Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the Model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try To assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the Figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any Equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant Values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgment on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.

Q. 1

a) Attempt any THREE of the following: **12M**

i) State the advantages of electric motor as prime mover.

Ans: (any 4 points, 4x1=4M)

Advantages of electric motor as prime mover:-

1. Electric drive is more flexible.
2. It is more economical.
3. It is more clean as there are no fuel, fumes etc.
4. It occupies less space as compared to other forms of drives and is, therefore, very compact source of drive.
5. Its operating characteristics can easily be modified.
6. It can be remote controlled.
7. It requires less maintenance.
8. It is reliable source of drive.

ii) Describe the working of single phase semi converter drive feeding a separately excited DC motor. Draw voltage and current waveforms.

Ans: (circuit diagram-(1. FREEWHEELING DIODE IS OPTIONAL 2. FIELD CAN BE CONTROLLED OR UNCONTROLLED 1MARK) description – 2M, V & I waveforms – 1M)

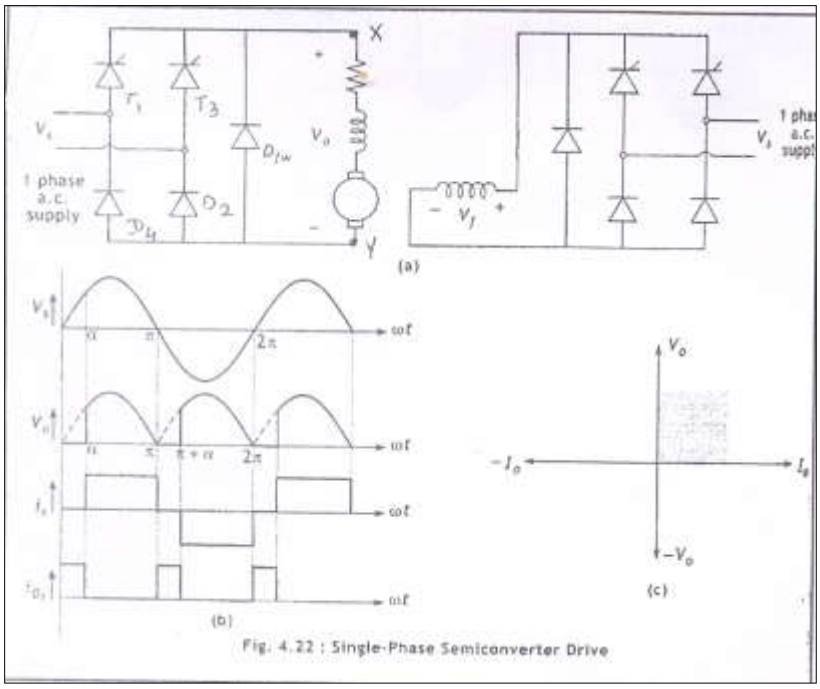
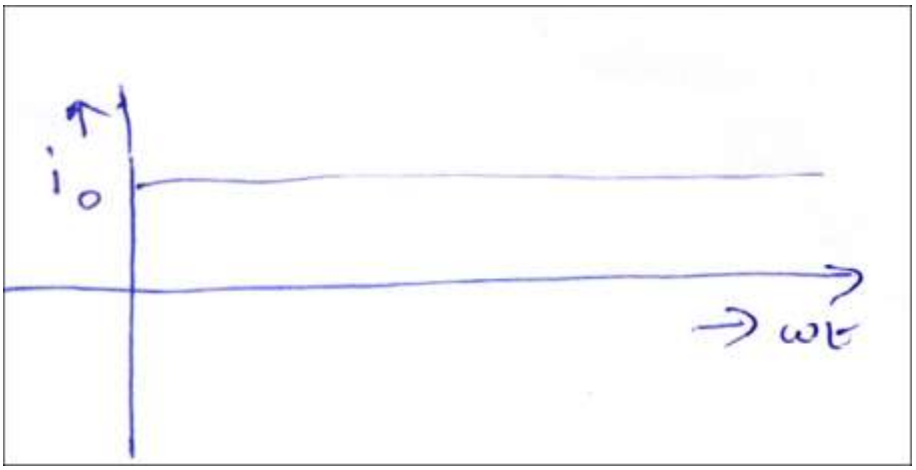


Fig. circuit diagram & waveforms



- The circuit diagram of single phase semi convertor is shown in figure. T1 turns on at α, D_2 turns ON at $0^{0,}$ T_1 turns off at ∏ + α, whereas D_2 turns off at ∏. Similarly, T_3 turns on at ∏ + α, D_4 at ∏ and T_3 turns off at 2∏ + α and D_4 at 2∏.
- T_1 and D_2 are on during the interval α to ∏ and the output voltage is equal to input voltage. Between ∏ to ∏ + α , T_1 and D_4 are ON , hence the load current freewheels in the path T_1-X-Y-D_4, no current is drawn from the source. The output voltage is equal to drop across conducting SCR and diode, which is negligibly small and equal to zero.

- Similarly, between ∏ + α and 2∏, T_3 and $D_4$are conducting, output voltage is equal to input voltage. Between 2∏ and 2∏ + α, T_3 and D_2 being on the output voltage is negligible.
- As semi convertor cannot give reverse voltage at output i.e. V_O, this converter can work only in 1st quadrant.
- Average output voltage $V_o = \frac{V_m}{\Pi}(1+\cos\alpha)$

iii) State the factors that should be considered for drive section.

Ans: (any 4 points, 4x1 = 4M)

Factors:-

1. **Nature of electric supply**: whether A.C. Or pure D.C. Or rectified A.C. supply is to be utilized for motor.
2. **Nature of the drive**: whether motor is to be drive individual machines or a group of machines.
3. **Nature of load**: whether the load requires light or heavy starting torque.
   Whether load torque increases with speed or remains constant.
   Whether load has heavy inertia which may require long starting time.
4. **Electrical characteristics of motors:**
   a) Starting characteristic.
   b) Running characteristic
   c) Speed control.
   d) Braking characteristics
5. **Size and rating of motor:**
   a) Whether motor is to run continuously, intermittently, or on a variable load cycle.
   b) Whether over load capacity and pull out torque are sufficient.
6. **Mechanical considerations:**
   a) Type of enclosures.
   b) Type of bearings.
   c) Transmission of drive.
   d) Noise level.
7. **Cost:**
   a) Capital cost.
   b) Running cost.

iv) Draw a neat diagram and explain the working of phase locked loop control of DC motor.

Ans: (diagram – 2M, Explanation -2M)

Working of phase locked loop control of DC motor:-

- The output of the encoder acts as the speed feedback signal of frequency f_0
- The phase detector compare the reference pulse train f_r with the feedback frequency f_0 and provides a pulse width modulated output voltage V_e which is proportional to the difference in phases and references and feedback pulse trains. The phase detector is available in integrated circuits. A low pass loop filter converts the pulse train V_e to a continuous dc level V_c which varies the output of the power convertor and in turn the motor speed.
- The response of the phase detector is very fast.

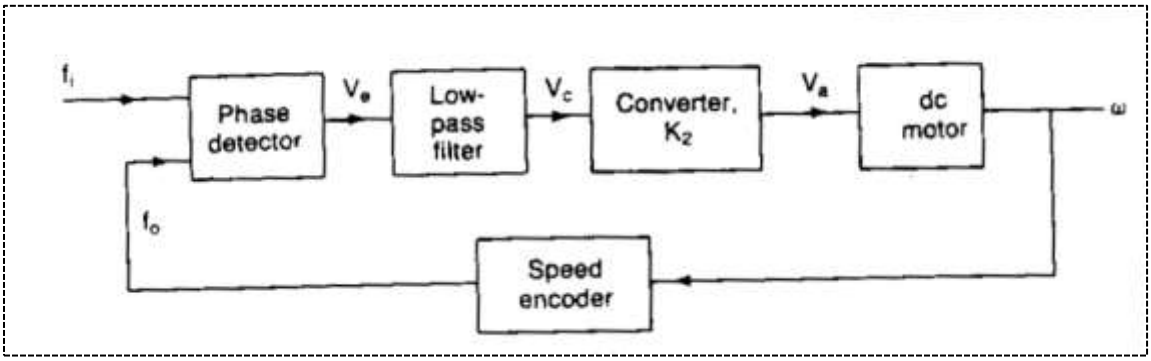


Fig. Phase locked loop control of DC motor

b) **Attempt any <u>ONE</u> of the following:** **6M**

i) Compare single phase and three phase full converter drive.

Ans: (Any six point) (6x1 = 6M)

Sr no.	**Single phase full convertor drive**	**Three phase full convertor drive**
1.	The output ripple is large compared to three phase drive.	The output ripple is small.
2.	They are used for low power application.	They are used for high power applications, up to megawatt power level.
3.	The ripple frequency is small.	The ripple frequency is large
4.	Filter requirement is high compared to three phase drives.	Filtering requirement is less.
5.	The armature current is not continuous. Motor heating is more due to harmonics	The armature current is mostly continuous. Motor heating is less .
6.	Motor performance is better.	Motor performance is good .

ii) Describe the four types of braking methods for induction motor.

Ans: (4x 1.5 =6M)

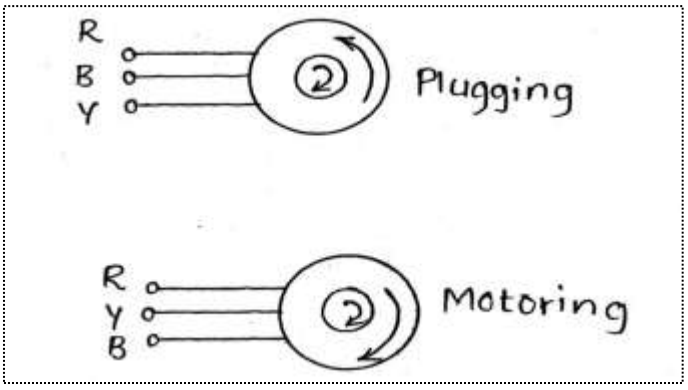
Braking Methods of induction motor:

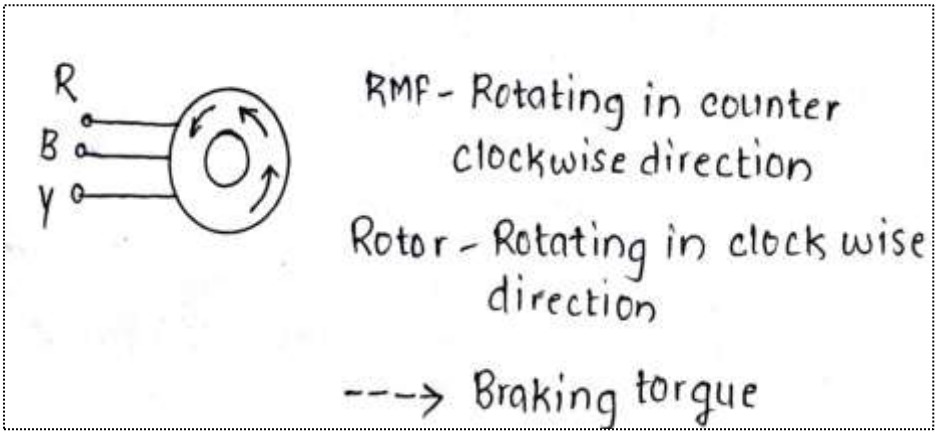
In order to decelerate the rotating motor quickly, some kind of braking system must be used. Various methods used for the braking of an induction motor are as follows:

1. Mechanical braking.
2. Dynamic braking.
3. Plugging.
4. Regenerative braking.

1. **Mechanical braking**:
   This is basically friction braking, and it is usually preferred only at low speeds of operation.

2. **Plugging :**
   This is achieved by interchanging any two phases of stator supply.





The sequence of events takes place as follows:

I. As soon as phase sequence is changed, the RMF starts rotating in the anti-clockwise direction whereas due to inertia rotor continues to rotate in the clockwise direction as shown in fig (b)
II. The induced voltage and current in the rotor change their direction.
III. Due to change in the direction of rotor current the rotor experiences a force in the anticlockwise direction in opposite to the direction of rotation. Due to this force acting on the rotor, the rotor speed reduces quickly.

3. Dynamic braking :

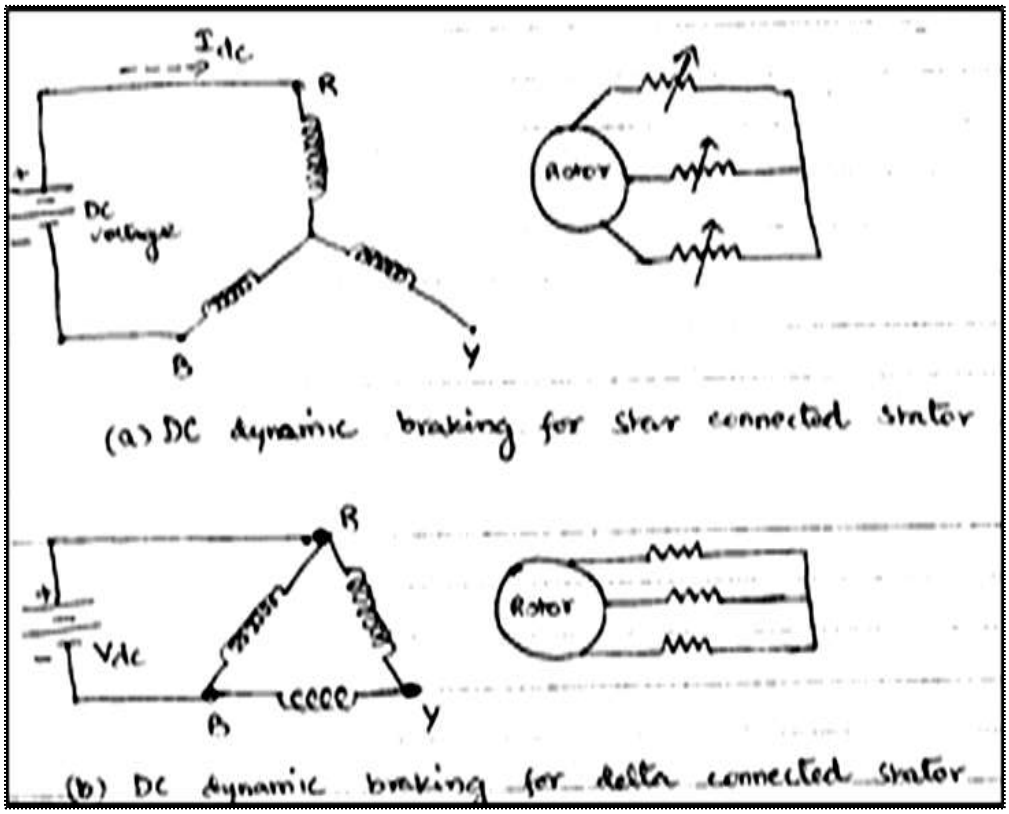


Fig. Dynamic braking

I. The dynamic braking is also known as the Dc injection braking.
II. Dc current flowing through the stator windings produces a stationary magnetic field.
III. Rotor continues to rotate due to inertia in thin stationary magnetic field, which induces a voltage in rotor.
IV. Due to this induced voltage, rotor current flows which also sets up a stationary field with respect to the stator.
V. The interaction of the field and rotor current produces a torque in the reverse direction causing braking action.

4. Regenerative braking:

I. For the regenerative braking to take place, the induction motor works as generator and the kinetic energy converted into electrical energy is returned back to ac supply.

II. The induction motor can work as a generator if and only if s is negative, that means N>Ns

Q2. Attempt any FOUR of the following: 16M

a) List various stages involved in textile mill and its speed ratings at each stage.

Ans: (Each stage with speed range ½ mark)

Various stages involved in textile mill and its speed ratings at each stage are:

1. **Ginning**: The process of separating seeds from raw cotton is called ginning. Speed range is 250-1450 rpm
2. **Blowing**: The ginned cotton is opened up and cleaned in the blowing room. Speed range is 1000-1500 rpm
3. **Carding**: The process of converting cleaned cotton into flat sheets is called carding. Speed range is upto1450 rpm
4. **Straightening**: The thick fibers called slivers are converted to uniform straight fibers. Speed range is up to 1000 rpm
5. **Combing/Lap operation**: This process upgrades the fiber. Speed range is 1000 rpm
6. **Spinning**: The thread is thinned down. Speed range is 500 rpm
7. **Winding, warping and sizing**: For these operations speed range is 100 rpm.
8. **Looms**: The weaving of cloth into yarn is done in looms. Speed range is 600-750 rpm

b) Describe four quadrant operation of hoist.

Ans: (Diagram 2 marks, Explanation 2 marks)

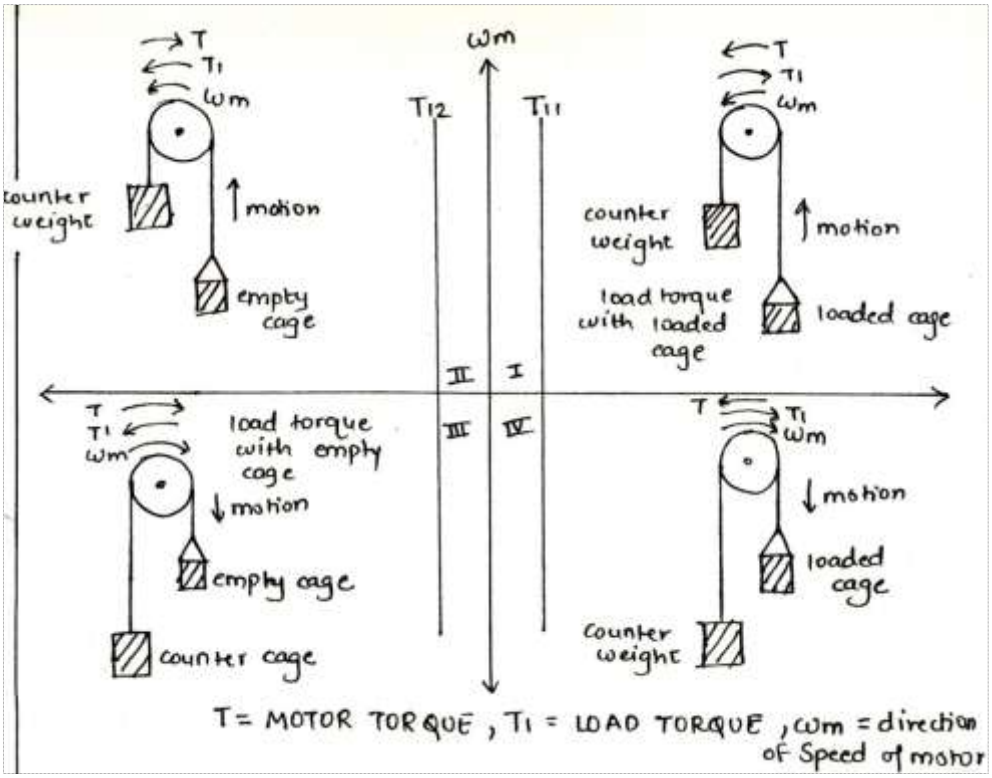


Fig. four quadrant operation of hoist

Explanation:

1. First quadrant operation-Forward motoring: The loaded cage moves in the upward direction. Power is positive.
2. Second quadrant operation-Forward Braking: The empty cage moves in the upward direction. Power is negative
3. Third quadrant operation-Reverse motoring: The empty cage moves in the downward direction. Power is positive
4. Fourth quadrant operation- Reverse braking: The loaded cage moves in the downward direction. Power is negative

c) Give the detailed classification of chopper controlled drives.

Ans: (4 marks)

Classification of chopper controlled drives:

1. Depending upon the quadrant of operation:
   - Single quadrant drive
   - Two quadrant drive
   - Four quadrant drive

2. Single quadrant drive:
   - Type A chopper
   - Type B chopper
3. Two quadrant drive:
   - Type C chopper
   - Type D chopper
4. Four quadrant drive:
   - Type E chopper

d) Describe the working of PWM control of Induction Motor.

Ans: (Diagram 2 marks, Explanation 2 marks)

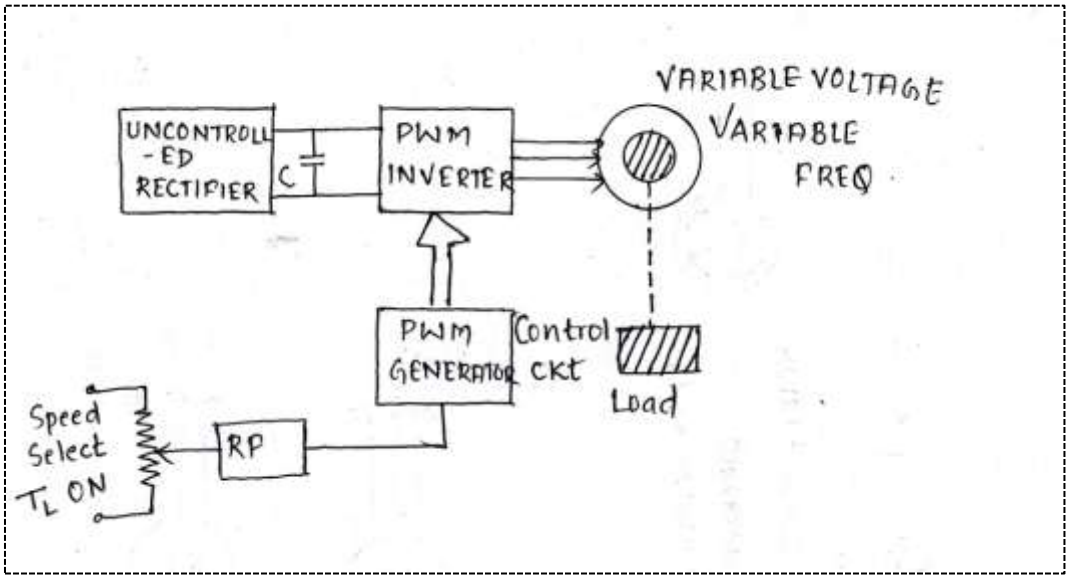


Fig. PWM control of Induction Motor

Explanation:

1. The rectifier used is an uncontrolled rectifier.
2. The capacitor provides constant DC voltage.
3. The output voltage of PWM inverter is changed by changing the modulation index.
4. The output frequency of PWM inverter is changed by changing the frequency of modulating signal.
5. The control voltage from the ramp function generator will control both the output voltage and frequency.
6. It provides soft start and soft stop for induction motor.

e) Sketch quadrant diagram for four quadrant chopper drive and write action of drive in each quadrant.

Ans: (Circuit Diagram or quadrant operation diagram- 2 marks, Explanation 2 marks)

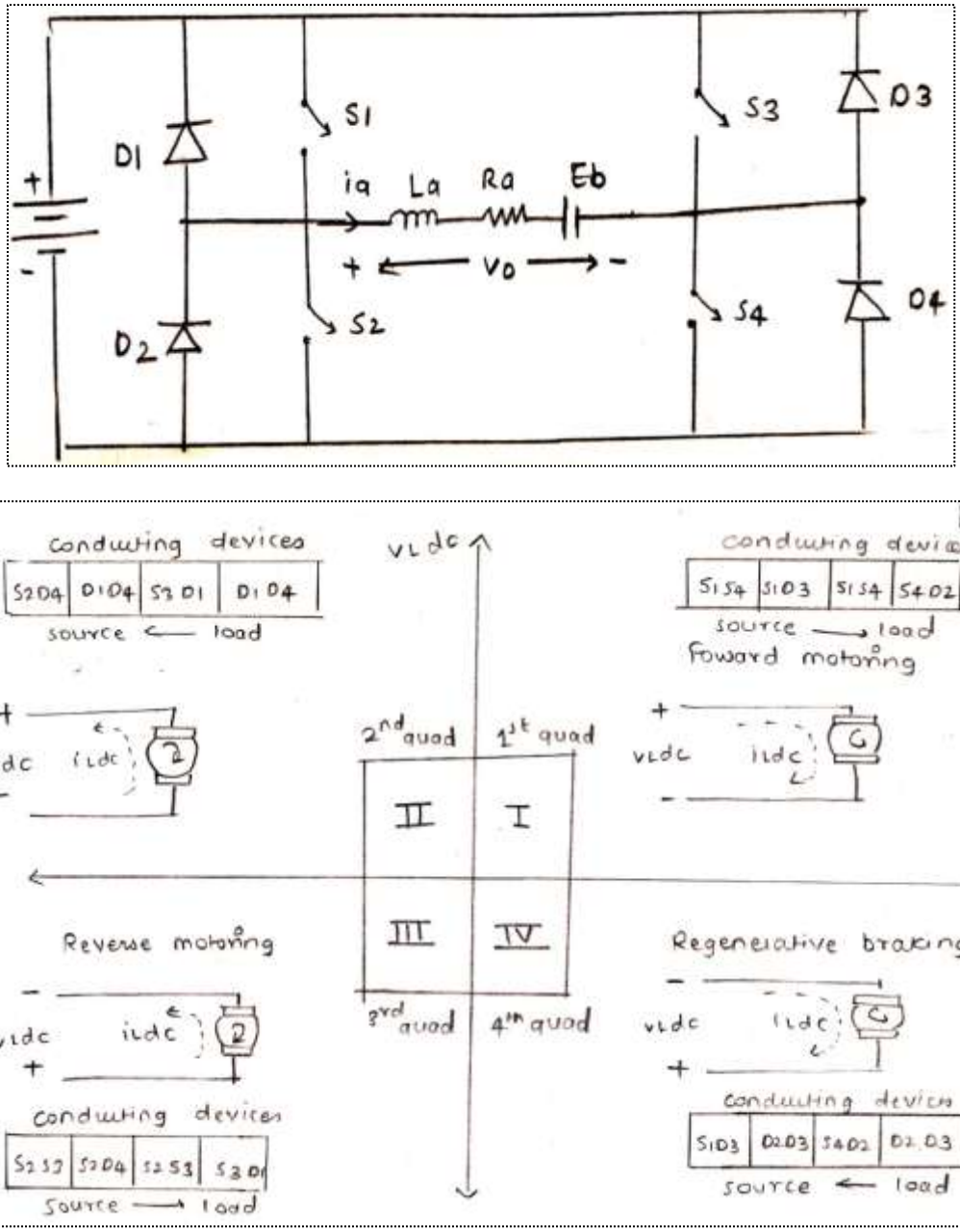


Fig. quadrant diagram for four quadrant chopper drive

Explanation:

Type E chopper is a four quadrant chopper.

1. First quadrant operation-Forward motoring:
2. Second quadrant operation-Forward Braking/Regenerative braking
3. Third quadrant operation-Reverse motoring
4. Fourth quadrant operation- Reverse breaking/ Regenerative braking

f) State the advantages of converter fed induction motor.

Ans: (Any 4 advantages 4 marks)

Advantages of converter fed induction motor:-

1. Smooth acceleration at constant current and torque can be obtained.
2. Smooth start-up can be achieved.
3. High moment of inertia can be accelerated.
4. Switching surges can be avoided.
5. Speed control method is easy.

Q3. Attempt any FOUR of the following: 16M

a) Compare AC and DC drives (any four points).

Ans: (Any 4 points -4 marks)

Sr.NO	DC DRIVES	AC DRIVES
1.	DC motor is used	AC motor is used
2.	Commutator makes the DC motor bulky and costly.	Less expensive compared to DC motor.
3.	Sparking at brushes makes it unsuitable in certain application	Can be used in such applications
4.	Speed and design ratings are limited	There is no upper limit for speed and design ratings
5.	Requires more maintenance	Requires less maintenance
6.	Power circuit used is AC to DC converter or a chopper	Power circuit used is CycloConverter or inverter
7.	Power/Weight ratio is less	Power/Weight ratio is more
8.	Line commutation is used	Forced commutation is used
9.	Used in M/C tool and traction applications	Used in traction, paper mills, textile mills, compressor drives

b) State suitable type of chopper for very large load current requirement. Justify with neat sketch.

Ans: (Name of chopper and Diagram 2 marks, Explanation 2 marks)

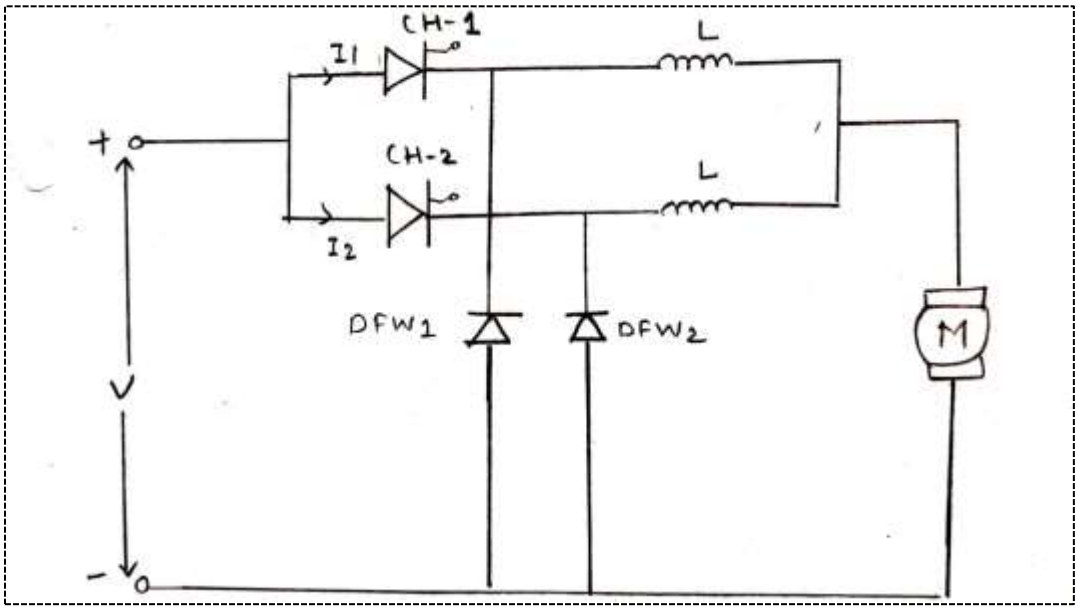


Fig. Multiphase chopper

Explanation:

Multiphase chopper is used for large load current requirement.

- It is a two chopper configuration. Chopper 1 and chopper 2 Class A choppers connected in parallel. DC motor is common load for chopper.
- Inductors L1 and L2 are connected in series with the motor load.

There are two operating modes:

- **In phase mode**: In this mode both the choppers are turned ON and turned OFF simultaneously.
- **Phase shift mode**: In this mode both the choppers are turned ON at different instants of time.

c) State suitable type of chopper for forward motoring and forward braking. Draw its quadrant of operation.

Ans: (2 marks circuit diagram/ quadrant operation diagram and name of chopper 2 mark)

Type C chopper is suitable for forward motoring and forward braking. It is a two quadrant chopper configuration. The first quadrant is forward motoring and second quadrant is forward braking.

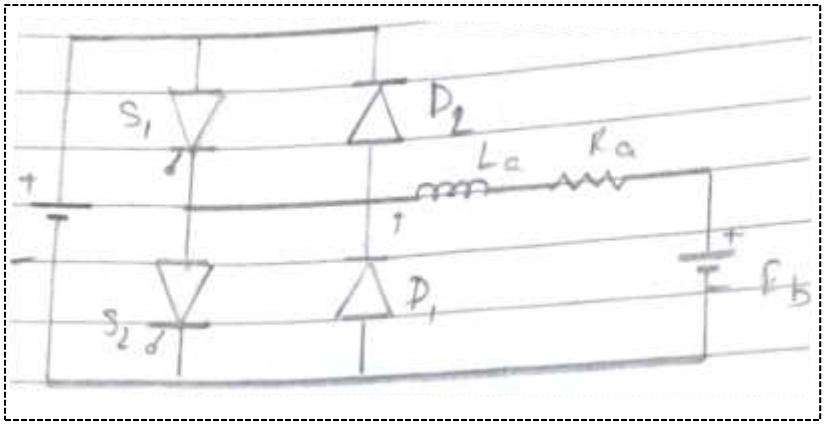


Fig. Circuit diagram of Type C chopper

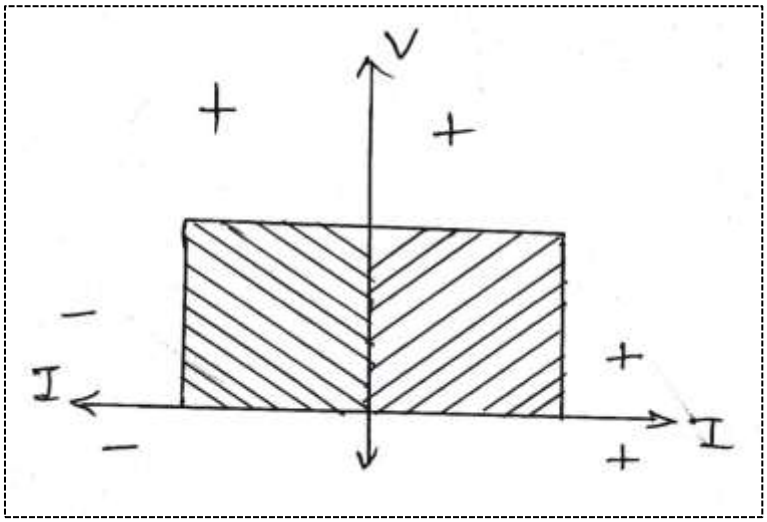


Fig. Quadrant operation diagram

d) Describe the operation of DC chopper using power MOSFET Also draw voltage and current waveforms.

Ans: (Circuit diagram 1 marks, Explanation 1 mark and voltage and current waveforms 2 marks)

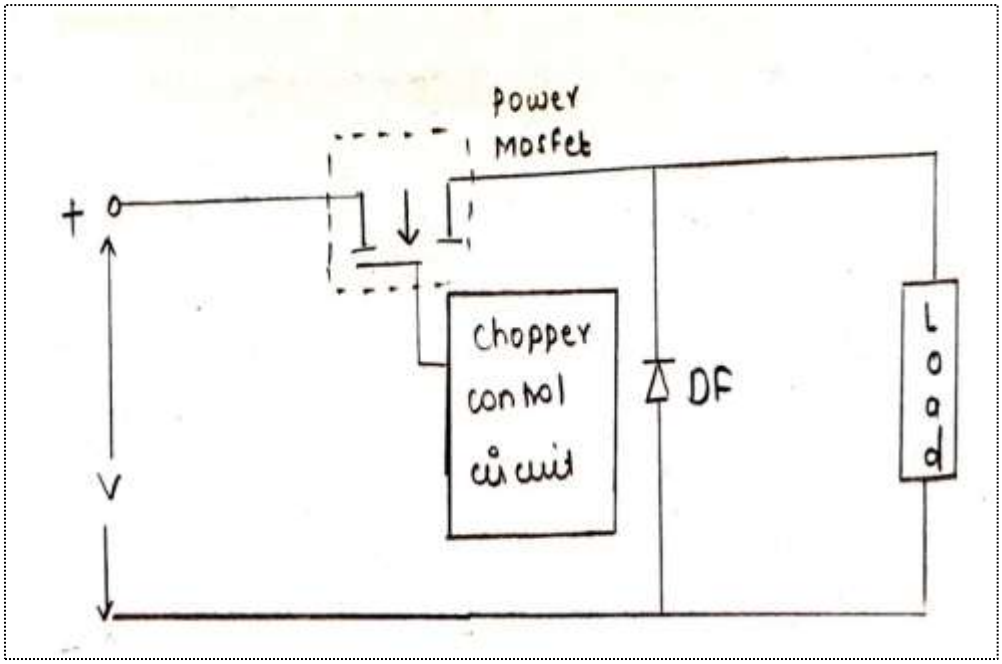


Fig. circuit diagram of DC chopper using power MOSFET

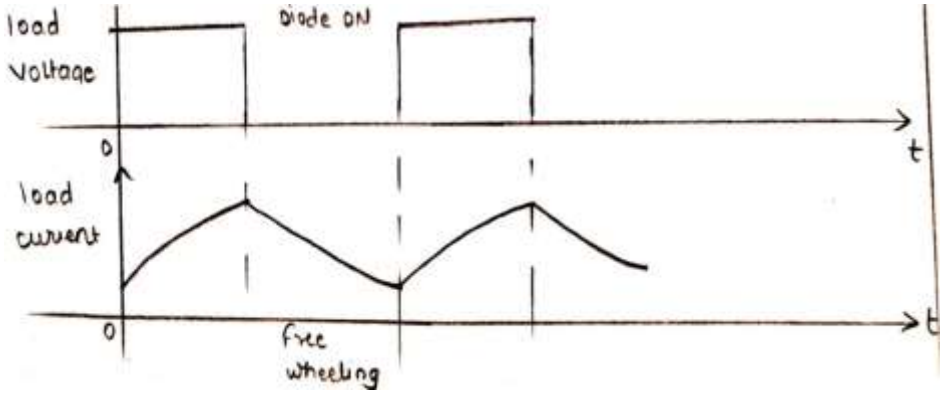


Fig. Voltage and current waveforms.

Explanation:

The semi-conductor device used is power MOSFET. Load is inductive and free-wheeling diode is used.

The gate control circuit provides rectangular voltage waveform. The duty cycle of the chopper can be controlled by varying this waveform. When the gate voltage is high, MOSFET is ON and acts like closed switch. Load voltage is positive and load current rises exponentially and inductor stores energy. When the gate voltage is zero, MOSFET is OFF and acts like open switch. Load voltage is zero and load current decays exponentially and stored energy in the inductor is dissipated.

e) With a neat circuit, explain the working of a 3 ϕ full converter drive. State the equation of average armature voltage.

Ans: (Circuit diagram 2 mark, explanation 1 mark, voltage equation 1mark)

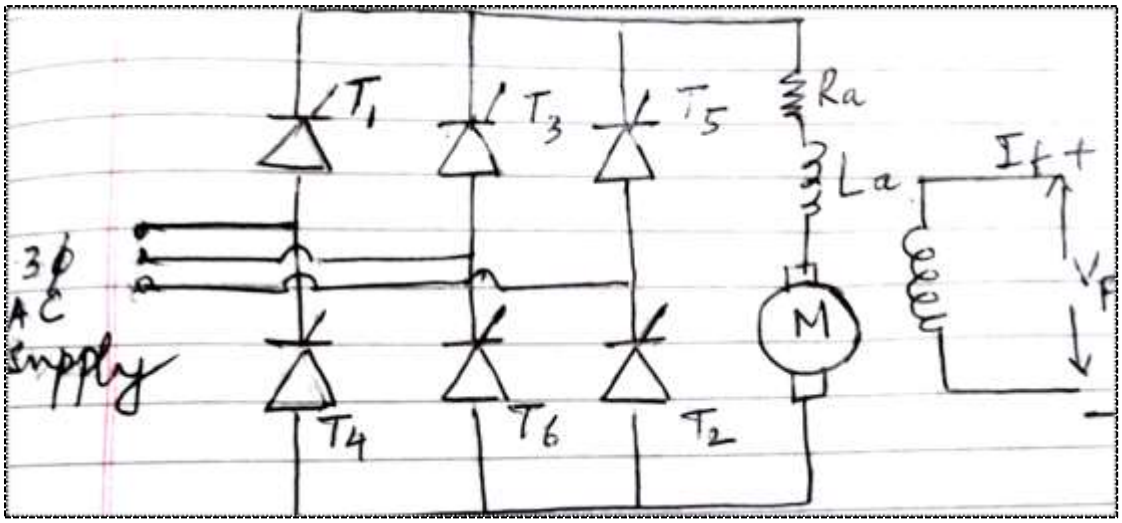


Fig. 3 ϕ full converter drive

Explanation:

Circuit uses 6 SCRs T1, T2, T3, T4, T5, T6.

Load is inductive.

The motor is separately excited DC motor.

Ra is the armature resistance and La is armature inductance.

Vm is maximum value of AC input voltage. Vf is the field voltage and If is the field current. α is the firing angle. Each SCR is fired at an interval of 60 deg and the firing sequence is T6-T1, T1-T2, T2-T3, T3-T4, T4-T5, T5-T6 and again T6-T1. Each SCR conducts for 120 deg and pair conducts for 60 deg.

The average DC voltage is given by:

$$\mathbf{Vdc=3\sqrt{3}Vm\ Cos\ \alpha/\pi}$$

Q.4

a) Attempt any THREE of the following: **12M**

i) Describe field failure protection in three phase drives.

Ans :(Field failure OR phase failure protection can be considered --Explanation- 4M)

Reasons for phase failure are: 1. Blown fuse in some part of power distribution system

2. Mechanical failure within the switching equipment

3phase induction motors running on 1phase draw all the current from the remaining two lines.

This will cause the motor to draw more current. This will cause heating of the motor and will damage the motor.

For this phase displacement sensor with relays are used.

Field Failure Protection: In this circuit arrangement is made to connect the DC supply to the armature winding if and only if the field winding is energized and drawing the rated field current. Relays are used for this protection.

.

ii) Draw torque vs speed/ slip characteristics of induction motor showing all regions. Explain it.

Ans: (Diagram – 2M, explanation-2M)

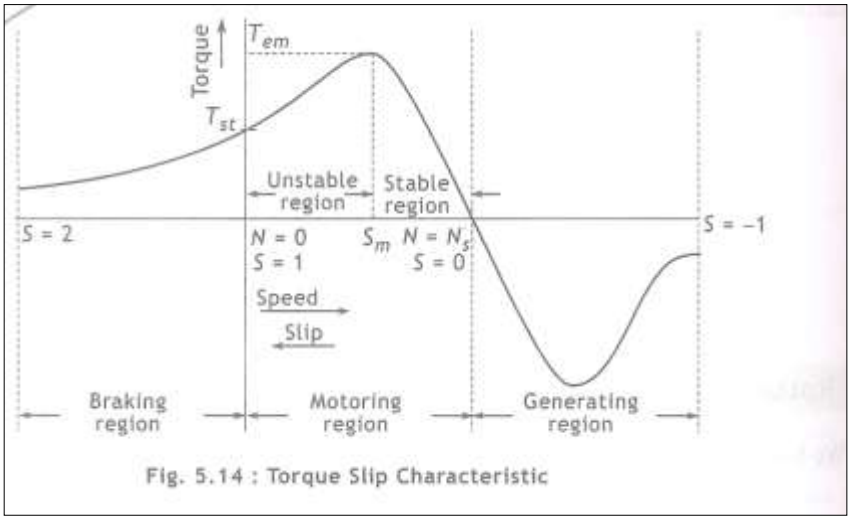


Fig. 5.14 : Torque Slip Characteristic

Fig. Torque vs speed/ slip characteristics of induction motor

Explanation:

1) Motor when $1 \geq S \geq 0$, i.e. when slip is positive.
2) Generator when $S < 0$, i.e. when slip is negative the induction machine must be driven above synchronous speed by a prime mover.
3) When $S > 1$, braking action called plugging takes place. For obtaining $S > 1$, i.e. for obtaining plugging any two stator leads are interchanged. With this the phase sequence is reserved and, therefore, the direction of rotating field becomes suddenly opposite to that of the rotor rotation.

iii) State the advantages of microcontroller based control for drives.

Ans: (Any 4 points – 4x1 = 4M)

1. These are very compact control systems.
2. The processing of speed and angular position is digital, hence it is more accurate.
3. Less expensive than analog discrete drives.
4. This type of control is totally software oriented. So the same software can be used for different types of drive applications with a very few modifications.
5. Very high quality of performance.
6. Very high reliability.
7. High precision.
8. These drives are very flexible and adaptable for application of all types.

iv) State eight functions of microprocessors in drives.

Ans: (8x0.5 = 4M)

1. Generating and providing firing pulses to the convertors.
2. Generating of necessary waveforms to feed the motors.
3. Processing the measured signal, such as voltage , current and speed.
4. Storing and processing the information of controlled quantities.
5. Identification and adaptation of variable parameters.
6. Adaptive control and optimization
7. General sequencing control
8. Monitoring and warning
9. Diagnostics and tests

b) Attempt any ONE of following: 6M

i) Which type of drive/motor is used in paper mill at each stage? State specification of drive at each stage.

Ans: (each stage 3M)

Paper mill:

- The raw material for paper making undergo two processes before the paper is available.
- The raw material –Pulp conversion.
- The Pulp to paper in paper making machines.

Raw material – Pulp:-

- It is accomplished by combination of mechanical and chemical processes.
- The mechanical process is first cutting log of wood into 1m length and are ground in big grinding machines.
- Grinders are convertor fed synchronous motor of pm in range 200-300.
- Then are trated with chemicals and the pieces are converted to pulp by means of beaters. The speed of beater operation is less than 200 rpm
- Slip ring induction motor are used for beaters (S.F.E. feed synchronous motor)
- For process of making pieces i.e. chipping and refining (chemical) synchronous motor is used.

Pulp – Paper:-

- It is accomplished in paper making machine.
- The water in the pulp is removed and its pressed to sheets of paper which are wound up on a mandrel.
- The section converting pulp – paper is wire (Couch) section, pressing section, dryer, calendar and reel section.
- The motor required can be AC/DC motor with group/ individual motor drive.

ii) Illustrate drives stability with the help of torque speed characteristics.

Ans: (Diagram – 3M, Explanation- 3M)

Note: Any other relevant stability diagram with condition of stability should be considered.

Explanation:-

- The motor is stable if the transient portion of the response dies down with the time.
- Consider point A, a small decreases in speed is followed by an increase in motor torque which accelerates the load and brings if back in equilibrium.
- After several overshot & oscillations the drives comes to a state of equilibrium.
- At point B, a small decrease in speed decreases the torque developed by the motor. This points is unstable because small variation in speed causes small changes in torque which is a cumulative process.
- A decrease in speed, the motor torque is greater than the load torque/ an increases in speed for same conditions.

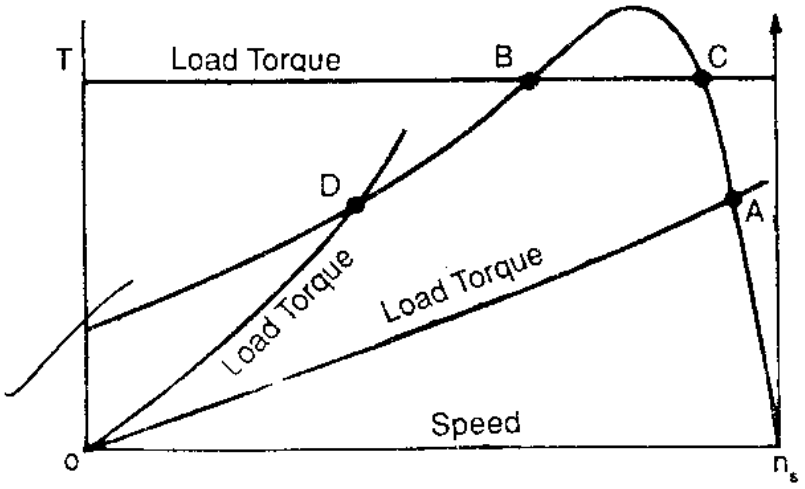


Fig. 2.15 *Steady-state stability of induction motor*

- A machine is stable **i**f its load speed-torque curves are such that for
  a) A decrease in speed, the motor torque is greater than the load torque.
  b) An increase in speed, the load torque is greater than the motor torque.
- From the condition it can also be seen that a decrease (increase) in speed must bring about a greater (smaller) change in the motor torque than in the load torque so that the machine can be accelerated (retarded) under the influence of the motor torque (load torque) to its original point of operation.

Q5. Attempt any FOUR of the following: 16M

a) Describe chopper controlled induction motor drive employing rotor resistance control technique.

Ans: (block diagram-2 marks, explaination-2 marks)

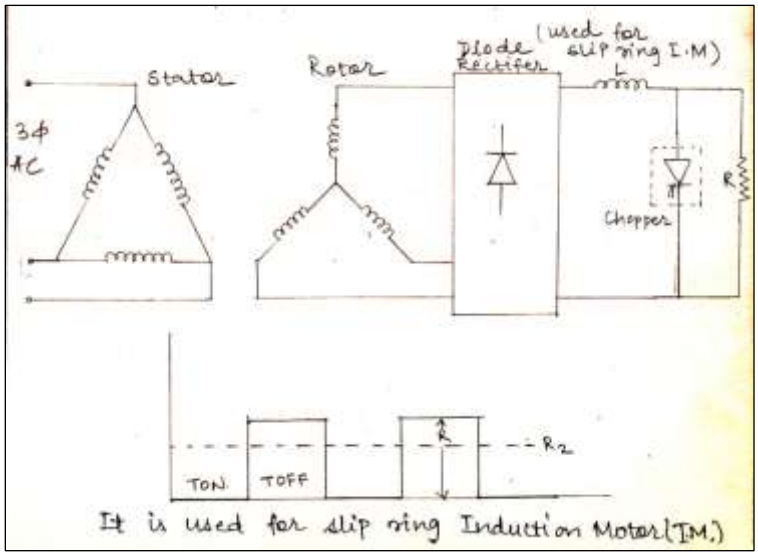


Fig. chopper controlled induction motor

Explanation:

i) Speed control by means of slip variation can be achieved by using a variable resistance in the rotor circuit. The maximum value of torque does not depend upon the value of rotor resistance.

ii) Rotor resistance influences the slip at which maximum torque occurs. External resistances can be added very conveniently to the phases of the slip ring induction motor.

iii) With the development of thyristors which has lead to the chopper control resistance in the rotor circuit.

iv) The resistance across output terminal of a chopper can be varied from 0 to R by changing the time ratio (Duty cycle) of the chopper. The slip power of the rotor is rectified through a diode bridge rectifier and fed to the chopper control resistance.

v) The smoothing induction is used in the circuit to maintain the current at constant value.

vi) The rating of the chopper decides the maximum rotor current of the motor.

vii) It is suitable for load such as elevators, lifts but the speed control range is limited by the resistance.

b) A single phase full converter fed from 230V, 50Hz supply provides a variable voltage supply to the armature of a separately excited DC motor. The specifications of motor are 10HP, 230V, 1200rpm, Ra=0.25Ω. Rated motor current is 40amp, motor voltage constant Ka Φ=0.182V/rpm. The firing angle is 30°. For the rated motor current. Calculate:

i) Motor Torque

ii) Speed of the motor.

Ans: (**Motor Torque- 2 marks, Speed of the motor- 2 marks)**

Note: Step-wise Marks should be given

Given Data

Supply= 230V, 50Hz

Motor Specification= 10HP, 230V, 1200rpm

Ra=0.25Ω

Ia=40A

Constant = Ka Φ=0.182V/rpm.

α =30◦

i) Speed of of the Motor(N)=

Equation of average voltage of full converter= Ea

$$Ea = \frac{2*Vm}{\pi} * Cos\alpha$$

Vrms=230v

$$Vrms = \frac{Vm}{\sqrt{2}}$$

$$Vm = \sqrt{2} * 230$$

Vm =325Volts

$$Ea = \frac{2*325*cos30}{\pi}$$

Ea =179.2Volts

$$V = Eb + IaRa$$

$$Eb = V - IaRa$$

$$Eb = 179.2 - 40(0.25)$$

Eb = 169.2Volts

$$Eb = \frac{2*\phi*N}{60} * \frac{P}{A} = Ka\,\Phi * N$$

$$N = \frac{Eb}{Ka\,\Phi}$$

$$N = \frac{169.2}{0.182}$$

N= 929.6 rpm

ii) Motor Torque (T) $= \frac{Eb * Ia}{2\pi N}$

$= \frac{169.2 * 40 * 60}{2\pi * 929.6}$

$=$ **69.52 N-m**

c) A 4-pole 1580rpm, 3 Φ Im is operated from a per phase voltage of 230V/60Hz and driving a constant torque load. Calculate the following at f=30Hz, Φ_{ag}=5.2

i) Supply Voltage/phase
ii) Slip
iii) Slip frequency
iv) **Slip at 30Hz**

Ans: (**Supply Voltage/phase-1 mark, Slip-1 mark, Slip frequency-1mark, Slip at 30Hz-1mark)**

Given Data

Motor =3 phase induction motor

Poles=4

Speed (N) =1580rpm

Per phase Voltage= 230V/60Hz

At f=30Hz, Φ_{ag}=5.2

We will find ,

i) Supply Voltage/phase:-

Supply voltage $\frac{V}{f} = \phi$

$\frac{V}{30} = 5.2$

Therefore, V = 30*5.2
V =156 Volts.

ii) Slip (S) at 60 Hz:-

$NS = \frac{120*F}{4} = \frac{(120)*(60)}{4}$ = 1800 rpm

Speed (N) = NS (1-S)
1580=1800(1-S)
$\frac{1580}{1800} = (1 - S)$
0.877 = 1-S
S = 1-0.877
Slip = 0.122
%Slip = 0.122*100
% Slip = 12.22%

iii) **Slip frequency(Sf):-** = slip * frequency
= 0.122*60
Sf = 7.33Hz

iv) Slip at 30 Hz:-

$S = \frac{Sf}{f} = \frac{7.33}{30}$

Slip = 0.244
%Slip=24.4%

d) Describe the role of drives in sugar mill.

Ans: (diagram- 1 mark, explanation- 3 marks)

Role of drives in sugar mill :-

1. In sugar mill the sugar crystals are separated from the syrup by mean of a centrifuge. The separation is accomplished by the centrifugal set up.
   -The centrifuge is started to a speed of around 200rpm at which the charging of syrup takes place.
   -during charging the motor is disconnected from the supply.
   -the centrifuge is spun at speed of 500 & 1000 rpm.
   -the speed is then reduced in steps to about50 rpm, at which plugging takes place.
   -A typical load cycle of a centrifuge is shown as:

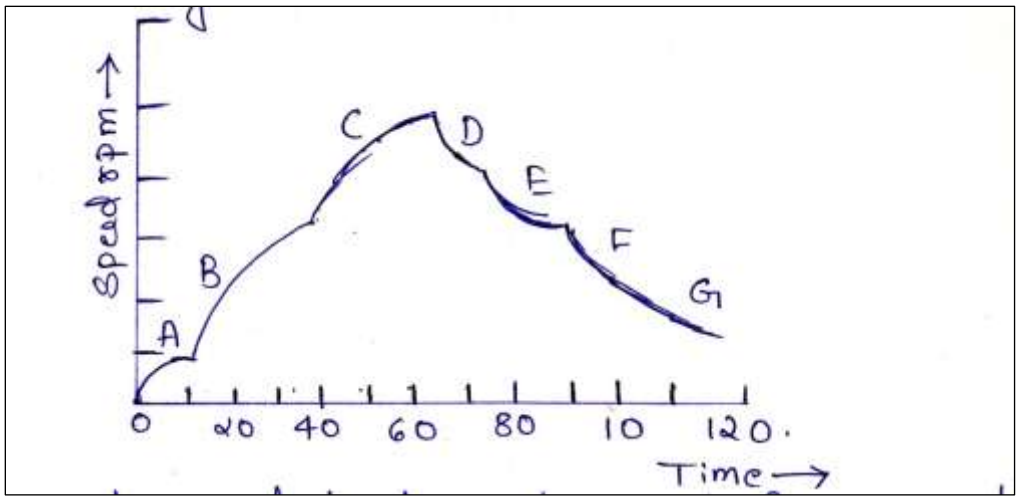


Fig. A typical load cycle of a centrifuge

2. Centrifuge: The motor used to drive the centrifuge is a variable speed motor like slip ring induction motor. Regenerative braking is employed. Stator voltage control can be used.
3. A synchronous motor or converter fed induction motor can also be used for speed control purposes.

e) Draw the power circuit for single phase full converter drive of DC series motor. Also draw voltage & current waveforms for continuous motor current.

Ans: (Power circuit-2 marks, Waveform- 2 marks)

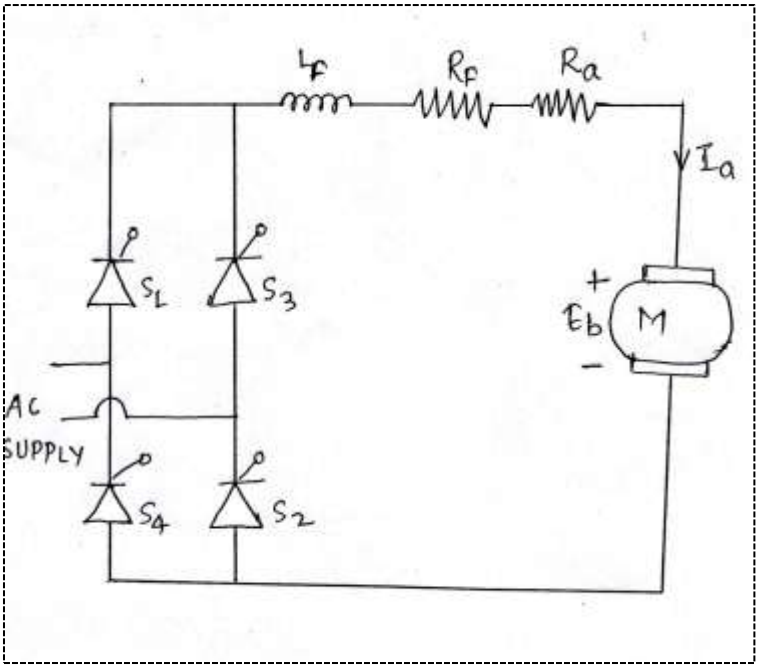


Fig. power circuit for single phase full converter drive of DC series motor

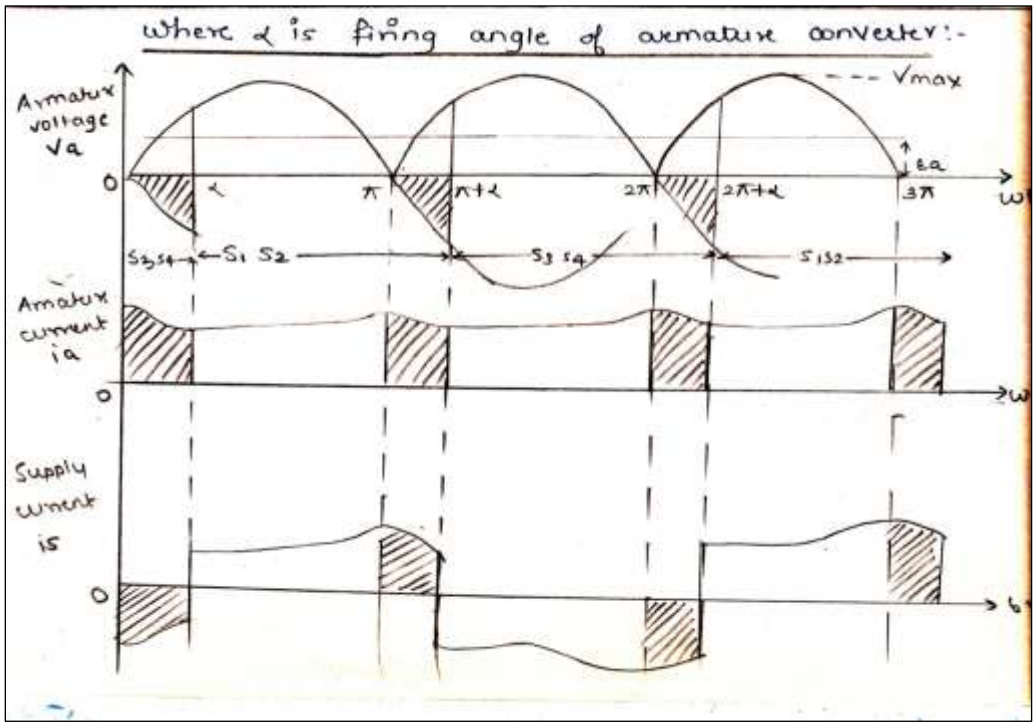


Fig. voltage & current waveforms for continuous motor current.

f) Draw the block diagram to drive separately excited DC motor using Microprocessor.

Ans: (Diagram- 2 marks, Labeling- 2 marks)

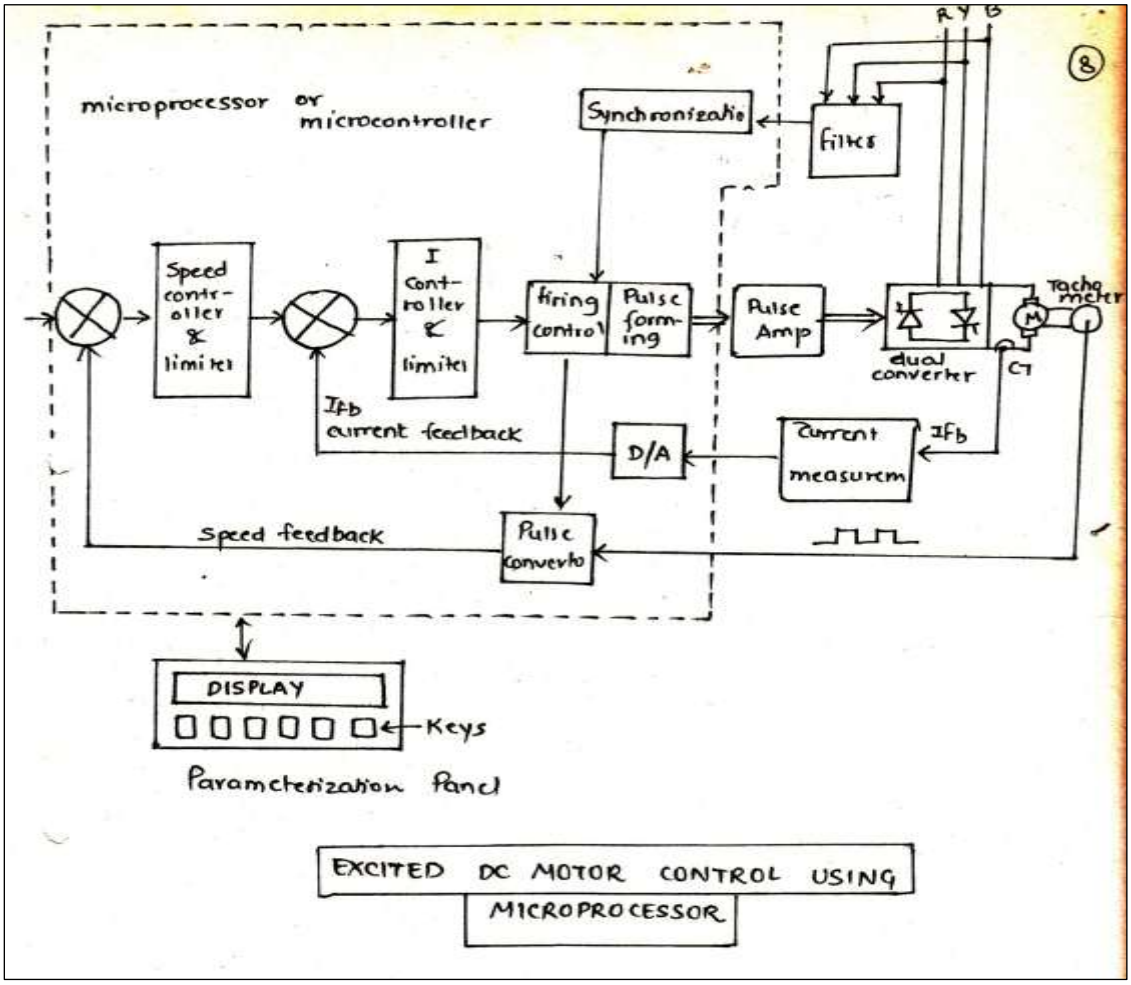


Fig. diagram to drive separately excited DC motor using Microprocessor

Q6. Attempt any FOUR of the following: 16M

a) Draw & explain the block diagram of synchronous motor drive using microcontroller.

Ans: (Block diagram-2marks, Explanation-2marks)

NOTE: ANY OTHER RELEVANT BLOCK DIAGRAM CAN ALSO SE CONSIDERED

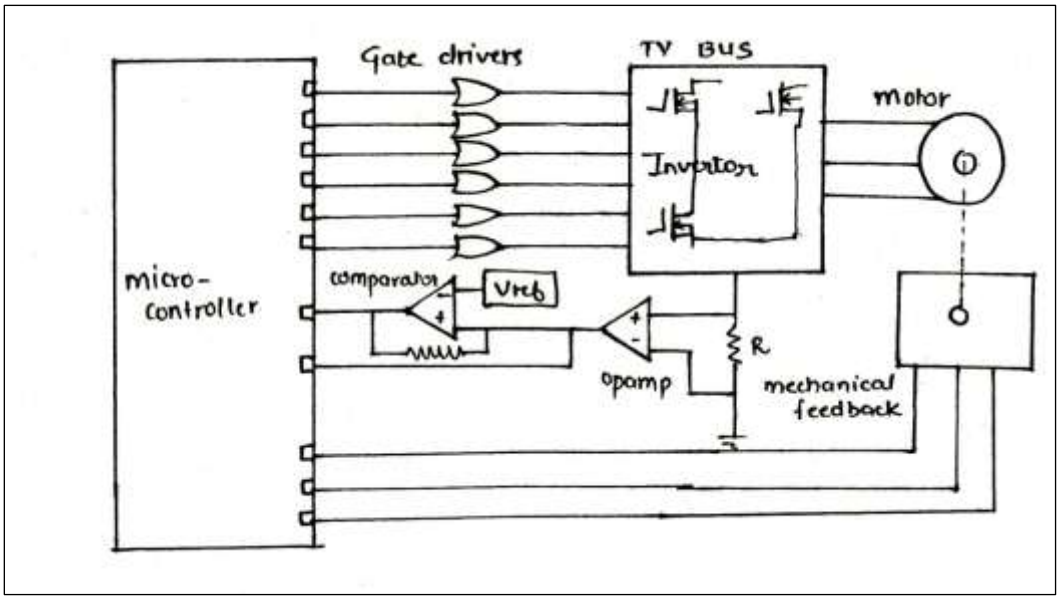


Fig. diagram of synchronous motor drive using microcontroller

Explanation:-

Here we are using permanent magnet synchronous motor.

1. Permanent magnet synchronous motor is similar to brushless DC motor.
2. It is having Permanent magnet rotor & windings on stator.
3. It is constructed in such a way that the back emf waveform of thr windings are sinosoidal.
4. Permanent magnet synchronous motor is controlled with sinosoidal waveform to match the back emf waveform.
5. Microcontroller having inputs like torque, speed, position in terms of analog voltage, potentiometer or digital communication.
6. Six output pins arr present for six gate drivers.
7. Driver output is given to six FEt's present in inverter circuit.
8. To obtain sox step sinewave output at the output side of inverter.
9. Inverter output is three phase supply lines for motor.
10. Comparator is used for speed measurement over current detection.
11. Input is captured for speed sensing.
12. Feedback can be sensors,optical encoder or back emf voltage.

b) Which type of drive motor is suitable for Robotic Arm? Explain its working with block diagram using microprocessor.

Ans: (Block diagram-2marks, Explanation-2marks)

NOTE: ANY OTHER RELEVANT BLOCK DIAGRAM USING STEPPER MOTOR CAN BE CONSIDERED

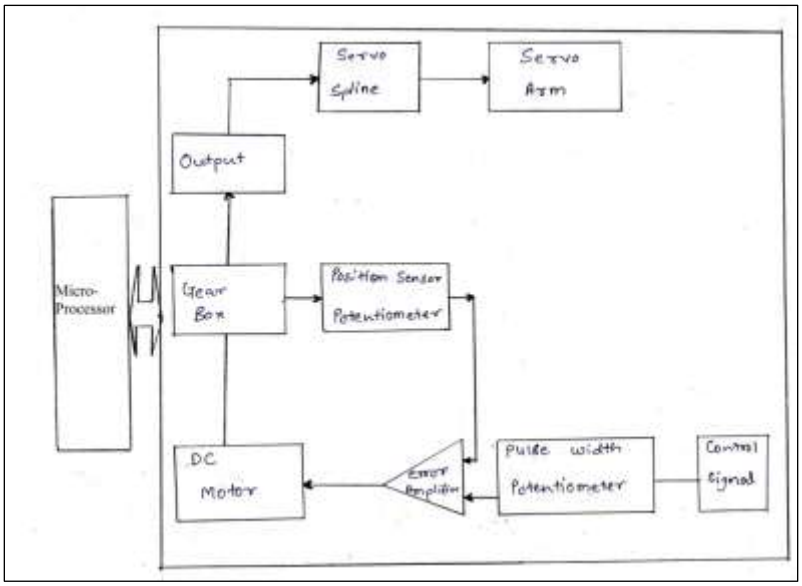


Fig. block diagram of DC servo motor

Explanation:-

DC servo motor is suitable for Robotic Arm.

1. Servo motor is nothing but a simple electrical motor with the help of servomechanism.
2. There are some application of motor where rotation of the motor is required for just a certain angle not continuously for long period of time.
3. A servo motor is mainly consist of a DC motor, gear system, a position sensor(potentiometer) and control element.
4. Motor is connected to gear box assembly to provide feedback to position sendor.
5. Output of motor is given to servomotor arm through servo spline.
6. Potentionmeter changes position according to current position of motor .
7. So change in resistance providechange in voltage.
8. And then it is compared with voltage from feedback potentiometer.
9. Then error singnal is amplified & given to motor and then much angle rotation of robotic arm/leg takes place.
10. Position or rotation of robotic arm /leg is depends on PWM control signal.

c) Compare stator voltage control & constant v/f control methods of speed control of induction motor.

Ans: (any 4 points- 1 mark for each)

Parameter	Stator voltage control	Constant v/f control
Voltage control technique	Stator voltage is used to control the speed of motor.	Stator voltage & frequency both are used to control the speed of motor
Rnge of speed	Range of control is limited	Wide speed range
Efficiency	Low	High
Power factor	Low input power factor as converter is used.	High power factor PWM inverter is used
Complexity	Less	More
Cost	Cheaper	expensive
Harmonic contain	Output consist of harmonic due to voltage waveform distortion	With PWM output harmonic are very low

d) Suggest suitable type of drive for machine tool application and justify your answer.

Ans: (Requirements-2 marks, Suitable drives-2 marks)

The requirements of motors used for machine tools are:

i) The motor must be reliable & low cost, requiring less maintainance.
ii) They must be capable of speed control.
iii) The acceleration & the motor should be sufficiently fast to avoid motor heating during starting.
iv) Some machine tools require very high speed of operation.
v) Numerically controlled machine tools are being prefrred to conventional machine tools.
vi) The requirements of the drive motor are fast response, wide range of speed control, low vibrations, bettter thermal capacity, low maintanance,etc.
vii)

Due to the simple, economical & robust construction, reliability & less maintanance, squirrel cage and converter fed induction motors are suitable for driving machine tools.

e) With the help of block diagram explain v/f control using square-wave inverter.

Ans: (Block diagram-2 marks, Explanation-2 marks)

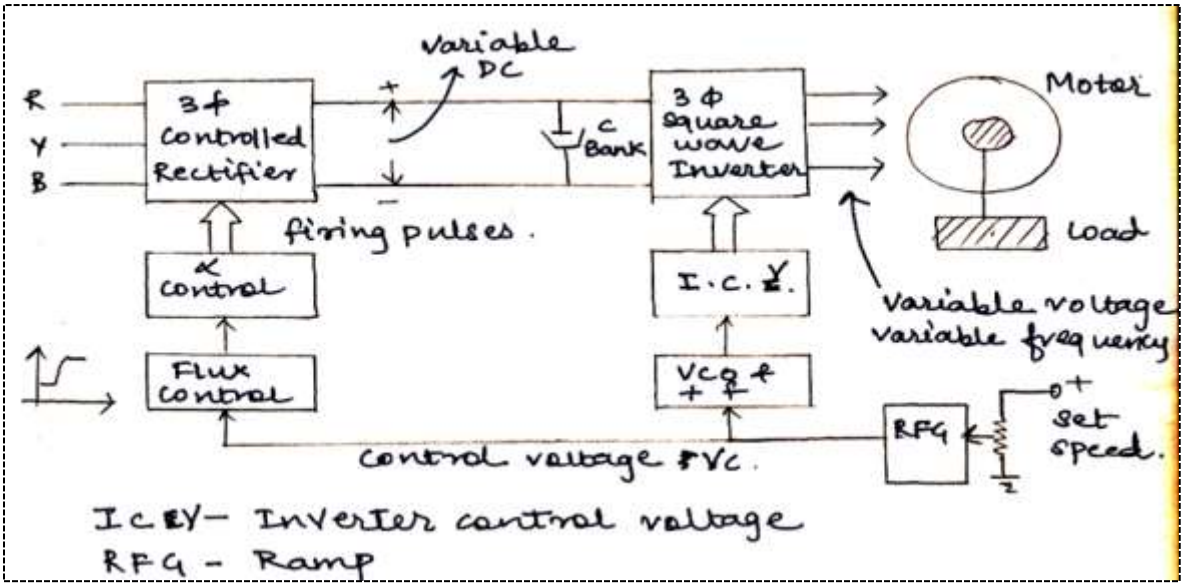


Fig. block diagram of v/f control using square-wave inverter

Explanation:

1. The output voltage of squarewave inverter a variable DC voltage is required on the input side of the inverter. This is obtained from a 3 phase converter, filter combination on the input side of the inverter. The output frequency of the Inverter can be changed by changing the rate at ewhich the devices connected in the inverter are switched ON & OFF. The VCO frequency will vary in proportional with DC controlled voltage to vary the inverter output frequency.
2. The output waveform of the Inverter is a 6 step square waveform. A low percentage of harmonics will reduce the meter heating. Both the output frequency & voltage of the inverter should be variable in order to vary them simulateneously to keep the ratio $\frac{E1}{F1}$ constant . acommon voltage control (V_c) is used to vary both F1 and to vary both F1 and α.
3. The firing angle of three phase converter is changed in proportional with output voltage of the flux control circuit. The control voltage (V_c) is obatained from a ramp function generator . The Ramp Frequency Generator provides the start required at the starting of Induction motor.

Disadvantages of Squarewave inverter:

i) The output voltage waveform contains lower order harmonics, which effects the motor heating specially.
ii) The input power factor of the converters is dependent on the firnig angle α which is very poor at high value of α i.e. at low motor speed.
(note: Disadvantages not compulsary)