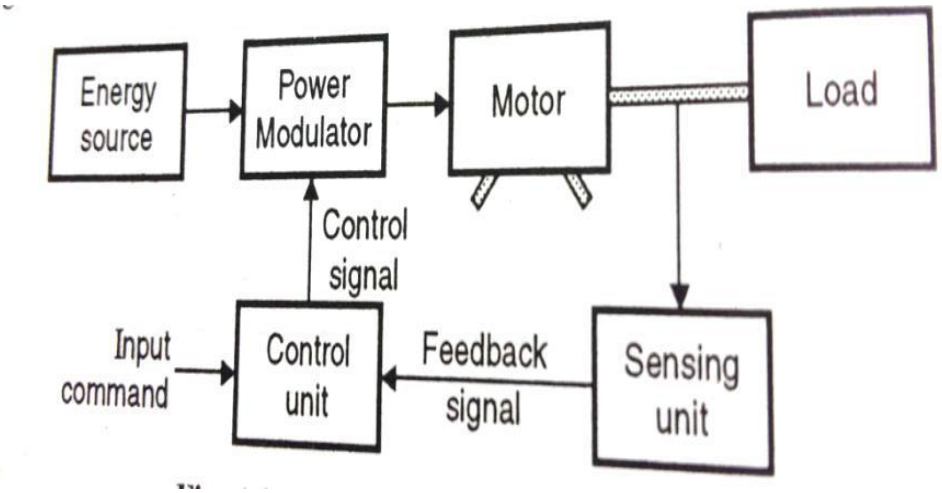
MODEL ANSWER

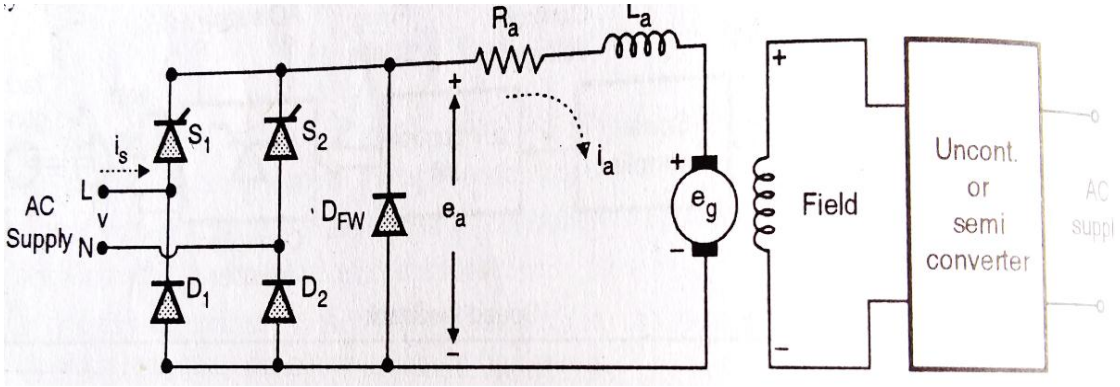
SUMMER– 17 EXAMINATION

Subject Title: Industrial Drives Subject Code: 17667

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 anyequivalent 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 judgement 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. No.	Sub Q.N.	Answer	Marking Scheme
Q.1	A	**Attempt any THREE:**	12-Total Marks
	a)	**Draw and explain the block diagram of electric drive.**	4M
	Ans:	**Block diagram:** 	2M
		Explanation: • Energy source: it can be an AC source or a DC source. It depends on the type of power modulator used. • Power Modulator: It modulates the power flow from source to the motor. It limits the source current during starting and braking. Examples are rectifier, chopper inverter etc.	2M

		• Motor: It converts electrical energy to mechanical energy. Types are servo motor, synchronous motor, etc. • Sensing unit: It senses the load parameter like speed or position and produces a signal proportional to the sensed parameter. The output goes to the control unit. • Control unit: It compares input command signal and feedback signal and produces a command signal which drives the power modulator to reduce the error.	
	b)	**State the need of electric drives.**	**4M**
	Ans:	**<u>Need of electric drive:</u>** • The motion control is required in large number of industrial and domestic applications. These applications include sugar mills, paper mills, textile mills etc. • The motors need to be operated at different speeds for which an electric drive is needed. • To meet good overload capacity • To improve the energy efficiency • For operating in all four quadrants of speed torque plane.	**(Any 4 points, Each Point-1M)**
	c)	**State eight functions of microprocessor in drive technology.**	**4M**
	Ans:	**<u>Eight functions of microprocessor in drive technology:</u>** 1. Generating and providing firing pulses to the convertors. 2. Generation 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	**(Any 8 points, each Point-½M)**
	d)	**Draw and explian the operation of single phase semi-converter drive with waveforms.**	**4M**
	Ans:	**<u>Circuit diagram:</u>**  **<u>Explanation:</u>** **Circuit description:** It is also called as half controlled converter. It uses two SCRs S1 & S2 and diodes D1 & D2 and a freewheeling diode DFW and a separately excited motor.	**1M** **2M**

Working:

Continuous conduction:

Mode 1(α to π): The circuit diagram of single phase semi convertor is shown in figure. S1 and D2 are forward biased during the positive half cycle and S1 turns on at α.

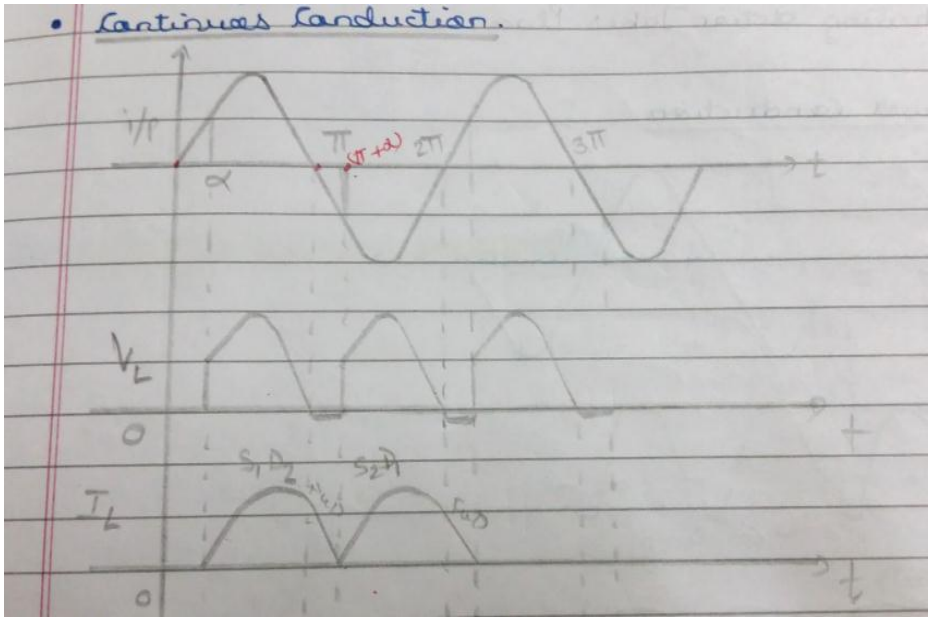
Mode 2(π to π+α): S1 and D2 turns off at Π, whereas FWD conducts from π to π+α.

Mode 3 (π+α to 2 π): S2 and D1 are forward biased during the negative half cycle and S2 turns on at π+α.

Mode 4 (2π to 2π+α): Freewheeling action takes place

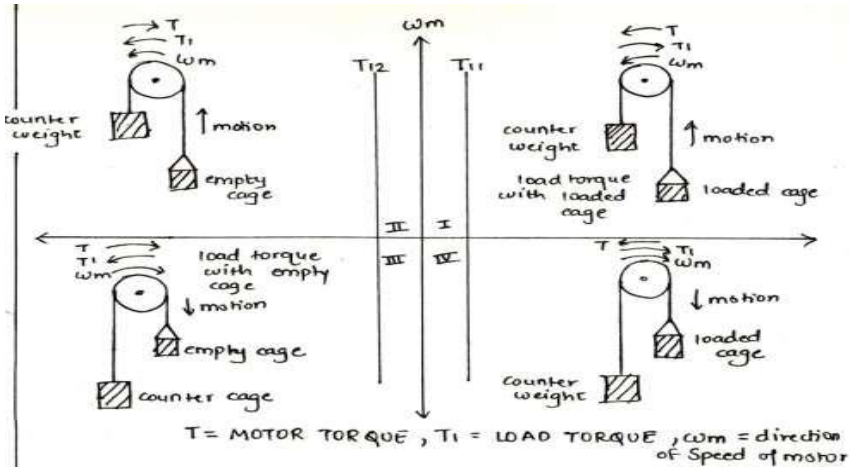
Average output voltage $V_o = (Vm / \Pi)(1+\cos\alpha)$

Waveforms:



1M

B)	**Attempt any ONE:**	**6M**
a)	**Explain the 4 quadrant operation of a drive.**	**6M**
Ans:	**Diagram:**	**3M**

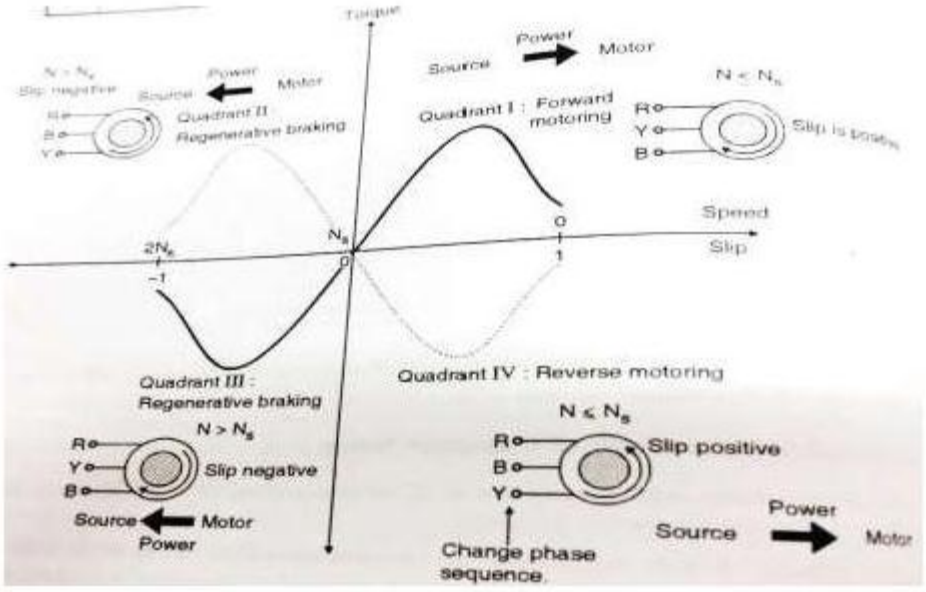


Explanation:

1. First quadrant operation-Forward motoring: The loaded cage moves in the upward direction. Power is positive. **3M**
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

OR

Diagram: **3M**



Explanation: **3M**

First quadrant operation-Forward motoring: Power is positive ie power flow is from source to load Motor rotates in clock wise direction.

Second quadrant operation-Forward Braking: Power is negative ie power flow is from load to source. Motor rotates in anti-clock wise direction.

Third quadrant operation- Reverse braking. Power is negative ie power flow is from load to source. Motor rotates in anti- clock wise direction.

Fourth quadrant operation-Reverse motoring:. Power is positive ie. power flow is from source to load. Motor rotates in clock wise direction.

b) **Compare semiconverter drives and full converter drives on the basis of** — **6M**

i. **Quadrant of operation**
ii. **Regenerative braking**
iii. **Power flow**
iv. **Harmonic contents**
v. **Peak motor current**
vi. **Motor heating**

Ans: **(Each point 1M)**

Sr. No	Single phase converter	Three phase converter
Quadrant of operation	Operates in first quadrant	Operates in first and fourth quadrant
Regenerative braking	Not possible	Possible
Power flow	Unidirectional from source to load	Bi-directional
Harmonic content	More	Less
Peak motor current	Less	More
Motor heating	Less	More

Q 2 **Attempt any FOUR:** — **16 M**

a) **State the factors to be considered for the selection of a drive.** — **4 M**

Ans: **(Any 4 factors, each Point 1M)**

Factor to be considered for drive selection are:

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:

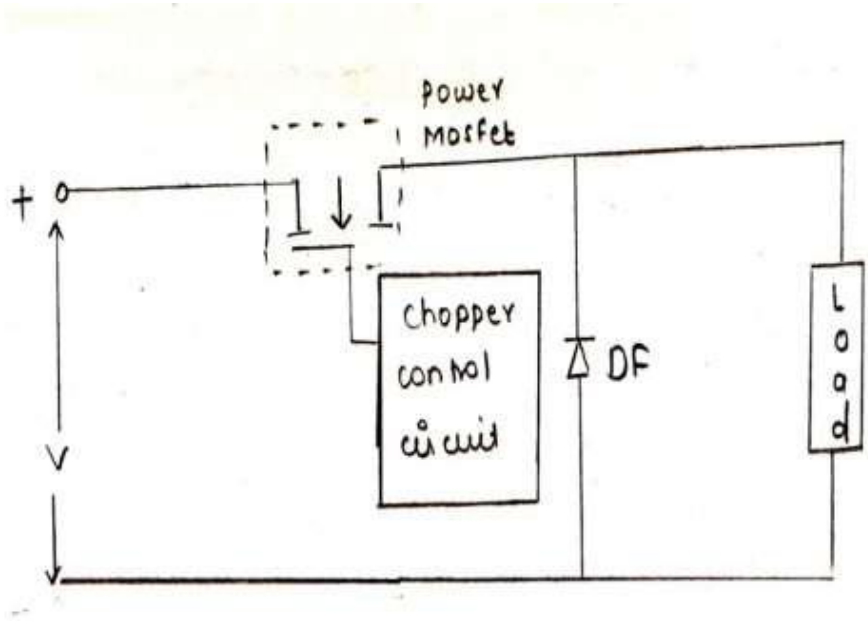
a) Whether motor is to run continuously, intermittently, or on a variable load cycle.
b) Whether over load capacity and pull out torque are sufficient.

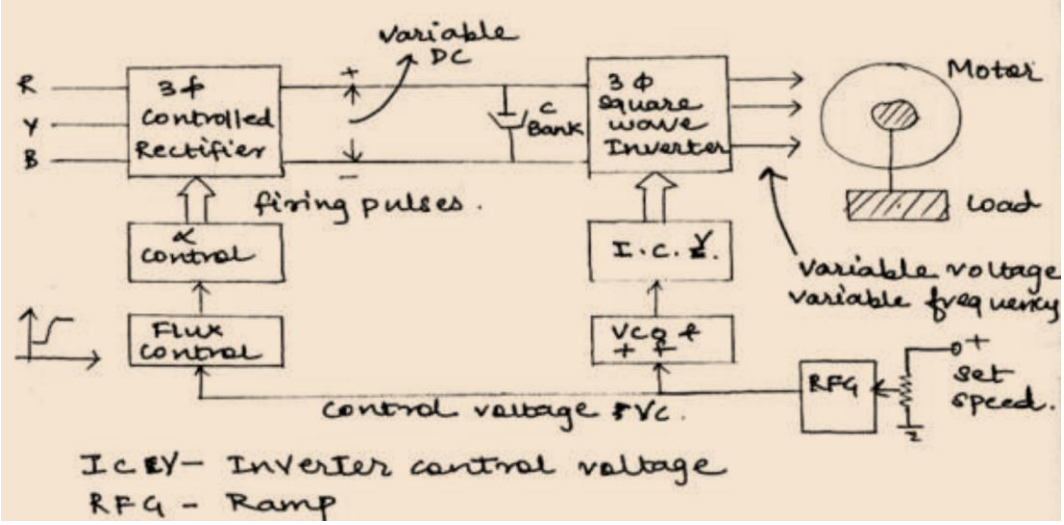
6. Mechanical considerations:

a) Type of enclosures.
b) Type of bearings.
c) Transmission of drive.
d) Noise level.

7. Cost:

a) Capital cost.
b) Running cost.

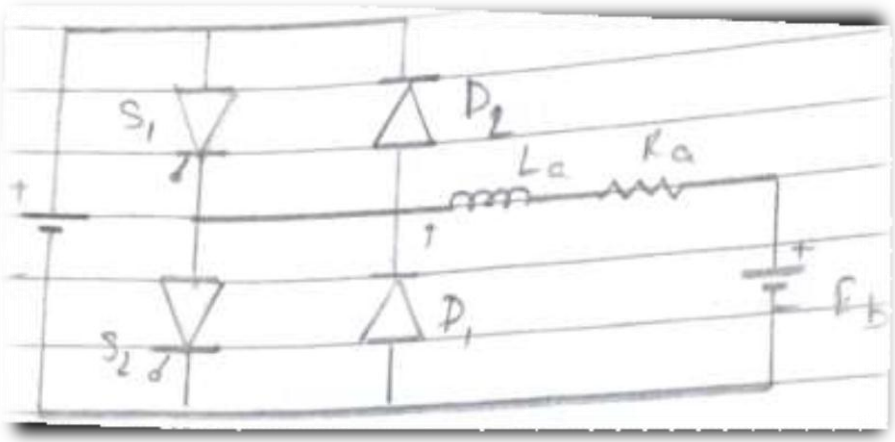
b)	**State the requirements and the types of drives used in sugar mills.**	**4M**
Ans:	1. In sugar mill the sugar crystals are separated from the syrup by mean of a centrifuge. The separation is accomplished by the centrifugal set up. The centrifuge is started to a speed of around 200rpm at which the 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. 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.	**4M**
c)	**Draw and explain a dc chopper using MOSFET.**	**4M**
Ans:	**Circuit diagram:**  	**2M**
	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.	**2M**
d)	**State four advantages of converter fed induction motors.**	**4 M**
Ans:	1.Smooth acceleration at constant current and torque. 2.Smooth start-up can be achieved. 3.High moment of inertia can be accelerated.	**(Any four points-1M)**

		4.Speed control is easy. 5.Switching surges can be avoided.	
	e)	**Draw the block diagram and explain V/f control using square wave inverter.**	**4 M**
	Ans:	**Block diagram:**  **Explanation:** • The output voltage of square wave inverter is a variable voltage and variable frequency. • The input required is DC on the input side of the inverter. • This is obtained from a 3 phase rectifier and capacitor filter combination on the input side of the inverter. • The output frequency of the Inverter can be changed by changing the rate at which 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. • The function of flux control block is providing a small voltage boost at low frequencies. • The firing angle of three phase rectifier is changed in proportional with the output voltage of the flux control circuit. • The control voltage (V_c) is obtained from a ramp function generator. The Ramp Frequency Generator (RFG) provides a smooth acceleration or deceleration of induction motor.	**2M** **2M**
	f)	**Draw and explain a 2 quadrant chopper drive.**	**4 M**

Ans: ***Note: Type C OR Type D can be considered.*** **2 M**

Type C chopper:

Diagram:



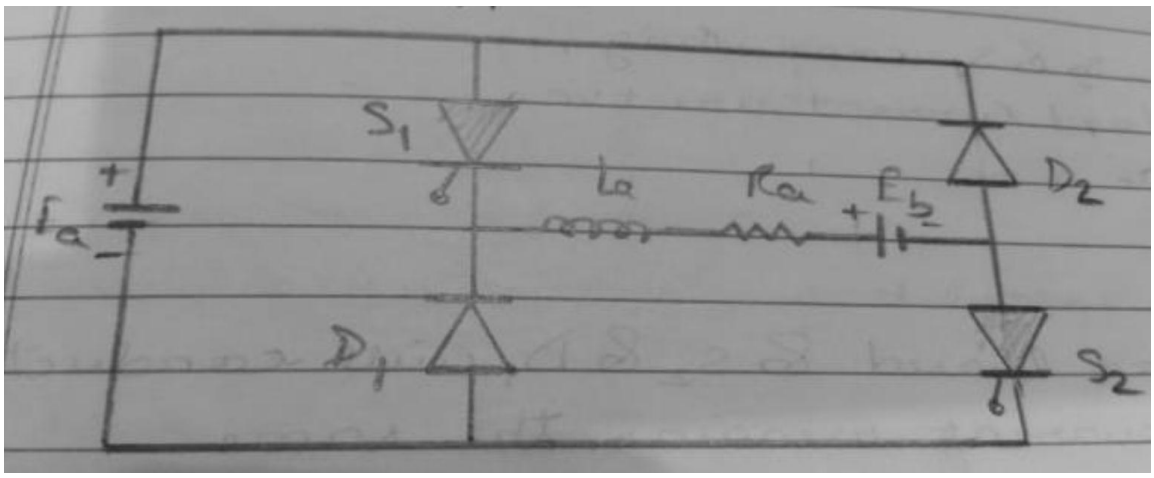
Explanation: **2M**

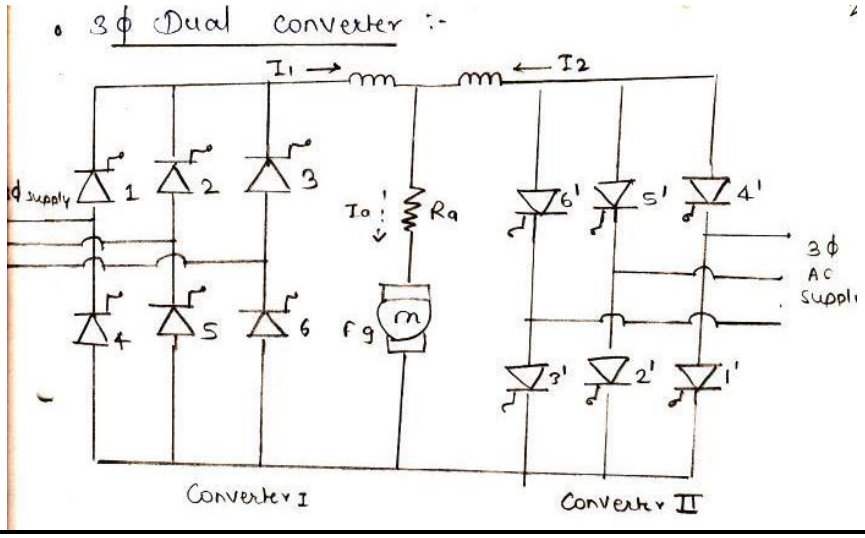
It is suitable for forward motoring and forward braking. It is a two quadrant chopper configuration. The first quadrant is forward motoring and second quadrant is forward braking.

OR

Type D chopper :

Is a two quadrant chopper drive. It is suitable for forward motoring and regenerative braking. The first quadrant is forward motoring and second quadrant is reverse braking. It operates in First and fourth quadrant.



Q. 3		Attempt any FOUR:	16M
	a)	**State the types of electric braking and state 2 advantages of electric braking.**	4M
	Ans:	**Types of Electric Braking methods:** i) Regenerative Braking ii) Plugging type braking/counter current braking iii)Dynamic braking/Rheostatic braking **Advantages of electric braking:** • Smooth and fast as compared to mechanical braking. • The system capacity can be increased • Energy efficient • Low maintenance cost • There is no wear and tear	2M (2M for any 2 points)
	b)	**State the stages involved in textile mills and the type of drives used for it.**	4M
	Ans:	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 yarn into cloth is done in looms. Speed range is 600-750 rpm	(Each stage with speed range ½ M)
	c)	**Draw the circit for three phase dual converter.**	4M
	Ans:	**Three phase dual converter:** 	4M

d)	**Draw and explain the operation of a chopper circuit used for reversible drive.**	**4M**
Ans:	**Explanation:** DC choppers provide variable dc output voltage from a fixed dc input voltage. Chopper circuit are operated in four quadrant ie. Forward Motoring, Forward Braking, and Reverse Motoring and Reverse braking. This type of chopper is widely used in reversible motor drive. . **Circuit Diagram:** ***Note: Mosfet, IGBT or power BJT can be considered inplace of SCR***	**2M** **2M**
e)	**Draw and explin the operation of multiphase chopper drive.**	**4M**
Ans:	**Diagram:** **Multi-phase chopper drive** **Working:** It is a two chopper configuration. Chopper 1 and chopper 2 Class A choppers connected in .parallel. DC motor is common load for the chopper. Inductors L1 and L2 are	**2M** **2M**

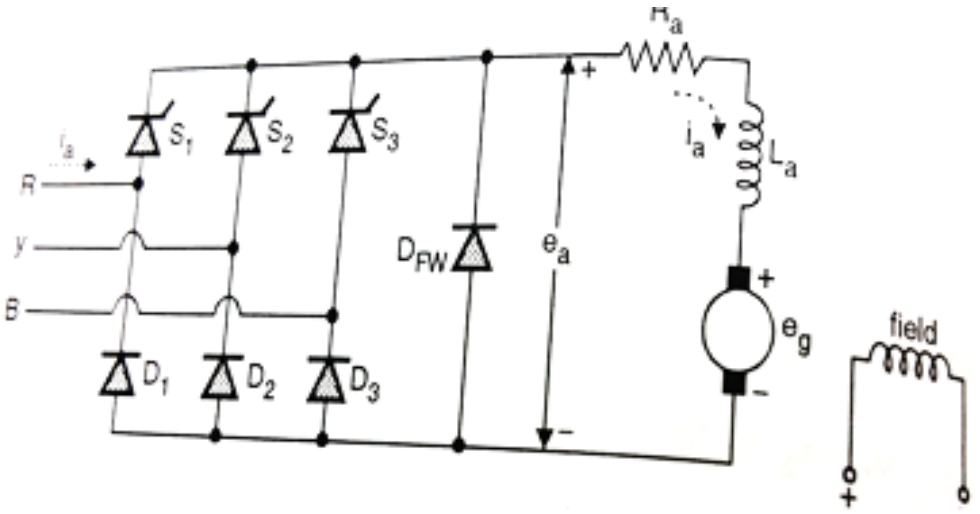
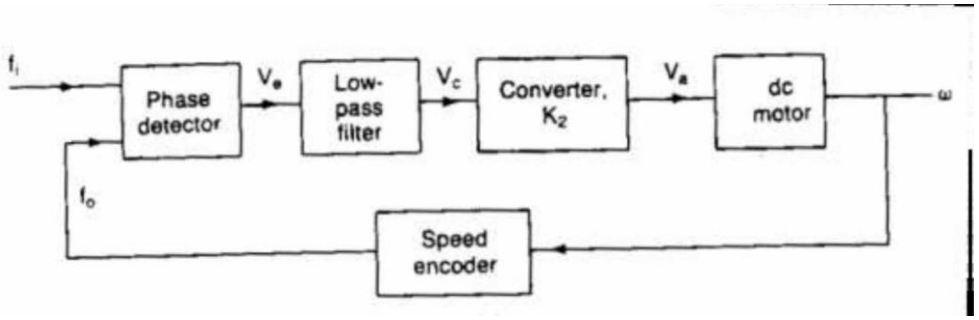
		connected in series with the load. There are two operating modes: 1 In phase mode: In this mode both the choppers are turned ON and turned OFF simultaneously. 2. Phase shift mode: In this mode both the choppers are turned ON at different instants of time.	
Q. 4	**A)**	**Attempt any Three:**	**12M**
	a)	**Draw the circuit of a three phase semiconverter drive. State the equation of average armature voltage.**	**4M**
	Ans:	**Diagram :**  **Equation:** **Average dc output voltage is $3\sqrt{3}Vm(1+\cos\alpha)/(2\pi)$**	**2M** **2M**
	b)	**State the methods of speed control of Induction motor.**	**4M**
	Ans:	The Speed of Induction Motor is changed from Both Stator and Rotor Side The speed control of three phase induction motor from stator side are further classified as : 1. Frequency control. 2. Changing the number of stator poles. 3. Controlling supply voltage. 4. Adding rheostat in the stator circuit. 5. Constant V/f control The speed controls of three phase induction motor from rotor side are further classified as: 1. Adding external resistance on rotor side. 2. Rotor voltage control	**(Any 4 methods, each Point 1M)**
	c)	**Draw and explain PLL control of dc motor.**	**4M**
	Ans:		

Diagram :



2M

Working of phase locked loop control of DC motor:-

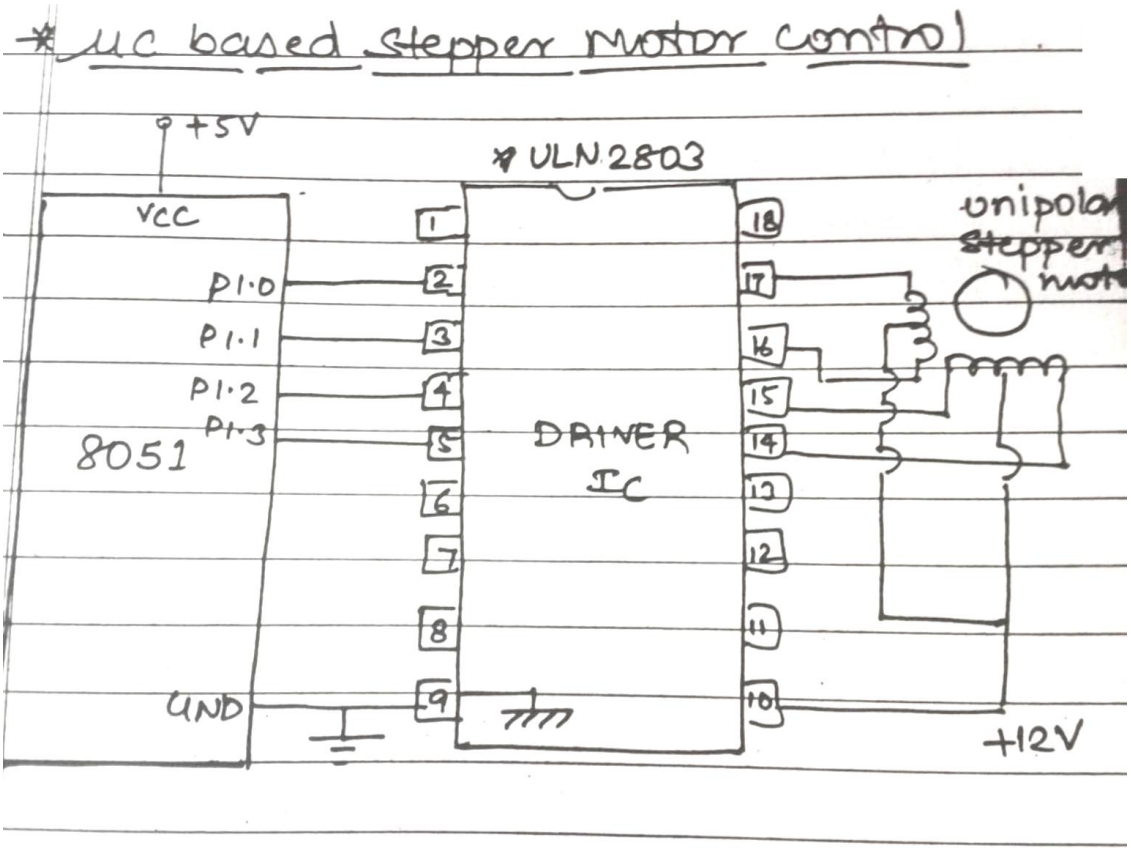
The output of the encoder acts as the speed feedback signal of frequency f0. The phase detector compares the reference pulse train fr with the feedback frequency f0 and provides a pulse width modulated output voltage Ve which is then passed through a low pass filter. The low pass loop filter converts the pulse train Ve to a continuous dc level Vc which varies the output of the power convertor and in turn the motor speed.

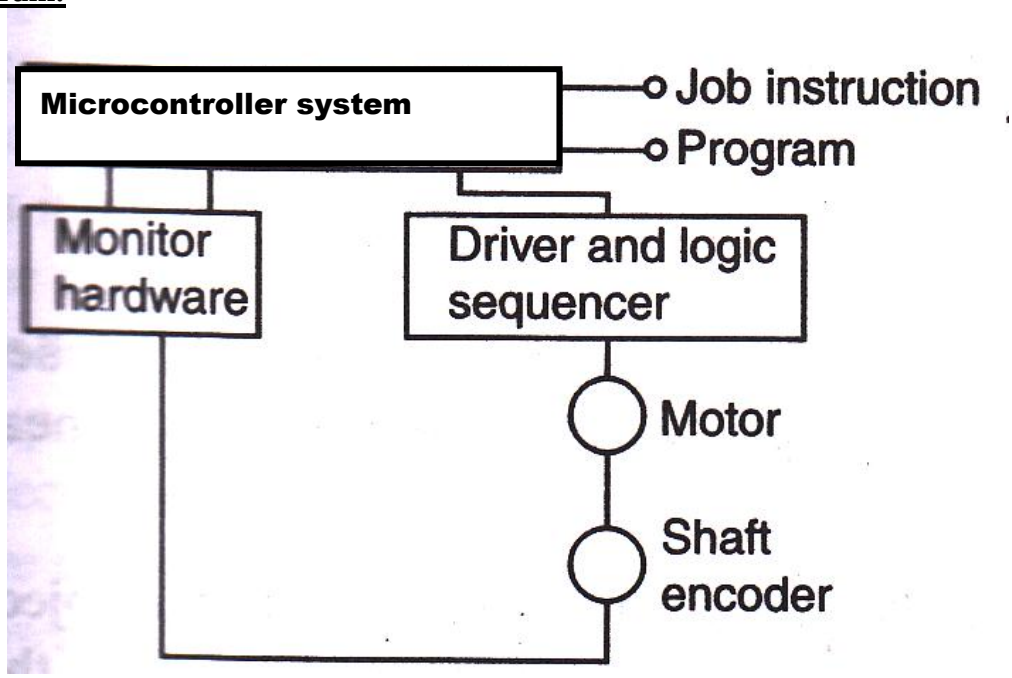
2M

d) Draw and explain stepper motor control using microcontroller. **4M**

Ans: **Diagram:**

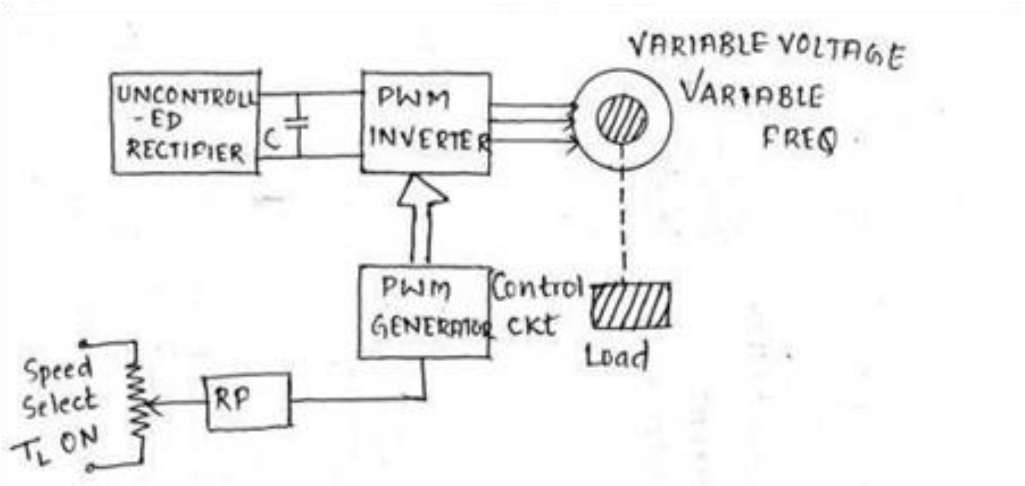
2M

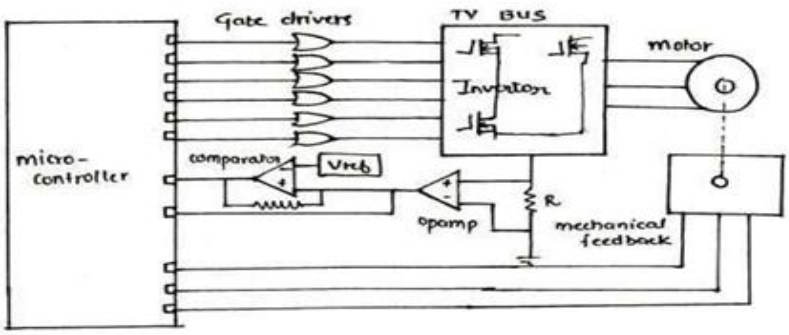


		Explanation: A stepper motor is a digital motor which rotates in steps. The motor has two phases with Centre tapped windings connected to 12V supply. The motor is rotated in steps by giving proper excitation sequence to these windings. Port1(P1.0, P1.1, P1.2 , P1.3) of microcontroller 8051 is used to generate excitation signals in a proper sequence. These signals are buffered using drives IC ULN 2803. The motor rotates 1.8degrees for each step. The speed of the motor depends upon the delay between the steps. **OR** **Diagram:**  **Explanation:** • The motor is excited by logic sequencer pulses. • Mechanical rotor position sensor with an optical encoder coupled to the shaft is used. • The rotor position may also be determined using machine voltages and currents. • The motor position is monitored and step completed. • The closed loop control with micro controller system improves the performance of stepper motor.	**2M** **2M** **2M**
	b)	**Attempt any ONE:**	**6M**
	a)	**State the different stages in paper mill and the type of drive used for it.**	**6M**
	Ans:	**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.	 **3M**

		• 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. **<u>Pulp – Paper:-</u>** • 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.	**3M**
	b)	**State the different stages in steel rolling mills and the type of drive used for it.**	**6M**
	Ans:	• Steel rolling mills are hot rolled and cold rolled. They are also reversible or continuous type. • Reverse hot rolling mills: Ward-Leonard method of speed control of DC motor is used. Induction motors and synchronous motors can be used. • Continuous hot rolling mills: Ward-Leonard method of speed control of DC motor is used. Ac motors fed by thyristor converters is used. • Reverse cold rolling mills: Ward-Leonard method of speed control of DC motor is used. Cyclo-converter fed synchronous motor may be used. • Continuous cold rolling mills: Ward-Leonard method of speed control of DC motor is used.	**1½M for each stage**
Q.5		**Attempt any Four:**	**16M**
	a)	**A 4 pole, 1440 rpm 3ϕ I/M is operated from per phase voltage of 240V, 50H_Z and driving a constant torque load. Calculate the following at frequency of 25 H_Z, ϕ_{ag}= 4.8 : (i) Supply voltage/phase, (ii) slip, (iii) slip frequency, (iv) slip at 25 H_Z.**	**4M**
	Ans:	Given Data Motor =3 phase induction motor Poles=4 Speed (N) =1440rpm Per phase Voltage= 240V/50Hz At f=25Hz, Φag=4.8 We will find , **i) Supply Voltage/phase:-** Supply voltage v/f = ϕ v/25= 4.8 Therefore, V = 25*4.8 V =120Volts **ii) Slip (S) at 50 Hz:-** NS =120*f/4 =120*50/4 = 1500 rpm Speed (N) = NS (1-S) 1440=1500(1-S)	**(Supply Voltage/phase-1M, Slip-1M, Slip frequency-1M, Slip at 25Hz-1M)**

		1440/1500 =(1-S) 0.96 = 1-S S = 1-0.96 Slip = 0.04 %Slip = 0.04*100 **% Slip = 4%** iii) **Slip frequency(Sf):-** = slip * frequency = 0.04*50 **Sf = 2Hz** iv) **Slip at 25 Hz:-** S= Sf/f = 2/25 Slip = 0.08 %Slip=8%	
	b)	**A semiconverter operated from 1 ϕ 230 V, 50H_Z supply drives a 10 H.P, 200 V, 1500 rpm separately excited dc motor. Rated armature current is 40 A, motor parameter are R_a = 0.5 Ω, L_a = 10mH, $K_a\phi_{constant}$ = 0.2 V/rpm. Find the following for α = 30^0** **(i)Average armature voltage** **(ii) speed of the motor**	**4M**
	Ans:	**Note:** (given value of La is Ia i.e 10A) Given Data Supply= 230V, 50Hz Motor Specification= 10HP, 200V, 1500rpm Ra=0.5Ω Ia=40A Constant = Ka Φ=0.2V/rpm . α=30◦ **Average armature voltage(Ea) =** i) Equation of average voltage of full converter= Ea=Vm/π*(1+ Cosα) Vrms=230v	(**Motor Torque- 2 M, Speed of the motor- 2M)**

		Vm= √2 * 230 Vm =325Volts. Ea=325/π*(1+cos30) Ea=193.04Volts. i) **Speed of of the Motor(N)= (**Vm/π)*[(1+ Cosα)/ K a ϕ] –IaRa =(325/π)*[(1+cos30)/0.2]-40*0.5 N =945.20 rpm	
c)	**Draw the block diagram and explain the working of PWM control of I/M.**		**4M**
Ans:	**<u>Diagram</u> :**  **<u>Working:</u>** The output voltage of PWM Inverter is varied by varying the modulation Inden 'm' which is defined as the ratio of the peak amplitude of the rectified sine wave and Triangular wave. The actual speed sensed by the Tachometer is compared with reference speed signal. The difference between two is the speed error signal and is applied at the input of the speed control The error in speed is processed by a speed controller and the slip speed regulator. The output of the speed controller and the slip speed regulator acts as a current reference and it will decide the maximum value of armature current. The frequency of the stator voltage is decided by adding the output of the slip speed regulator to the actual speed. The frequency deciding signal is then passed through a flux control block to ensure constant air gap by keeping V/F ratio constant. The flux controller output is compared with the actual armature current and the error in current is applied to current controller which is proportional and integral controller. The output of this is used to adjust the value of modulation inden 'm; which in term will adjust the output voltage of the PWM Inverter. Because of the use of the PWM Inverter an uncontrolled recitifer is used along with capacitive filter. The ramp FG is used for providing the gradual acceleration and deacceleration. The PI controller has Fast response and zero static error.	**2M** **2M**
d)	**List different requirements of motors used for machine tools.**		**4M**

	Ans:	The requirements of motors used for machine tools are: •The motor must be reliable & low cost, requiring less maintenance. • They must be capable of speed control. • The acceleration & the motor should be sufficiently fast to avoid motor heating during starting. • Some machine tools require very high speed of operation. • Numerically controlled machine tools are being preferred to conventional machine tools. • The requirements of the drive motor are fast response, wide range of speed control, low vibrations, better thermal capacity, low maintenance etc. • Due to the simple, economical & robust construction, reliability & less maintenance, squirrel cage and converter fed induction motors are suitable for driving machine tools.	**(Any four requirements 1M each)**
	e)	**State the types of SCR controlled drives. State 4 advantages of converter controlled drives.**	**4M**
	Ans:	**<u>Types of SCR controlled drives:-</u>** 1 Phase SCR controlled Drive: a) 1 Phase semi converter b) 1 Phase half converter c) 1 Phase full converter d) 1 Phase dual converter 3 Phase SCR controlled Drives: a) 3 Phase semi converter b) 3 phase half converter c) 3 Phase full converter. d) 3 Phase dual converter **<u>Advantages of converter fed induction motor:- (Any 4)</u>** 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.	**2M** **2M**
	f)	**Draw and explain microprocessor based control of synchronous motor.**	**4M**
	Ans:	**<u>Diagram:</u>** 	**2M**

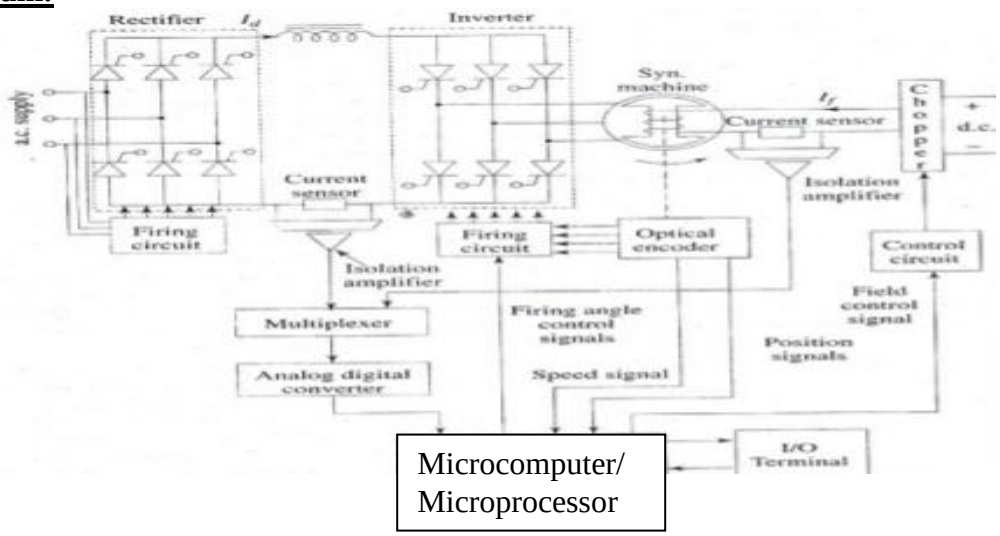
Explanation:-

Here we are using permanent magnet synchronous motor. **2M**

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 waveforms of the 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 are present for six gate drivers.
7. Driver output is given to six FET's present in inverter circuit.
8. To obtain six step sine wave 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.

OR

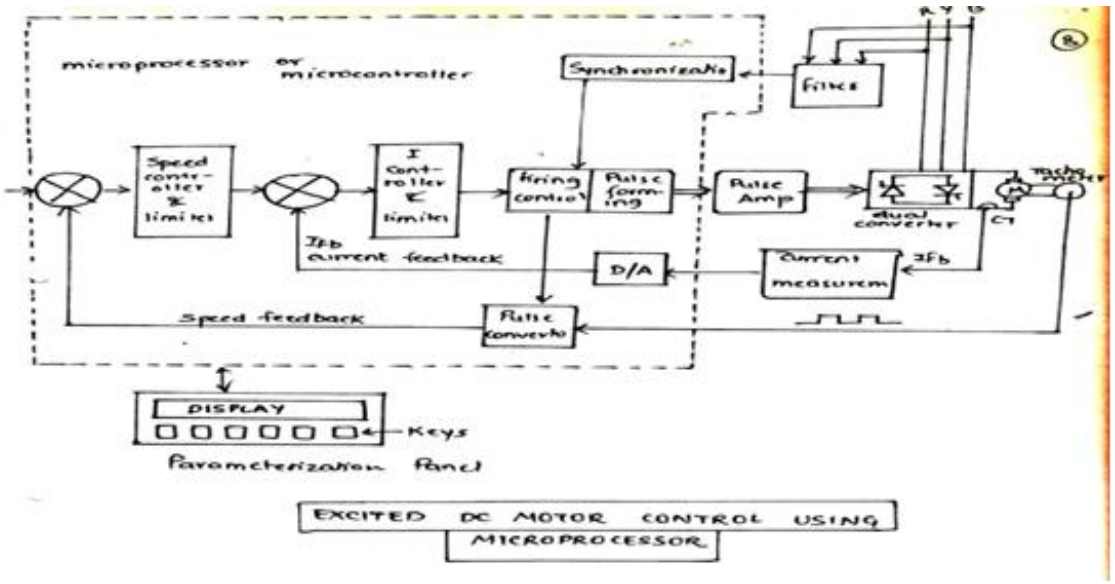
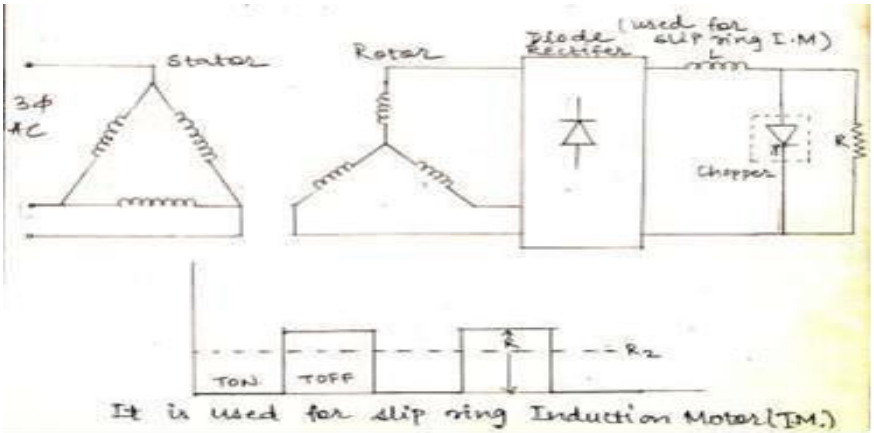
Diagram:

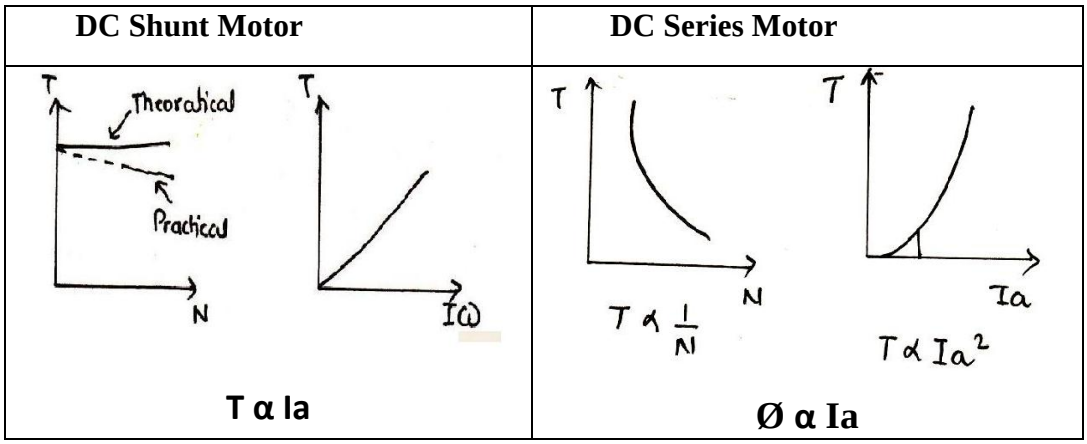


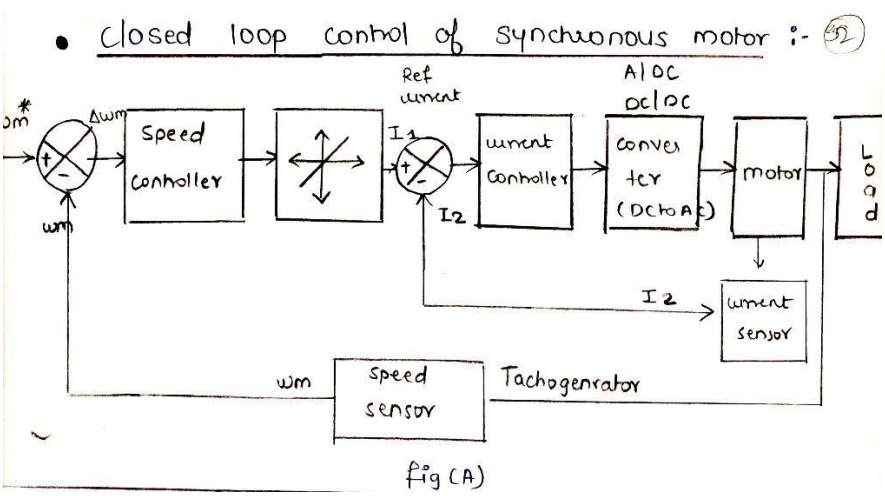
2M

Explanation:-

- In this circuit two feedback circuits are used.
- The speed of the synchronous motor is sensed by optical encoder and it is applied to microprocessor. **2M**
- The field current is sensed by current sensor and through isolation transformer is applied to multiplexer.
- The output of the multiplexer is given to microprocessor through analog to digital converter .
- The output of the microprocessor is controlled the firing angle of the converters so that the output of the converter is used to change the speed of the motor that is

		the speed of the motor is to be controlled.	
Q.6		**Attempt any FOUR:**	**16M**
	a)	**Draw the block diagram of microprocessor based control of dc motor.**	**4M**
	Ans:	**Diagram:** 	**4M**
	b)	**State eight advantages of microprocessor based control of drives.**	**4M**
	Ans:	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.	**4M**
	c)	**Draw the block diagram and explain the working of motor resistance control using chopper.**	**4M**
	Ans:	**Diagram:** 	**2M**

		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	**2M**
d)		**Draw the charectristics of dc shunt and series motor.**	**4M**
Ans:			**2M for each motor**
e)		**Draw the block diagram and working of closed loop control of synchronous motor.**	**4M**
Ans:		**Diagram:**	**2M**



OR

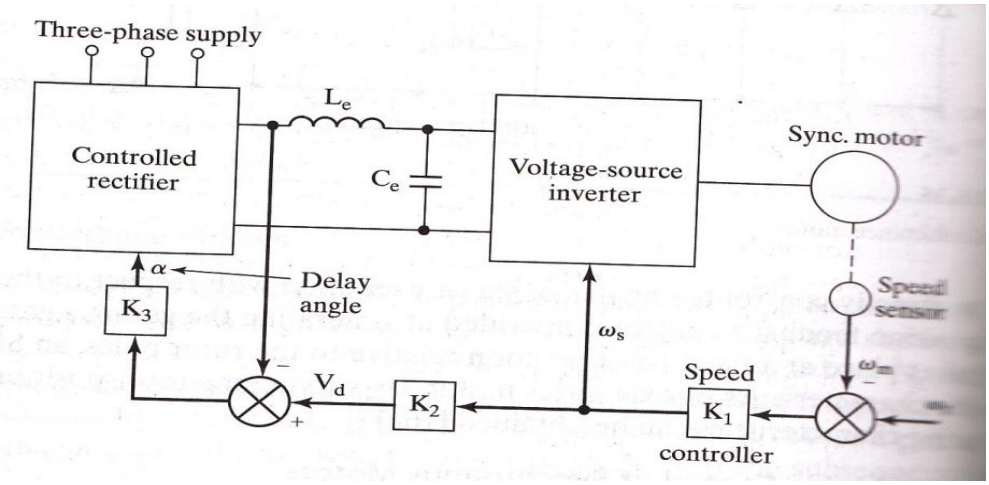


Fig (A) shows the block diagram of closed loop control of synchronous motor.

- In this circuit the two feedbacks are used.
- For sensing the speed tachogenerator is used and for sensing the current transformer is load.

Working principle:

2M

- As given in the circuit, synchronous motor is used.
- The feedback from the output is given to the input through speed sensor (tachogenerator).
- The output (wm) is compared with input (wm*) using comparator.
  wm* - wm = Δwm (error signal)
- By comparing input & output the error signal is produced that is Δwm

		• This error signal then given to the speed controller which controls the speed of motor • This controlled signal is further given to current limiter which limits the current till specified limit. • Now, output of the current limiter is then compared with feedback current (I_2)from the current sensor.(I_1 -I_2) • The current I_1 & I_2 compared using comparator & o/p of this comparator is given to current controller which controls the Reference current. • Now, further o/p of current controller is provided to converter which is the type of DC to AC converter .As the type of motor is synchronous motor, • Now, this AC controlled signal is given to synchronous motor and then to load.	