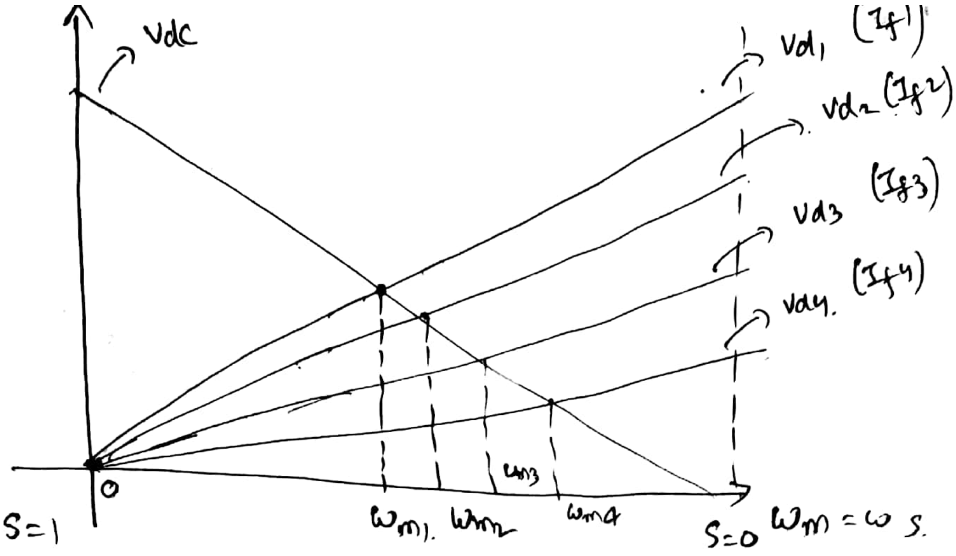
$$V_d \propto \phi \cdot \omega_m$$

$$V_d \propto I_f \cdot \omega_m \quad [\phi \propto I_f)$$

For a rated (const field current)

$$\boxed{V_d \propto \omega_m}$$

a)



Vdc ∝ S.

Vd ∝ ωm.

ωm1 < ωm2 < ωm3

If1 > If2 > If3

=) At steady state. Vd = Vdc. machine runs at speed ωm1.

=) ↓. Vd ∝ If↓ωm (If the If (field current) decreases).

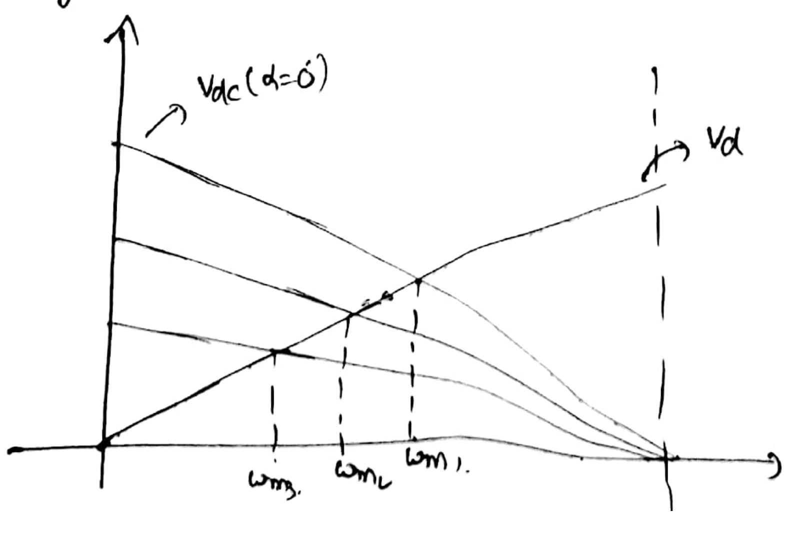
Vd decreases the new characteristics is Vd2 (The steady state speed is ωm2).

=) As the field changes (decreases) Vd (decreases) and speed of the machine Increases.

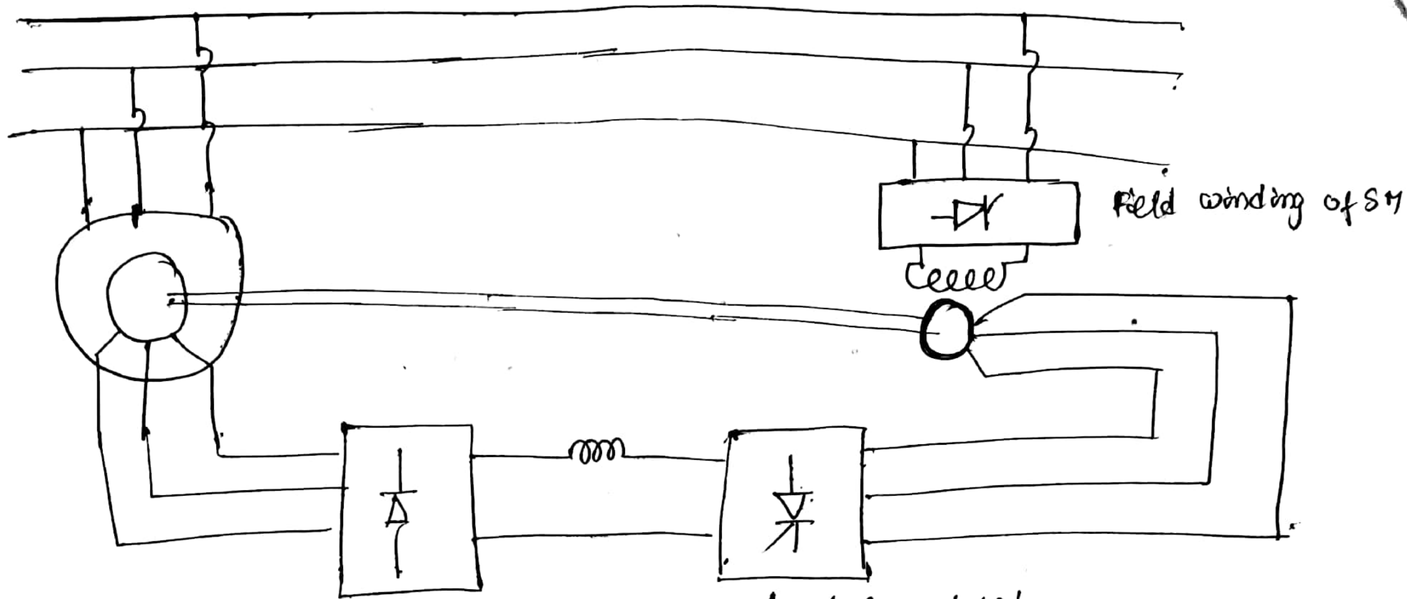
* By changing field current the speed of the machine changes near to synchronous speed.

* The lower speeds below ωm1 can be achived by replacing the diode Bridge rectifier with controlled rectifier then $V_{dc} = \frac{3V_{mL}}{\pi}\cos\alpha$

* As α changes 'Vdc' changes and the speed of the machine change (keeping Vd const)



Modified Krammer drive: (Commutator less Kramer Drive)



→ In Kramers drive the DC Motor is replaced by Synchronous motor because of high maintainance and commutation losses in DC Machines these are Replaced

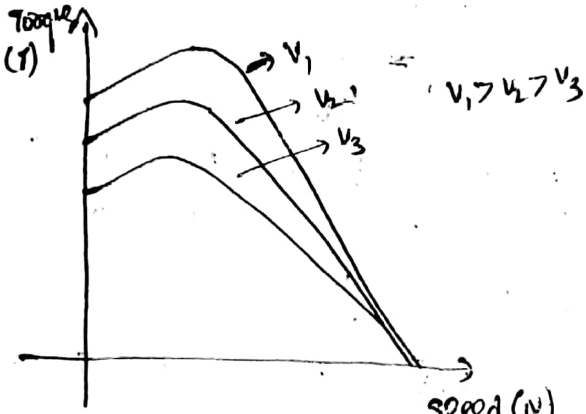
→ In this the slip power is converted to DC and it is given to load commutated inverter

→ The AC Power is given to the synchronous motor whose shaft is directly conneced to the Induction machine.

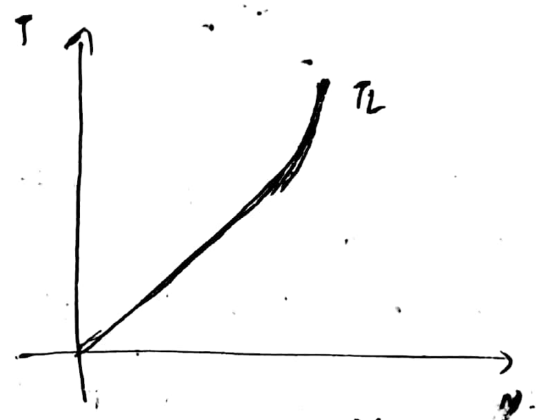
→ The speed of the motor can be controlled by controlling the field current

Q) Why Stator voltage control is suitable for fan & pump load?

A) Stator Voltage Control is a method is used to control the Speed of Induction motor. Here the speed of I/m is varied by varying the supply voltage keeping frequency constant. The torque-speed characteristics of 3φ Induction motor for varying supply voltage and also for fan load is given below

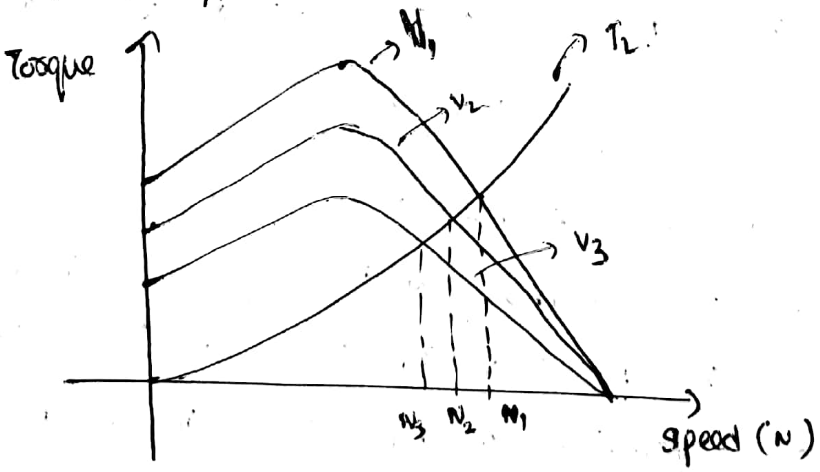


$T_m \propto V^2$



$T_L \propto N^2$ (or)
$T_L \propto \omega_m^2$

→ Combined Characteristics:

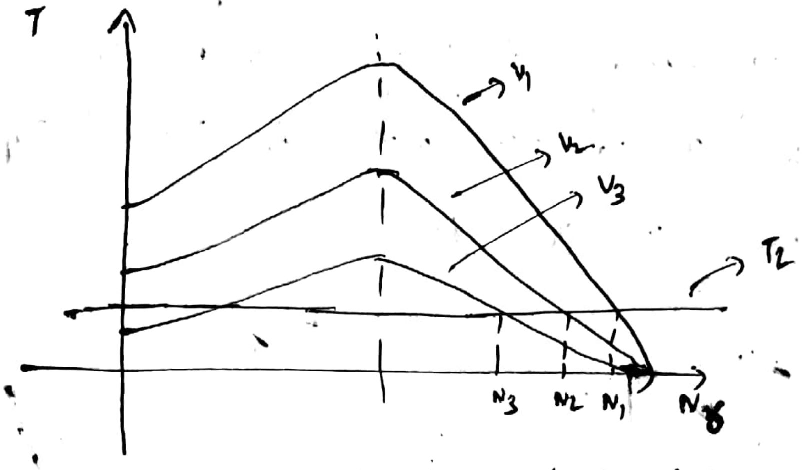


→ Here $T_m \propto V^2$ (motor Torque) $T_L \propto \omega_m^2$ (load torque)

→ The load torque characteristics of the fan load decreases with the speed of the Induction machine this can be achived by applying lower Voltage with out Exceeding the motor current

→ By using this control for fans & pump loads the range of speed control is high compare to other load torques.

For constant Torque loads: (T_L = Const)



→ This is not suitable for constant torque loads because it needs constant load torque at all the voltages so for low voltages for the same load torque it will take high current from the source.

→ The range of speeds for this speed control is very less compare to other loads.

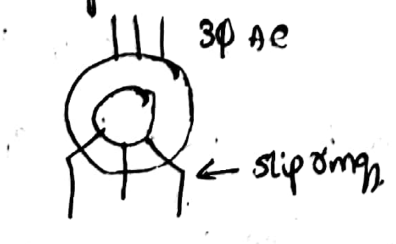
* So basically this speed control is achieved by following methods

* By connecting primary Resistors → By using Auto transformer

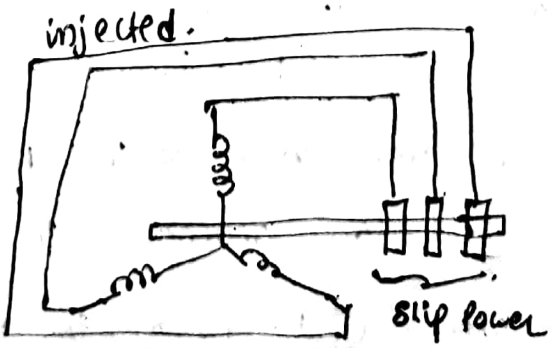
* By using AC Voltage controllers

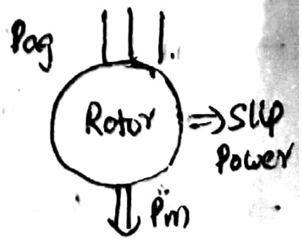
Q). Explain the concept of slip power?

Ans The power that is available at the slip rings is called slip power. This power can be controlled for controlling speed of Induction machine. Induction machine will run at Below rated speeds if slip power is taken out. It will run at super synchronous speeds if the power is injected.



Slip Power





$P_s = S P_{ag}$

13/3/17

6. Synchronous Motor Drives

* Variable Frequency Control Of Synchronous Drive:-

1) As synchronous speed is directly proportional to ~~synchronous~~ frequency the motor speed can be controlled by varying frequency of supply.
2) As in Induction machines a constant flux operation below base speeds is acheived by operating the machine with constant $\frac{V}{f}$ ratio. ~~This~~ which gives constant pull out torque.

3) At higher speeds than base speeds this machine should operate at rated Voltage and variable frequency and pullout torque decreases with ~~decrease~~ increase in frequency.

* Modes Of Variable Frequency Control:-

1) This is employed in 2 modes -
   a) True Synchronous mode (Seperately controlled mode)
   b) self controlled mode.

a) True Synchronous Mode:- (1)

1) In true synchronous mode the stator frequency is controlled from an independent Oscillator.

2) In this the frequency must be changed from initial to desired value gradually so, that rotor speed will track changes in synchronous speed.

3) In this the variable frequency control not only allows speed Control It can also be used for smooth starting and regenerative braking as long as changes in frequency is slow enough for the Rotor to track changes in Synchronous Speed.

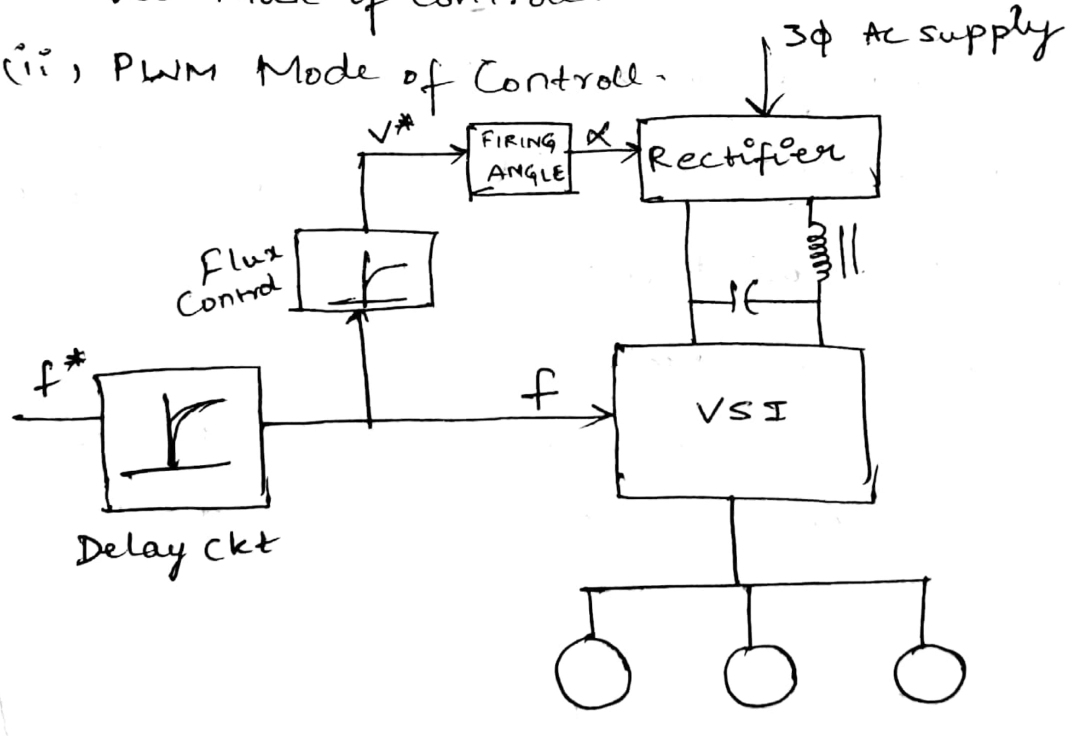
4) This method is best Suited for Multiple Synchronous Reluctance machines And permanent magnetic machines.

5) This is mainly for the applications of textile mills, papers and fibre spinning mills.

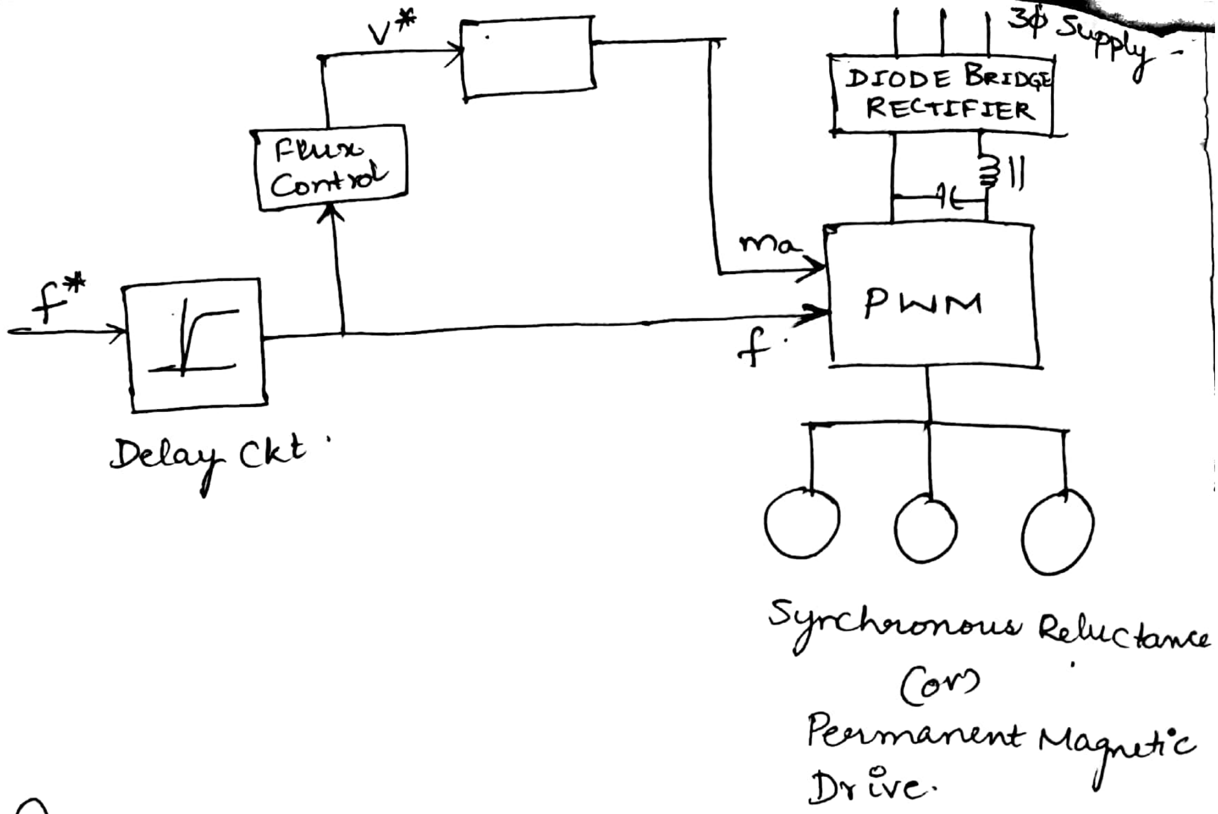
6) Examples for true synchronous mode of operation are given below.

(i) VSI Mode of Controll.

(ii) PWM Mode of Controll.



Synchronous Reluctance
(or)
Permanent Magnetic drive.



OPERATION :-

1) In this the machines are connected in parallel to the same Inverter and the speed is controlled with the change in frequency command f*.

2) This frequency f* is applied to v/g source Inverter through a delay Ckt so that Rotor speed is Able to track the changes in frequency.

3) Along with the freq V/g need to be changed for keeping flux constant.

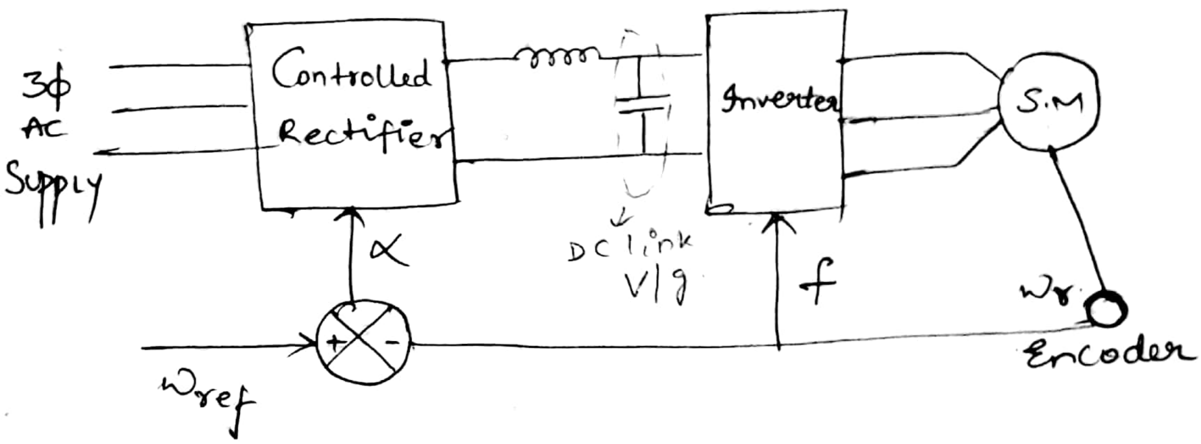
4) So, this freq Command is given to flux Control block that will give v/g for which system need to be operated to keep flux Constant.

5) This v* will develope Corresponding α to the rectifier (or) Modulation Index the PWM Inverter which will change v/g of System along with frequency.

DISADVANTAGES OF SEPERATELY CONTROLLED MODE:-

1) Problems of Instability
2) Poor dynamic behaviour
3) Hunting of Motor.

*SELF CONTROLLED MODE:- (2)



OPERATION:-

1) In this stator frequency is changed in proportion to the rotor speed so that rotating magnetic field and rotor should moves at ~~s~~ same speed.

2) In this the stator of synchronous motor is fed by an Inverter which generates variable frequency.

3) This inverter may be CSI (or) VSI depend on the Source. (i.e) Voltage Source (or) Current Source.

4) The Encoder is mounted on the shaft of the rotor to know the exact position of the rotor at any instant.

5) Unlike seperately controlled mode where the controll of Inverter is from external

Oscillator. Here the frequency is controlled by Rotor position so that the rotor speed and mmf will be same at all Instants.

6) The switching of the Inverter will always taken at right time to produce required torque on motor because the Inverter knows where the rotor is at every instant of time.

7) Due to some load the rotor slows down, the stator frequency automatically changes so the rotor is in synchronism.

8) The speed of Induction motor is controlled by varying ω_{ref} which changes the α to the Controlled Rectifier which indeed Changes the DC link voltage.

* VSI/PWM FED SYNCHRONOUS MOTOR DRIVES :-

Theese are 3 types - (Configurations) (3)

1) square wave Inverters

2) PWM Inverters

3) chopper with square wave Inverter

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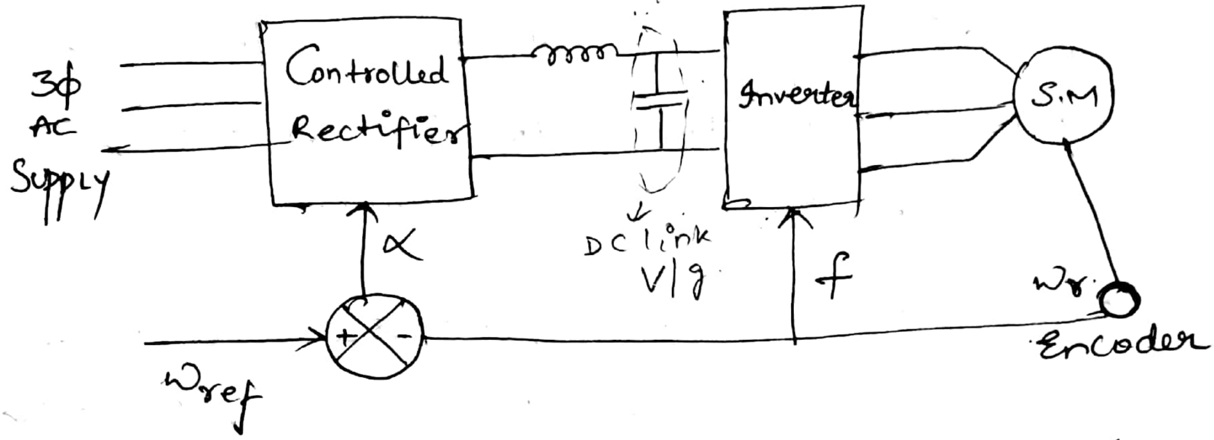

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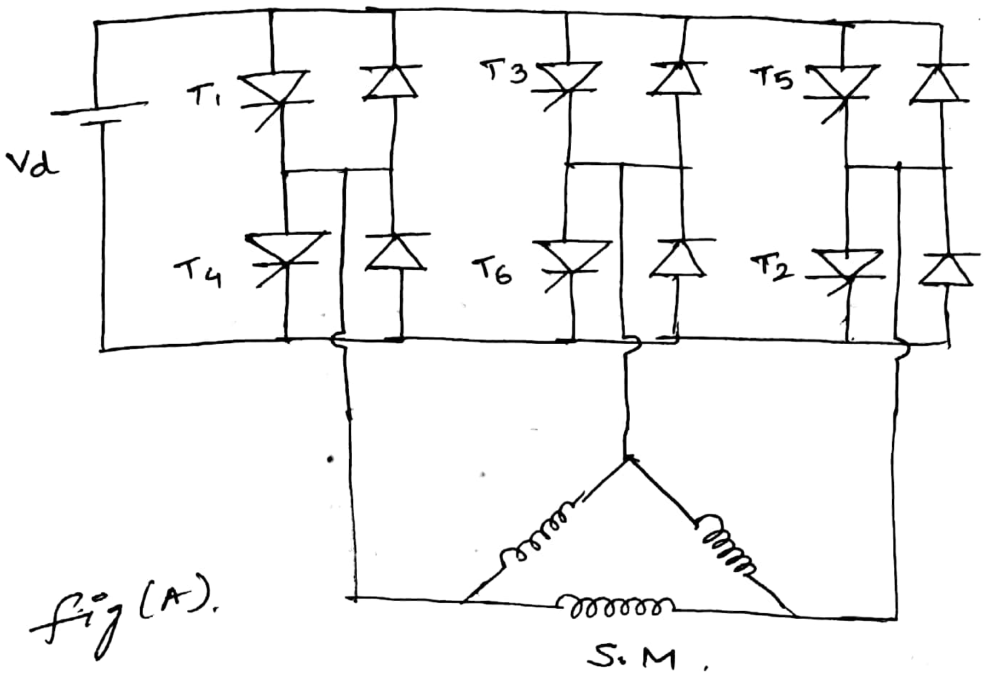
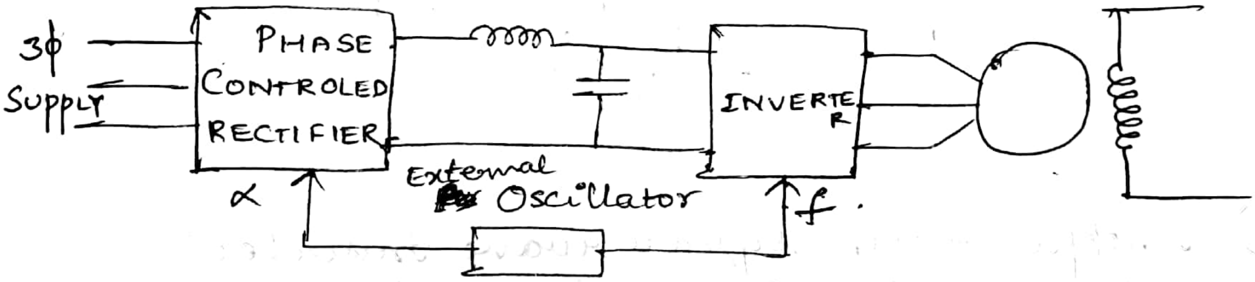


fig (A).

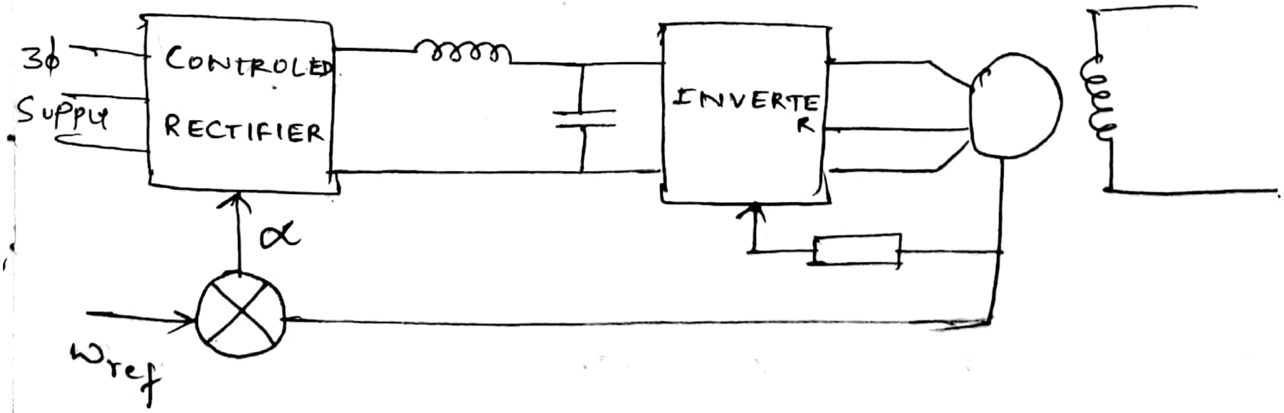
① square wave Inverters :-

a) seperately control :-



(i)

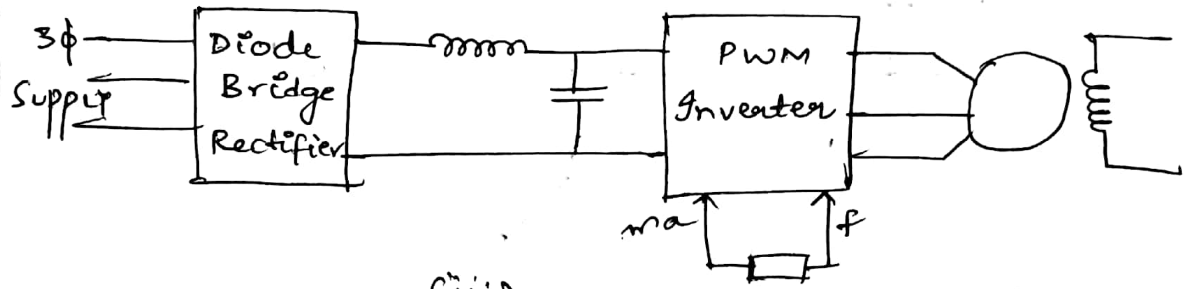
b) self control :-



(ii)

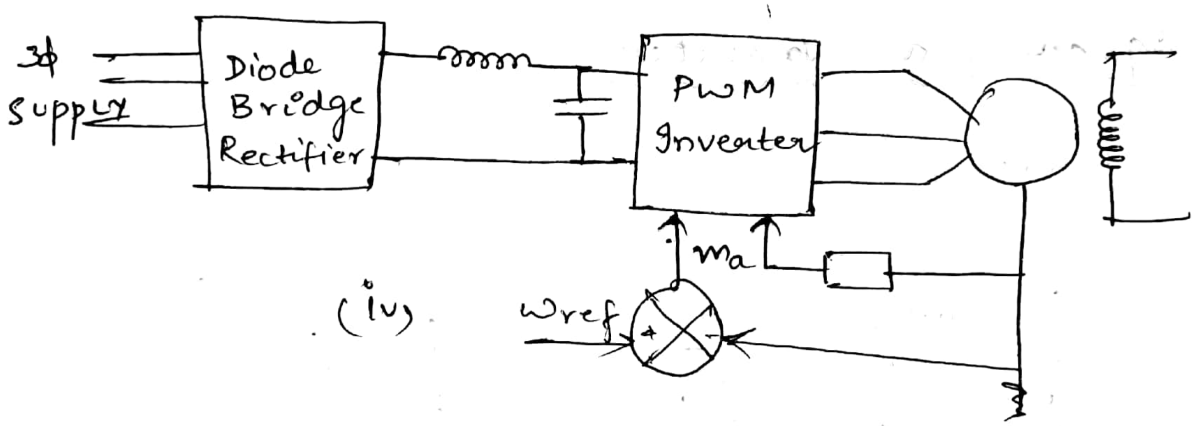
② PWM Inverters:-

a) seperately controll



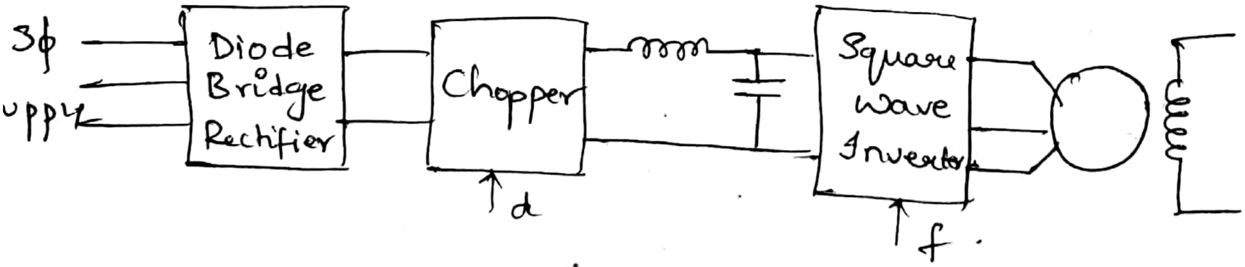
(iii)

b) self control



(iv)

③ chopper with square wave Inverter:-



(V).

1) A typical power ckt of VSI fed synchronous motors is shown in figure A.

2) In recent trends attention is paid towards understanding the behaviour of Synchronous

motors fed from VSI.

3) These drives are developed to have two modes of operation. (i) Self Controlled mode
(ii) Seperately " ".

4) Three combinations are possible to provide a variable v/g and variable frequency supply through VSI fed synchronous motors.

(i) Square wave Inverters
(ii) PWM Inverters.
(iii) chopper with square wave Inverters

1) Square Wave Inverters:-

- Here DC link v/g is variable due to the v/g control obtained by using ~~f~~ phase controlled rectifier.

- Fig (i) and (ii) shows the seperate Control and self control of synchronous motor fed by a square wave Inverter.

- The main disadvantage in this is Commutation is very difficult at low Speeds hence it's applicable for medium & high speed Applications

2) PWM Inverters:-

- This second method is to have v/g Control within itself using Pulse width Modulation.

- Fig (iii) & (iv) Shows Self and Seperate Controll of

Synchronous motors fed from PWM Inverters.

- Here the DC link v/g is Constant because of Diode bridge Rectifier.
- Doesnot have difficulties in commutation at low speeds. So, it is usefull for widerange of Speed Aplications.

3) Chopper with square wave Inverter:-

- This 3rd method is to improve a DC chopper in between diode rectifier and Inverter.
- Though it seem to be Complex Circuitory it has its Own Advantages.
- In this due to the presence of choper size of the filter or Inductor gets decreases.

* PERFORMANCE ANALYSIS AND COMPARITIVE STUDY:-

1) Since the o/p v/g's of Inverters are non sinusoidal hence the behaviour of machine is different from Conventional method (Sinusoidal supply).
2) If Synchronous motor is fed from square wave Inverter there will be huge harmonics.
3) This harmonics causes losses and heating of machine and these are also Causes ~~[illegible]~~ pulsating torque on motor

4) By Using this square wave Inv stator currents will have sharp peaks.

5) If PWM Inverters are used the harmonic effects are reduced which reduces the losses, heating & pulsating torques.

6) The stator currents taken by PWM Inverters are less ~~peaky~~ (less peaky (less peak).

About Powerfactor:-

1) In Order to reduce losses in inverter it is prefered to ~~operate rotator~~ operate the motor in unity p.f.

2) In square wave Inverter due to presence of phase Controlled Rectifier on the line side the powerfactor is low.

3) while in PWM Inverters since the Diode bridge Rectifier is present the p.f improves to unity

4) In both the cases p.f can be improved by changing the field control.

5) For Regenerative braking in squarewave Inverter ~~mode~~ we need to provide an Additional phase Controlled Rect on ~~the~~ ~~to~~ line side.

6) If PWM Inverter is used two cases may arise.

Inverter can be fed from DC Source or from diode bridge Rectifier.