MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION
(Autonomous)
(ISO/IEC - 27001 - 2005 Certified)

Summer 2016– EXAMINATION

Subject Code: **17667** **Model Answer**

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the 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.

Q1 a) Attempt any three of the following: 12

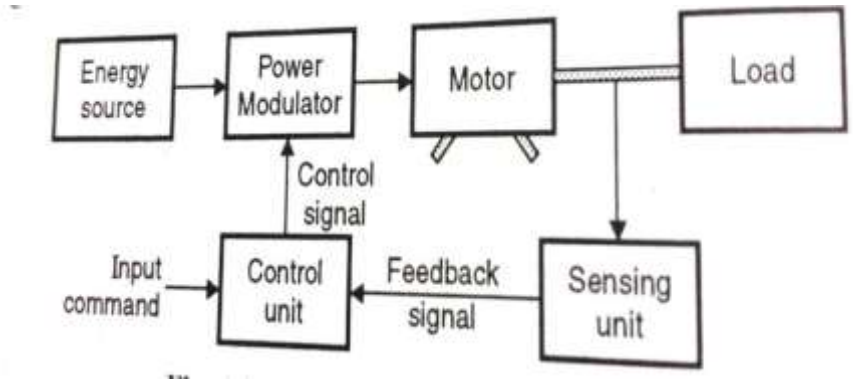
(i) What is the need of an electric drive and draw the block diagram of an electric drive. 4marks

Ans: Need of an electric drive -2 Marks

Need of an electric drive**:**

1. To have smooth speed control over a wide range.
2. To meet good overload capacity
3. For operating in all four quadrants of the speed torque plane.
4. To improve the energy efficiency.

Block diagram --2 Marks



Electric Drive

(ii) List four advantages of microcontroller or microprocessor based control for drives

Ans: Any 4 advantages-- 4 marks

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.

(iii) Write four advantages of electric motor as prime movers.

Ans: **Advantages of electric motor as prime mover: Any 4 ---1Mark each**

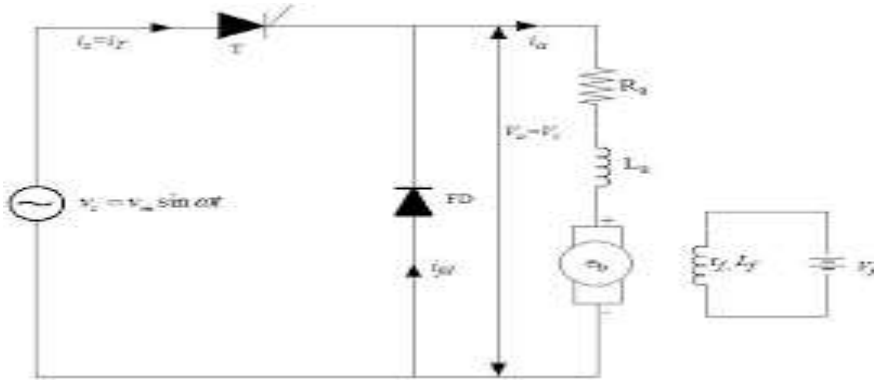
1. Electric drive is more flexible.
2. It is more economical.
3. It is cleaner as there is no fuel, fumes.
4. It occupies less space as compared to other forms of drives and is, therefore, very compact source of drive.
5. Its operating characteristics can easily be modified.
6. It can be remote controlled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

8. It is reliable source of drive.

(iv) Draw and label half wave converter drive using separately excited motor.

Ans: Note: Half wave converter with and without FWD can be considered

Circuit diagram—4 Marks



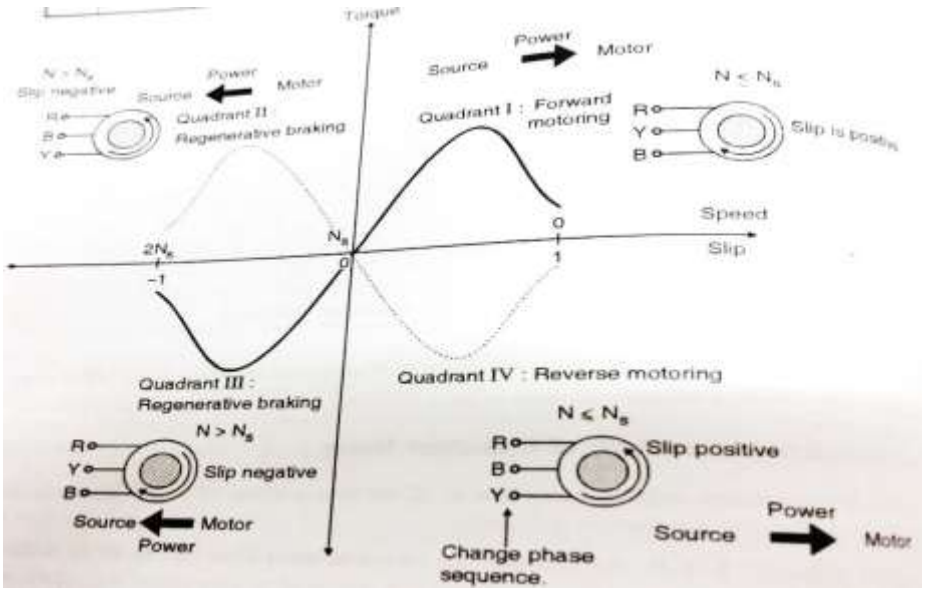
Half Wave Converter Drive for separately excited motor

b) Attempt any ONE of the following: 6 marks

(i)) Explain four quadrant operation of a drive with a neat diagram.

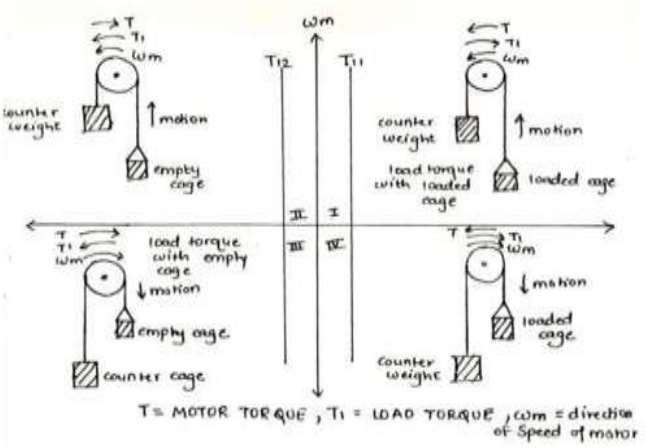
Ans: Note: Even 4 quadrant operation of hoist can be considered.

Diagram --3 marks



Four Quadrant Operation of Drive

OR



Four Quadrant Operation of Hoist Drive

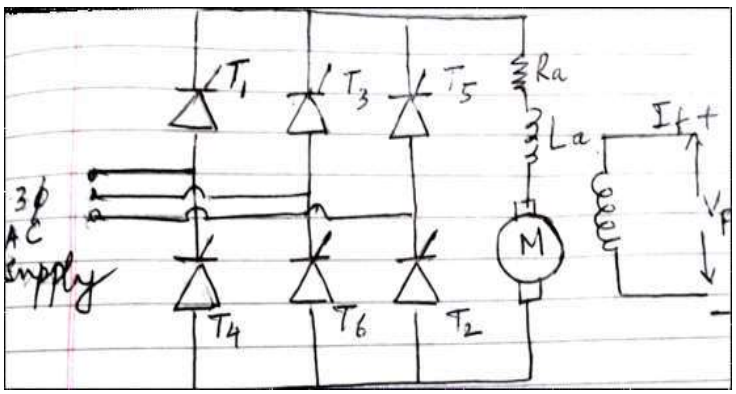
Explanation--- 3Marks

1. First quadrant operation-Forward motoring: Power is positive ie power flow is from source to load Motor rotates in clock wise direction.
2. Second quadrant operation-Forward Braking: Power is negative ie power flow is from load to source. Motor rotates in anti-clock wise direction.
3. Third quadrant operation-Reverse motoring:. Power is positive ie. power flow is from source to load. Motor rotates in clock wise direction.
4. Fourth quadrant operation- Reverse braking. Power is negative ie power flow is from load to source. Motor rotates in anti- clock wise direction.

(ii) Explain with a neat circuit diagram, 3 f full wave converter drive using DC shunt motor and also explain the need of freewheeling diode.

Ans: Circuit diagram-2 Marks.

Please note that circuit diagram with and without free -wheeling diode should be considered.



Three phase full wave converter drive

Explanation: 2 Marks

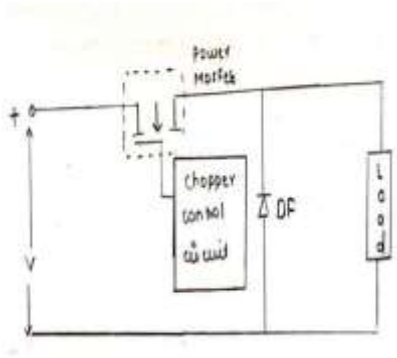
Circuit uses 6 SCRs T1, T2, T3, T4, T5, T6. Load is inductive. The motor is separately excited DC motor. Ra is the armature resistance and La is armature inductance. Vm is maximum value of AC input voltage. Vf is the field voltage and If is the field current. α is the firing angle. Each SCR is fired 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.

Need for a free-wheeling diode: **2 Marks**
Without freewheeling diode the average output voltage and average power will be less. Harmonics will be more and losses will be more. Thyristor heating will be more.

Q2. Attempt any four of the following: 16 Marks

a) Draw and explain DC chopper using power MOSFET.

Ans: Diagram: 2 Marks



DC Chopper using power MOSFET

Explanation: 2 Marks
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.

b) List eight industrial applications of drives.

Ans: Each application: 1/2 mark
(Note: Any relevant application can be considered)

1. Textile mills
2. Steel Rolling Mills
3. Elevators
4. Paper Mills
5. Sugar mills
6. Machine tools
7. Hoist
8. Cement
9. Traction
10. Compressor

c) Compare semi-converter drive and full converter drives on the basis of i) quadrant operation ii) Power flow iii) Regenerative braking iv) Motor heating

Ans: Each point-- 1 mark

Parameter	Semi-converter drive	Full-converter drive
Quadrant operation	First	First and Fourth
Power flow	Uni-directional(From Source to load)	Bi-directional(From load to Source and source to load)
Regenerative braking	Not possible	Possible
Motor heating	Is less	Is more

d) List any four advantages of converter fed induction motor.

Ans: 1Mark each

Advantages of converter fed induction motor:- (Any 4points)

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.

e) A 3phase IM is wound for 4 Poles and is supplied from 6oHz System. Calculate synchronous speed.

Ans: 4 Marks

Ns=120f/p

Ns= (120*60)/4

Ns=1800 RPM

f) What are various electric braking methods of DC motor and explain any one of them.

Ans: 2 marks for types of braking, 2marks for explanation and any one braking method can be explained

Types of Electric Braking methods

i) Regenerative Braking
ii) Plugging type braking/counter current braking
iii)Dynamic braking/Rheostatic braking

Regenerative Braking:

Regenerative braking takes place whenever the speed of the motor exceeds the synchronous speed. This braking method is called regenerative braking because here the motor works as a generator. The direction of current flow through the circuit and direction of the torque reverses and braking takes place..

Plugging:

In this method the terminals of supply are reversed, as a result the generator torque also reverses and as a result the speed decreases. During plugging external resistance is connected to the circuit to limit the current.

Dynamic Braking

In this method of braking the motor which is at a running condition is disconnected from the source and connected across a resistance. When the motor is disconnected from the source, the rotor keeps rotating due to inertia and it works as a generator. The flow of the current and torque reverses.

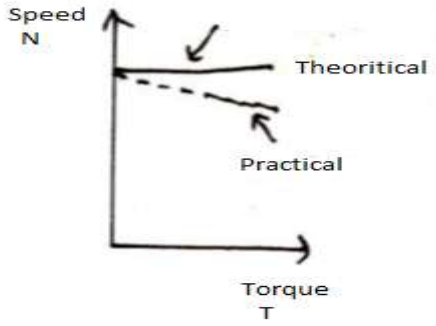
3. Attempt any four of the following: 16

a) Write the working principle of DC motor and draw the characteristics of DC shunt motor (Torque-Speed).

Ans: Working Principle-2 Marks

It is based on Flemming's left hand rule which states that when a current carrying conductor is placed in a magnetic field, it experiences force.

Characteristics: 2 Marks



Torque Speed Characteristics of DC Shunt Motor

b) Classify chopper drives with respect to
i) Input/output voltage
ii) Output voltage-Current direction

Ans: Input/Output voltage—2 Marks, Output voltage-Current direction—2 marks

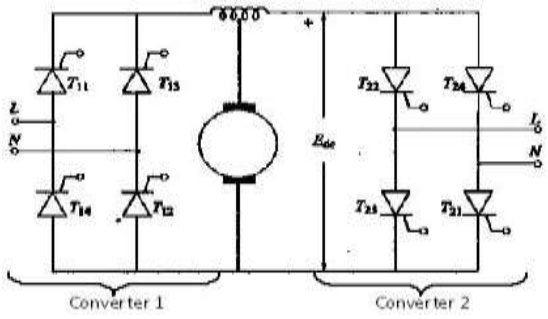
i) Depending on input/out put voltage

a) Step down chopper – output voltage less than input
b) Step up chopper – output voltage more than input

ii)Depending upon the direction of the output current and voltage, the converters can be classified into five classes namely

a) Class A [One-quadrant Operation]
b)Class B [One-quadrant Operation]
c) Class C [Two-quadrant Operation]
d) Class D Chopper [Two-quadrant Operation]
e) Class E Chopper [Four-quadrant Operation]

c) Draw neatly single phase dual converter drive and explain in detail.
Ans: Circuit diagram -- 2 marks



Single Phase Dual Converter Drive

Explanation: 2 marks

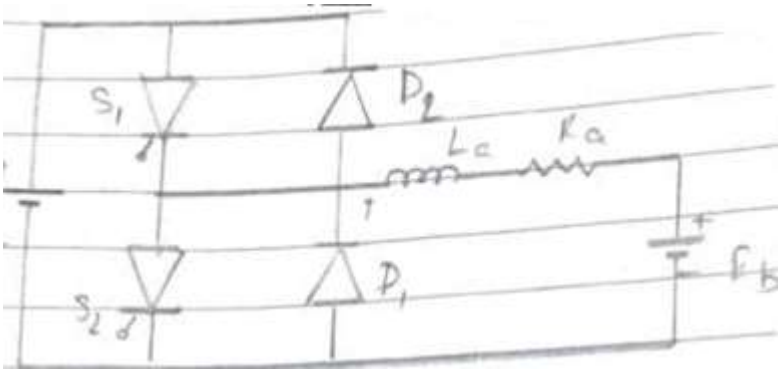
When two full converters are connected back to back, the configuration is known as dual converter. It allows four quadrant operations. Converter 1 operates in rectifier mode(α<90) and converter 2 operates in inversion mode(α>90).They are normally used for high power, variable speed,, reversible drives. There are two modes of operation: non-circulating current mode and circulating current mode.

d) Draw the suitable circuit diagram of chopper for forward motoring and forward braking and explain the working.

Ans: Explanation: 2 Marks

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.

Circuit diagram: 2 Marks



Chopper for Forward motoring and Braking

e) Compare AC drives and DC drives on the basis of: i. Type of motor ii Speed of operation iii. Power circuit used iv. Application
Ans: Each parameter 1 mark

Parameter	AC drive	DC drive
Type of motor	AC motor	DC motor
Speed of operation	Speed ratings are limited	There is no upper limit for speed ratings
Power circuit used	Power circuit used is AC to DC converter	Power circuit used is CycloConverter or inverter

	or a chopper	
Application	Used in M/C tool and traction applications	Used in traction, paper mills, textile mills, compressor drives

f) List any four functions performed by microprocessor in speed control of industrial drives
Ans:- Any four points- 1Mark each

Functions of microprocessor in speed control of industrial drives
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

Q4. a) Attempt any three of the following: 12

i) Draw and label the phase failure protection circuit used in 3phase drives.
Ans:- Any 4 points- 1Mark each

The reasons for phase failure are:
1. Blown fuse in some part of power distribution system.
2. Mechanical failure within the switching equipment
3. Three phase induction motors running on 1phase draw all the current from the remaining two lines.
4. Because of these reasons the motor will draw more current. This will cause heating of the motor and will damage the motor.
5. Hence phase failure protection is required. Relays are used for protection.

ii) List various methods of control the speed of AC drives.

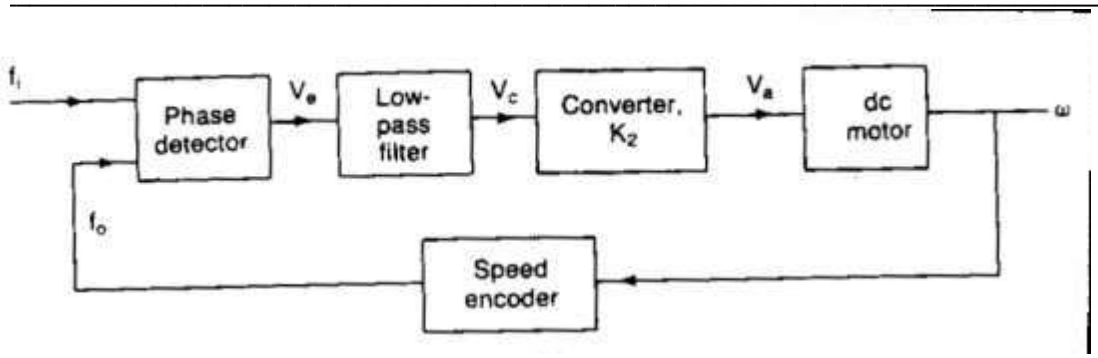
Ans: 4 Marks

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. V / f control or frequency control.
2. Changing the number of stator poles.
3. Controlling supply voltage.
4. Adding rheostat in the stator circuit.

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

iii) Draw and explain the working of PLL based dc drive.
Ans:

Block Diagram: 2 Marks



Working of phase locked loop control of DC motor:- 2 Marks

The output of the encoder acts as the speed feedback signal of frequency f_0. The phase detector compares the reference pulse train fr with the feedback frequency f_0 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.

iv) Write four important ratings and four specifications of stepper motor.
Ans: Any four points -4Marks

Ratings of stepper motor are

1. Step angle –full step or half step-1.8 deg/0,9deg
2. Micro stepping -bipolar unipolar
3. Holding torque- 2000gm-cm
4. NEMA frame size size 17
5. Shaft diameter- 0.197 inches
6. Power – 5 watts
7. Voltage and current – 12V and 400mA
8. Phase windings-4/2
9. Ambient temperature-10 -55 deg centigrade
10. Insulation resistance-greater than 100Mega Ohm at 500V D.C

b) Attempt any ONE of the following: 6Marks

(i) Write the sequence of stages and drives required in each stage for sugar mills.

Ans: Different stages: 2 Marks

1. Separation: 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.

2. Charging:-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.

3. Plugging:-The centrifuge is spun at speed of 500 & 1000 rpm. The speed is then reduced in steps to about50 rpm, at which ploughing takes place.

Drives used for sugar mills: 2Marks

1. 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.

2. A synchronous motor or converter fed induction motor can also be used for speed control purposes.

(ii) Write eight important factors to select a drive.

- **Ans:**
- 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: i. Starting characteristic. ii. Running characteristic iii. Speed control. iv. Braking characteristics.
- 5. Size and rating of motor: i. Whether motor is to run continuously, intermittently, or on a variable load cycle. ii. Whether over load capacity and pull out torque are sufficient.
- 6. Mechanical considerations: i. Type of enclosures. ii. Type of bearings. iii. Transmission of drive. iv. Noise level.
- 7. Cost: i. Capital cost. ii. Running cost.
- 8.Analog,Digital ,Microprocessor/Microcontroller based control
- 9. Open loop or Closed loop drive system

Q5. Attempt any FOUR of the following: 16 marks

a) A three phase half controlled bridge rectifier fed from 230V, 50 Hz supply provides a variable voltage supply to the armature of a separately excited DC motor. The specification of motor a R=0.2 ohm, L=0.002 henry, Constant of motor =2.25V/rad; rated current 500 amp. Determine the firing angle of α so that the motor runs at 1500 rpm speed.

Ans: Given : R=0.2 ohm, L=0.002 henry, Constant of motor, k =2.25V/rad; rated current Ia =500 amp, N 1500 rpm, Vrms = 230 V

$\omega = 2\pi N/60$

$\omega = 2\pi * 1500/60$

= 157 rad/sec

$Eb = k * \omega$

Eb = 2.25 * 157 **1 mark**

= 353.25 Volts

V= Eb + IaRa

= 353.25 + 500 * 0.2

= 453.25 Volts = Ea **1 mark**

Vm=Vrms* √2 = 230 *√2 =325.2 V

Ea = 3√3 Vm (1 + cosα)/ (2π**)** **1 mark**

453.25 = 3√3 * 325.2 (1 + cosα)/ (2π)

Cosα = 0.684,

Firing angle , α = 46.84 deg **1 mark**

b) Write the equation between speed, frequency and no. of poles of IM and also define slip of the induction motor.

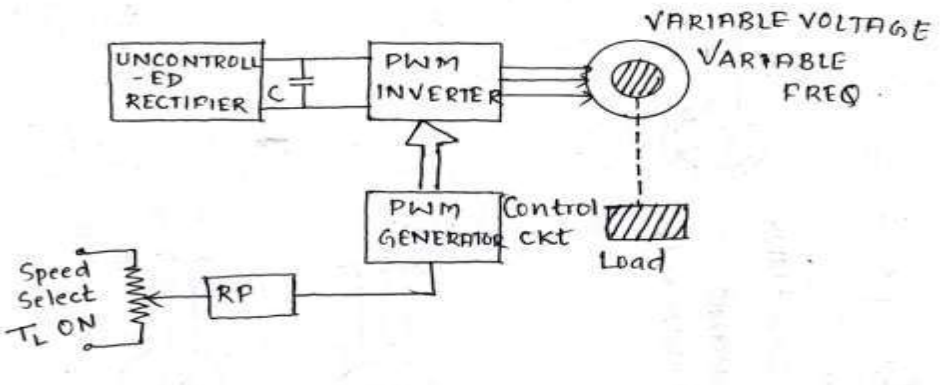
Ans: Synchronous speed, Ns = 120 f/p where f is frequency and p is no of poles **2 Marks**

Slip = (Ns-N)/Ns

Slip is defined as diference between synchronous speed to rotating speed. **2 Marks**

b) Draw labeled block diagram of PWM controlled method of induction motor. List any two advantages

Ans:- Diagram – 2 M



PWM Control of three phase induction motor

Advantages: (Any two points 2 marks)

1. Torque pulsations are avoided.
2. Losses are reduced.
3. Lower order harmonics are completely eliminated.
4. Input power factor is high.
5. Filters need not be used.

d) Explain the drives that are used in machine tools.

Ans: (any 4 points-4 marks)

The requirements of motors used for machine tools are:

i) The motor must be reliable & low cost, requiring less maintenance.
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 preferred to conventional machine tools.
vi) The requirements of the drive motor are fast response, wide range of speed control, low vibrations, better thermal capacity, low maintenance, etc.
vii) Due to the simple, economical & robust construction, reliability & less maintenance, squirrel cage and converter fed induction motors are suitable for driving machine tools.

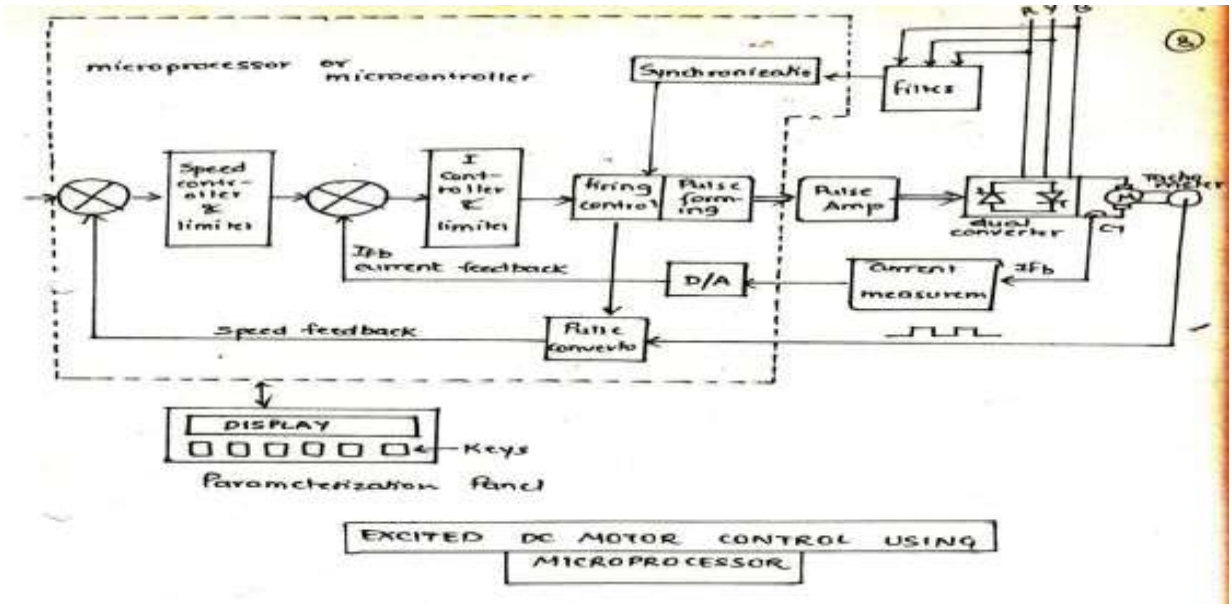
e)List advantage of induction motor drive over DC motor drive

Ans: (any 4 points 4 marks)

Advantages provided by AC drives are:
1. Reduced power line disturbances, lower power demand on start,
2. Controlled acceleration,
3. Controlled starting current,
4. Adjustable operation speed, and adjustable torque
5. DC technology does not lend itself to hazardous or explosive applications.
6.Above one horsepower the higher maintenance cost of DC technology (motor brush wear) must be considered but may be offset by the additional personnel skill requirements previously mentioned

f) Draw the block diagram of Microprocessor based DC motor controller.
Ans: (Diagram- 2 marks, Labeling- 2 marks)

Note: any other relevant diagram can be considered.



Q 6. Attempt any FOUR of the following: 16 marks

a) Which type of drive motor is suitable for elevator control? Explain the same.

Ans: Type of drive motor : 2marks

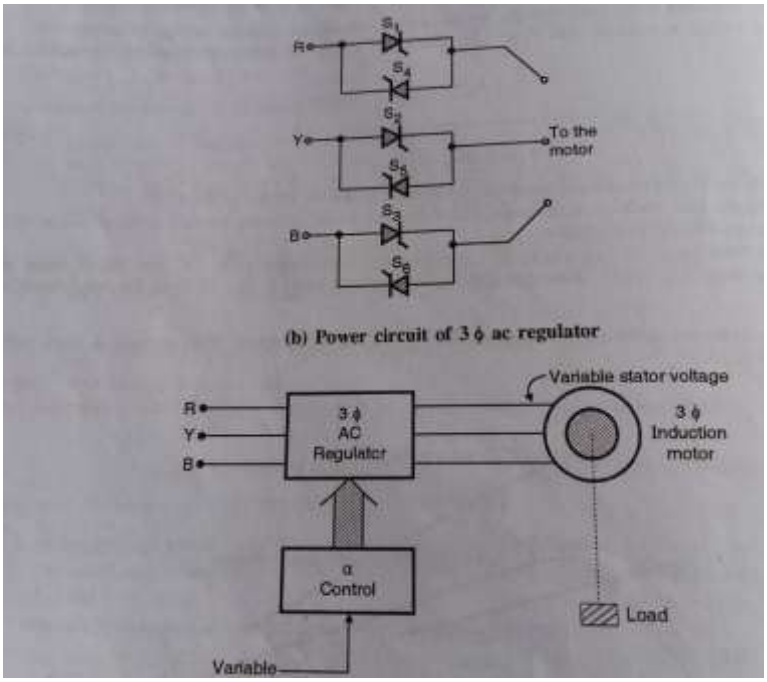
Slip ring induction motor or DC Series motor can be used for elevator control**.**

Explanation: 2 marks
Traction drive or roping system.
The elevator converts electrical power into mechanical power. A roping system is used to attach the gear, elevator car and the counter weight.
The traction drive converts the input mechanical power into the vertical movement of the elevator. When this drive is rotated power is transferred from it to the elevator car and counter weight.
Gears: The elevator converts electrical power into mechanical power. This system consists of elevator car, motor and worm gear system. The motor can be AC or DC motor.

b) Write the procedure to achieve soft start of induction motor using thyristor circuit. Justify

Ans: Circuit diagram 2 marks

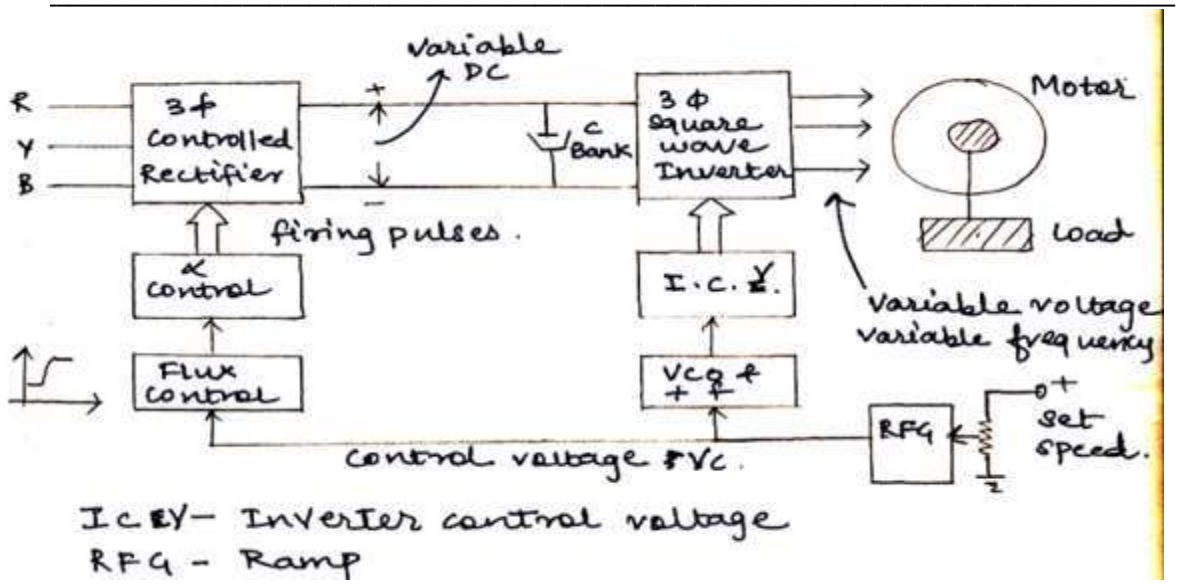
soft start of induction motor using stator voltage control



Soft Start of Induction Motor using Stator Voltage Control
Procedure: 2 marks

1. The motor speed can be controlled by varying the supply voltage.
2. This voltage can be changed by changing the firing angle of the SCRs of the 3 phase AC regulator keeping frequency constant.

Or
soft start of induction motor using V/f control



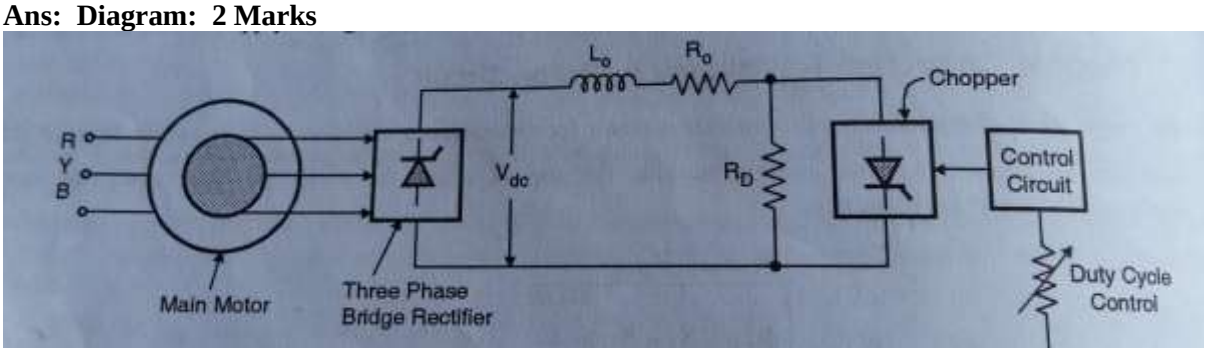
Soft Starting using V/F Control

Procedure: 2 marks

i) The output voltage of square wave inverter is a variable voltage and variable frequency.
ii) The input required is DC on the input side of the inverter.
iii) This is obtained from a 3 phase rectifier and capacitor filter combination on the input side of the inverter.
iv) The VCO frequency will vary in proportional with DC controlled voltage to vary the inverter output frequency.
v) The Ramp Frequency Generator (RFG) provides a soft start of induction motor.

c)Draw neatly the block diagram and working of motor resistance control using chopper.

Ans: Diagram: 2 Marks



Motor Resistance control using Chopper

Explanation: 2 Marks

i) This is a static rotor resistance control.
ii)The rotor resistance can be varied using a chopper
iii)External resistance is added to the rotor winding through slip rings and brushes.
iv)The induced voltage in the rotor is rectified through a diode bridge rectifier and fed to the chopper control resistance.
v) The smoothing inductor Lo is used in the circuit to maintain the current at constant value.
vi) When the chopper is in the ON state R_D is shorted and when the chopper is in the OFF state R_D is connected in the circuit.
vii)The resistance across output terminal of a chopper can be varied by varying the Duty cycle of the chopper.

d) Explain various speed drives that are used in paper-mills at every stage of operation.

Ans:- The paper mill machine should satisfy the following requirements. (Any four points**) 01 M each**

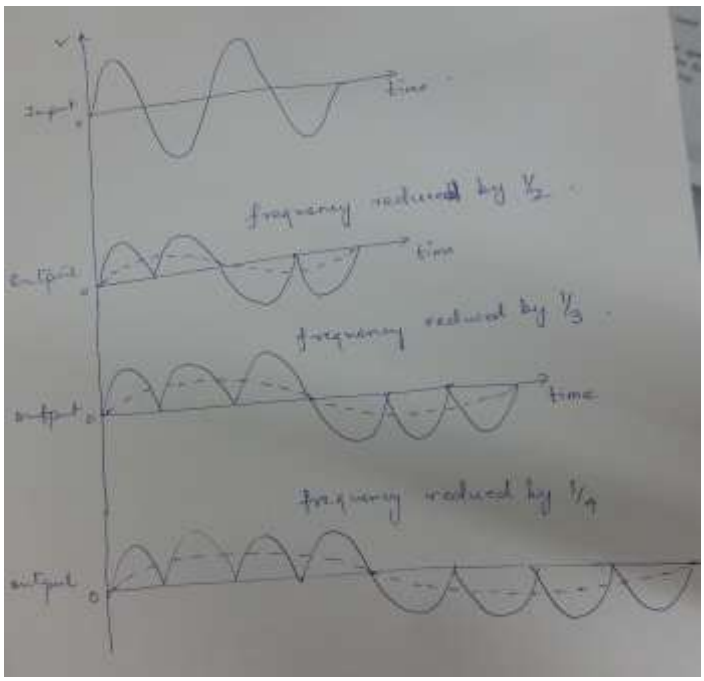
1. The speed of the paper machine must be constant in video of economy while forming the sheets of paper.

1. A speed control range of 10:1 is required so that it is suitable for performing several jobs.
2. The arrangement should be capable of taking up sag.
3. Even with correct speeds in the last 2 sections, uneven drying or the paper may cause variations in tension, which must be taken care of by suitable tension control.
4. The motor must be capable of including in order that the wire be cleaned up.
5. Every section must be able to run at crawling speeds.
6. The starting and acceleration of the sections must be smooth as well as quick.

e)Write the principle of operation of low speed AC motor with cyclo converter. Draw its output wave form for single phase and write two applications of cyclo converter drive.

Ans: Principle of operation—2Marks
A cyclo converter converts fixed frequency AC into a low frequency AC. The AC motor is started with low voltage, low frequency. Hence, the speed of the motor is less. Gradually the frequency is increased and the speed of the motor increases.

Note: The graph shown is for ½, 1/3rd and 1/4th frequency.
Any one waveform can be considered-----1 Mark



Input and Output Waveforms for single phase cycloconverter

Applications of cyclo converter: -----Any two apllications –1 mark

They are used for:

1. driving mine hoists,
2. rolling mill main motors,
3. cement kilns
4. ship propulsion systems