UNIT I
DRIVE CHARACTERISTICS

PART-A
(2 MARK QUESTIONS WITH ANSWERS)

1. What is meant by electrical drives?

Systems employed for motion control are called drives and they employ any of the Prime movers such as diesel or petrol engines, gas or steam turbines, hydraulic motors and electric motors for supplying mathematical energy for motion control. Drives employing electric motion are called electric drives.

2. Draw the electric drive system.

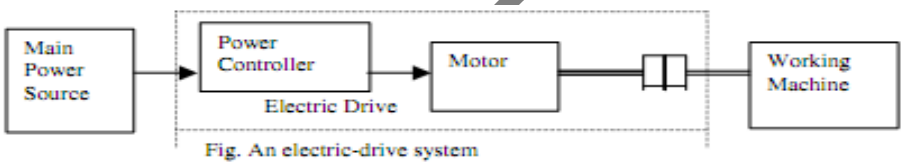
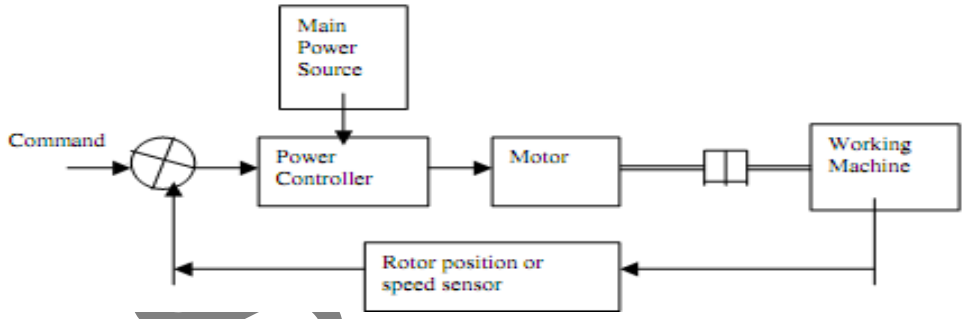


Fig. An electric-drive system



Modern Electric Drive system using power electronic converter

3. Specify the functions of power modulator.

Power modulator performs one or more of the following four functions.

a. Modulates flow of power from the source to the motor in such a manner that motor is imparted speed-torque characteristics required by the load.

b. During transient operations, such as starting, braking and speed reversal, it restricts source and motor currents within permissible values; excessive current drawn from source may overload it or may cause a voltage dip.

4. Mention the different types of drives.

- Group drive

- Individual drive
- Multi-motor drive

5. List the different types of electrical drives.

- Dc drives
- Ac drives

6. What are the advantages of electric drives?

- They have flexible control characteristics. The steady state and dynamic characteristics of electrical drives can be shaped to satisfy load requirements.
- Drives can be provided with automatic fault detection systems, programmable logic controllers and computers can be employed to automatically ctrl the drive operations in a desired sequence.
- They are available in which range of torque, speed and power.
- It can operate in all the four quadrants of speed-torque plane. Electric braking gives smooth deceleration and increases life of the equipment compared to other forms of braking.
- Control gear required for speed control, starting and braking is usually simple and easy to operate.

7. What are the functions performed by electric drives?

Various functions performed by electric drives include the following.

- Driving fans, ventilators, compressors and pumps etc.
- Lifting goods by hoists and cranes
- Imparting motion to conveyors in factories, mines and warehouses
- Running excavators and escalators, electric locomotives, trains, cars, trolley buses, lifts and drums winders etc.

8. What are the disadvantages of electric drives?

The disadvantages of electric drives are

- Electric drives system is tied only up to the electrified area.
- The condition arising under the short circuits, leakage from conductors and breakdown of overhead conductor may lead to fatal accidents.
- Failure in supply for a few minutes may paralyses the whole system.

9. What are the advantages of group drive over individual drive?

The advantages of group drive over individual drive are

a. Initial cost: Initial cost of group drive is less as compared to that of the individual drive.

b. Sequence of operation: Group drive system is useful because all the operations are stopped simultaneously.

c. Space requirement: Less space is required in group drive as compared to individual drive.

d. Low maintenance cost: It requires little maintenance as compared to individual drive.

10. What the group drive is not used extensively.

Although the initial cost of group drive is less but yet this system is not used extensively because of following disadvantages.

a. Power factor: Group drive has low power factor

b. Efficiency: Group drive system when used and if all the machines are not working together the main motor shall work at very much reduced load.

c. Reliability: In group drive if the main motor fails whole industry will come to stand still.

d. Flexibility: Such arrangement is not possible in group drive i.e., this arrangement is not suitable for the place where flexibility is the prime factor.

e. Speed: Group drive does not provide constant speed.

f. Types of machines: Group drive is not suitable for driving heavy machines such as cranes, lifts and hoists etc.

11. Write short notes on individual electric drives.

In individual drive, each individual machine is driven by a separate motor. This motor also imparts motion to various other parts of the machine. Examples of such machines are single spindle drilling machines (Universal motor is used) and lathes. In a lathe, the motor rotates the spindle, moves the feed and also with the help of gears, transmits motion to lubricating and cooling pumps. A three phase squirrel cage induction motor is used as the drive. In many such applications the electric motor forms an integral part of the machine.

12. Mention the different factors for the selection of electric drives?

- Steady state operation requirements.
- Transient operation requirements.
- Requirements related to the source.
- Capital and running cost, maintenance needs life.
- Space and weight restriction.
- Environment and location.
- Reliability.

13. Mention the parts of electrical drives.

- Electrical motors and load.
- Power modulator
- Sources
- Control unit
- Sensing unit

14. Mention the applications of electrical drives

- Paper mills
- Electric traction
- Cement mills
- Steel mills

15. Mention the types of enclosures

- Screen projected type
- Drip proof type
- Totally enclosed type
- Flame proof type

16. Mention the different types of classes of duty

- Continuous duty
- Discontinuous duty
- Short time duty
- Intermittent duty

17. What is meant by regenerative braking?

Regenerative braking occurs when the motor speed exceeds the synchronous speed. In this case the IM runs as the induction m\c is converting the mechanical power into electrical power which is delivered back to the electrical system. This method of braking is known as regenerative braking.

18. What is meant by dynamic braking?

Dynamic braking of electric motors occurs when the energy stored in the rotating mass is dissipated in an electrical resistance. This requires a motor to operate as a gen. to convert the stored energy into electrical.

19. What is meant by plugging?

It is one method of braking of IM. When phase sequence of supply of the motor running at the speed is reversed by interchanging connections of any two phases of stator with respect to supply terminals, operation shifts from motoring to plugging region.

20. What is critical speed?

It is the speed that separates continuous conduction from discontinuous conduction mode.

21. Which braking is suitable for reversing the motor?

Plugging is suitable for reversing the motor.

22. Define equivalent current method

The motor selected should have a current rating more than or equal to the current. It is also necessary to check the overload of the motor. This method of determining the power rating of the motor is known as equivalent current method.

23. What are the methods of operation of electric drives?

- Steady state
- acceleration including starting
- deceleration including starting

24. Define four quadrant operation.

The motor operates in two modes: motoring and braking. In motoring, it converts electrical energy into mechanical energy which supports its motion. In braking, it works as a generator, converting mathematical energy into electrical energy and thus opposes the motion. Motor can provide motoring and braking operations for both forward and reverse directions.

25. What is meant by mechanical characteristics?

The curve is drawn between speed and torque. This characteristic is called mechanical characteristics.

26. Mention the types of braking

- Regenerative braking
- Dynamic braking
- Plugging

PART-B
(13 MARK QUESTIONS)

1. Label the essential parts of electric drive. Explain its function. **(8)**
2. Discuss and Draw the speed-torque characteristics of various types of loads. **(7)**
3. Discuss in detail about the multi quadrant dynamies of electric drives. **(8)**

4. Define how the following speed transitions are carried out:
Increase in speed in same direction. (ii) Decrease in speed in same direction (iii) Speed reversal. **(13)**

5. Show a motor is coupled to a load having the following characteristics: Motor: Tm = 15 – 0.6 ωα Load: TL = 0.5 ω α 2 Find out the stable operating point for this condition **(13)**

6. Explain in detail about steady state stability in electrical drive system. **(7)**

7. Discuss in detail the multi quadrant dynamics in the speed – torque plane **(8)**

8. Explain the four quadrant operation of low speed hoist in detail. **(13)**

9. Explain and derive an equation to find out equivalent load torque in a motor load system with translational and rotational motion? **(13)**

10. Compose the mathematical condition to obtain steady state stability of equilibrium point? **(8)**

11. Explain in detail the multi quadrant operation of low speed hoist in speed torque plane **(13)**

12. Solve a motor drives two loads. One has rotational motion. It is coupled to the motor through a reduction gear with a = 0.1 and efficiency of 90%. The load has a moment of inertia of 10 kg-m2 and a torque of 10 N-m. Other load has translational motion and consists of 1000kg weight to be lifted up at a uniform speed of 1.5 m/s. coupling between this load and the motor has an efficiency of 85%. Motor has inertia of 0.2 kg-m2 and runs at a constant speed of 1420 rpm. Determine equivalent inertia referred to the motor shaft and power developed by the motor **(13)**

13. Define in detail about the braking of DC and AC drives. **(7)**

14. Discuss the different modes of operation of an electrical drive **(13)**

UNIT-II
CONVERTER / CHOPPER FED DC MOTOR DRIVE
PART-A
(2 MARK QUESTIONS WITH ANSWERS)

1. What are the advantage and disadvantages of D.C. drives?

The advantages of D.C. drives are,

a. Adjustable speed

b. Good speed regulation

c. Frequent starting, braking and reversing.

The disadvantage of D.C. drives is the presence of a mechanical commutator which limits the maximum power rating and the speed.

2. Give some applications of D.C. drives.

The applications of D.C. drives are,

- Rolling mills
- Paper mills
- Mine winders
- Hoists
- Machine tools
- Traction
- Printing presses
- Excavators
- Textile mills
- Cranes.

3. Why the variable speed applications are dominated by D.C. drives?

The variable speed applications are dominated by D.C. drives because of lower cost, reliability and simple control.

4. What is the use of flywheel? Where it is used?

It is used for load equalization. It is mounted on the motor shaft in compound motor.

5. What are the advantages of series motor?

The advantages of series motors are,

- High starting torque
- Heavy torque overloads.

6. How the D.C. motor is affected at the time of starting?

A D.C. motor is started with full supply voltage across its terminals; a very high current will flow, which may damage the motor due to heavy sparking at commuter and heating of the winding. Therefore, it is necessary to limit the current to a safe value during starting.

7. Define and mention different types of braking in a dc motor?

In braking, the motor works as a generator developing a negative torque which opposes the motion. Types are regenerative braking, dynamic or rheostat braking and plugging or reverse voltage braking.

8. List the drawbacks of armature resistance control?

In armature resistance control speed is varied by wasting power in external resistors that are connected in series with the armature. Since it is an inefficient method of speed control it was used in intermittent load

applications where the duration of low speed operations forms only a small proportion of total running time.

9. What is static Ward-Leonard drive?

Controlled rectifiers are used to get variable d.c. voltage from an a.c. source of fixed voltage controlled rectifier fed dc drives are also known as static Ward-Leonard drive.

10. What is a line commutated inverter?

Full converter with firing angle delay greater than 90 deg. is called line commutated inverter. Such an operation is used in regenerative braking mode of a dc motor in which case a back emf is greater than applied voltage.

11. Mention the methods of armature voltage controlled dc motor?

When the supplied voltage is ac,

- Ward-Leonard schemes
- Transformer with taps and un controlled rectifier bridge
- Static Ward-Leonard scheme or controlled rectifiers

When the supply is dc:

- Chopper control

12. How is the stator winding changed during constant torque and constant horsepower operations?

For constant torque operation, the change of stator winding is made form series – star to parallel – star, while for constant horsepower operation the change is made from series-delta to parallel-star. Regenerative braking takes place during changeover from higher to lower speeds.

13. Define positive and negative motor torque.

Positive motor torque is defined as the torque which produces acceleration or the positive rate of change of speed in forward direction. Positive load torque is negative if it produces deceleration.

14. What are the disadvantages of conventional Ward-Leonard schemes?

- Higher initial cost due to use of two additional m\cs.
- Heavy weight and size.
- Needs more floor space and proper foundation.
- Required frequent maintenance.

- Higher noise and higher loss.

15. Mention the drawbacks of rectifier fed dc drives?

- Distortion of supply.
- Low power factor.
- Ripple in motor current

16. What are the advantages in operating choppers at high frequency?

The operation at a high frequency improves motor performance by reducing current ripple and eliminating discontinuous conduction.

17. Why self-commutated devices are preferred over thyristors for chopper circuits?

Self-commutated devices such as power MOSFETs power transistors, IGBTs, GTOs and IGCTs are preferred over thyristors for building choppers because they can be commutated by a slow power control signal and don' t need commutation circuit.

18. State the advantages of dc chopper drives?

Dc chopper device has the advantages of high efficiency, flexibility in control, light weight, small size, quick response and regeneration down to very low speed.

19. What are the advantages of closed loop c of dc drives?

Closed loop control system has the adv. of improved accuracy, fast dynamic response and reduced effects of disturbance and system non-linearities.

20. What are the types of control strategies in dc chopper?

- Time ratio control.
- Current limit control.

21. What is the use of controlled rectifiers?

Controlled rectifiers are used to get variable D.C. Voltage form an A.C. Source of fixed voltage.

22. What is known as half-controlled rectifier and fully controlled rectifier?

The rectifiers that provide control of dc voltage in either direction and therefore, allow motor control in quadrants I and IV. They are known as fully-controlled rectifiers. The rectifiers that allow dc voltage control

only in one direction and motor control in quadrant I only. They are known as half-controlled rectifiers.

23. What is called continuous and discontinuous conduction?

A dc motor is fed from a phase controlled converter the current in the armature may flow in discrete pulses in called continuous conduction. A dc motor is fed from a phase controlled converter the current in the armature may flow continuously with an average value superimposed on by a ripple is called discontinuous conduction.

24. What are the three intervals present in discontinuous conduction mode of single phase half and fully controlled rectifier?

The three intervals present in half controlled rectifier are,

- Duty interval
- Free, wheeling interval
- Zero current interval.

The two intervals present in fully controlled rectifier are

- Duty interval
- Zero current interval.

25. What is called inversion?

Rectifier takes power from D.C. terminals and transfers it to A.C. mains is called inversion.

PART-B
(13 MARK QUESTIONS)

1. Explain the steady state analysis of the single phase fully controlled converter fed separately excited DC motor drive for continuous current mode. Also explain its operation in motoring and regenerative braking mode. **(13)**
2. Solve a 250V separately excited dc motor has an armature resistance of 2.5Ω when driving a load at 600 r.p.m. with constant torque, the armature takes 20 A. This motor is controlled by a chopper circuit with a frequency of 400 Hz and an input voltage of 250 V. (i) what should be the value of the duty ratio if one desires to reduce the speed from 600 to 540 r.p.m. with the load torque maintained constant? (ii) Find out the value of duty ratio for which the per unit ripple current will be maximum **(13)**
3. Describe about Electrical –mechanical characteristics of commonly used electric motors. **(13)**
4. Explain the operation of four quadrant dc chopper drive **(13)**
5. Solve a 220 V, 20 A, 1000 rpm separately excited dc motor has an armature resistance of 2.5 Ω. The motor is controlled by a step-down

chopper with a frequency of 1 kHz. The input dc voltage to the chopper is 250V. Identify what will be the duty cycle of the chopper for the motor to operate at a speed of 600 rpm delivering the rated torque? **(13)**

6. Explain in detail the single phase fully controlled rectifier control of dc separately excited motor with heat waveforms **(8)**

7. Solve a 220 V, 1500 rpm, 10 A separately excited DC motor has an armature resistance of . It is fed from a single phase fully controlled rectifier with a source voltage of 230 V 50 Hz. Assuming continuous load current. Compute (1) Motor speed at the firing angle of 30◦ and Torque of 5 Nm. (2) Developed Torque at the firing angle of 45◦ and speed of 1000 rpm.

8. Define in detail about the regenerative operation of three phase fully controlled rectifier control of separately excited DC motor. **(13)**

9. Define in detail about the four quadrant operation of chopper fed drive Compose the operation of single phase controlled converter fed separately excited DC motor in continuous and discontinuous modes with neat diagram, waveforms and comment the steady state analysis? **(13)**

10. Discuss the different control techniques of chopper in detail **(13)**

11. Discuss the four quadrant operation of DC-DC converter. **(13)**

UNIT III
INDUCTION MOTOR DRIVES

PART-A
(2 MARK QUESTIONS WITH ANSWERS)

1. What are the different methods of braking applied to the induction motor?

- Regenerative braking
- Plugging
- Dynamic braking.

2. What are the different methods of speed control of IM?

- Stator voltage control
- Supply freq. control
- Rotor resistance control
- Slip power recovery control.

3. What is meant by stator voltage control?

The speed of the IM can be changed by changing the stator voltage because the torque is proportional to the square of the voltage.

4. Mention the application of stator voltage control.

This method is suitable for applications where torque demand reduced with speed, which points towards its suitability for fan and pump drives.

5. Mention the applications of ac drives.

AC drives are used in a no. of applications such as fans, blowers, mill run-out tables, cranes, conveyors, traction etc.

6. What are the three regions in the speed-torque characteristics in the IM?

- Motoring region (0<=s<=1)
- Generating region(s<0)
- Plugging region (1<=s<=2) where s is the slip.

7. What are the advantages of stator voltage control method?

- The control circuitry is simple
- Compact size
- Quick response time
- There is considerable savings in energy and thus it is economical method as compared to other methods of speed control.

8. What is meant by soft start?

The ac voltage controllers show a step-less control of supply voltage from zero to rated voltage. They are used for soft start for motors.

9. List the advantages of squirrel cage IM?

- Cheaper
- Light in weight
- Rugged in construction
- More efficient
- Require less maintenance
- It can be operated in dirty and explosive environment

10. Define slip.

The difference between the synchronous speed (Ns) and actual speed (N) of the rotor is known as slip speed. The % of slip is given by, %slip s = [(Ns-N)/Ns]x 100

11. Define base speed.

The synchronous speed corresponding to the rated freq is called the base speed.

12. What is meant by frequency control of IM?

The speed of IM can be controlled by changing the supply freq because the speed is directly proportional to supply frequency. This method of speed ctrl is called freq control.

13. What is meant by V/F control?

When the frequency is reduced, the I/P voltage must be reduced proportionally so as to maintain constant flux otherwise the core will get saturated resulting in excessive iron loss and magnetizing current. This type of IM behaviour is similar to the working of dc series motor.

14. What are the advantages of V/F control?

- Smooth speed control
- Small i/p current and improved power factor at low frequency start
- Higher starting torque for low case resistance

15. What are the two modes of operation in the motor?

The two modes of operation in the motor are, motoring and braking. In motoring, it converts electrical energy to mechanical energy, which supports its motion. In braking, it works as a generator converting mechanical energy to electrical energy and thus opposes the motion.

16. What is braking? Mention its types.

The motor works as a generator developing a negative torque which opposes the motion is called barking. It is of three types. They are,

- Regenerative braking.
- Dynamic or rheostat braking.
- Plugging or reverse voltage braking.

17. What are the three types of speed control?

The three types of speed control as,

- Armature voltage control
- Field flux control
- Armature resistance control.

18. What are the advantages of armature voltage control?

The advantages of armature voltage control are,

- High efficiency
- Good transient response
- Good speed regulation.

19. Give some drawbacks and uses of Ward-Leonard drive

The drawbacks of Ward Leonard drive are

- High initial cost
- Low efficiency

The Ward-Leonard drive is used in rolling mills, mine winders, paper mills, elevators, machine tools etc.

20. Give the applications of induction motors drives.

Although variable speed induction motor drives are generally expensive than D.C. drives, they are used in a number of applications such as fans, blowers, mill run-out tables, cranes, conveyors, traction etc., because of the advantages of induction motors. Other applications involved are underground and underwater installations, and explosive and dirty environments.

21. Where is the V/f control used?

The V/f control would be sufficient in some applications requiring variable torque, such as centrifugal pumps, compressors and fans. In these, the torque varies as the square of the speed. Therefore at small speeds the required torque is also small and V/f control would be sufficient to drive these leads with no compensation required for resistance drop. This is true also for the case of the liquid being pumped with minimal solids.

22. What is indirect flux control?

The method of maintaining the flux constant by providing a voltage boost proportional to slip frequency is a kind of indirect flux control. This method of flux control is not desirable if very good dynamic behaviour is required.

23. What is voltage source inverter?

Voltage source inverter is a kind of D.C. link converter, which is a two stage conversion device.

24. What are the effects of harmonics in VSI fed induction motor drive?

The motor receives square wave voltages. This voltage has harmonic components. The harmonics of the stator current will cause additional losses and heating. These harmonics are also responsible for torque pulsations. The reaction of the fifth and seventh harmonics with the fundamental gives rise to the seventh harmonic pulsations in the torque developed. For a given induction motor fed from a square wave inverter

the harmonic content in the current tends to remain constant independent of input frequency, with the range of operating frequencies of the inverter.

25. What is a current source inverter?

In a dc link converter, if the D.C. link current is controlled, the inverter is called a current source inverter, The current in the D.C. link is kept constant by a high inductance and he capacitance of the filter is dispensed with . A current source inverter is suitable for loads which present low impedance to harmonic currents and have unity p.f.

26. How is super synchronous speed achieved?

Super synchronous speed can be achieved if the power is fed to the rotor from A.C. mains. This can be made possible by replacing the converter cascade by a cyclo-converter. A cyclo-converter allows power flow in either direction making the static sherbets drive operate at both sub and supper synchronous speeds.

27. What is static Kramer drive?

Instead of wasting the slip power in the rotor circuit resistance, it can be converted to 50 Hz A.C. and pumped back to the line. The slip power controlled drive that permits only a sub synchronous range of speed control through a converter cascade is known as static Kramer drive.

28. Give the four modes of operation of a Scherbius drive

The four modes of operation of static Scherbius drive are,

- Sub synchronous motoring.
- Sub synchronous regeneration
- Super synchronous motoring
- Super synchronous regeneration

PART-B
(13 MARK QUESTIONS)

1. Discuss in detail with suitable diagrams and waveforms the v/f control applied to induction motor drives. **(13)**
2. Tell why a cycloconverter fed induction motor drive is preferred over inverter controlled synchronous motor drive for low speed applications? **(8)**
3. Define in detail about the principle of vector control of induction motor drive. **(13)**
4. Explain the four modes of operation of a static Scherbius drive **(13)**
5. Describe the VSI fed induction motor drive **(8)**

6. Explain in detail the static rotor resistance control in the induction motor **(7)**
7. Explain in detail about the vector control for an induction motor **(8)**
8. Describe the concept of v/f control scheme. **(7)**
9. Describe the variable frequency operation of induction motor in closed loop with constant -gap flux. **(13)**
10. Describe the v/f control scheme of induction motor drive with a neat diagram **(7)**
11. Show and explain with a neat diagram the field weakening mode control of induction motor drives **(13)**
12. Compare VSI and CSI fed induction motor drive **(8)**
13. Show and Explain the block diagram of vector control of induction motor drive **(7)**
14. Compose in detail about the closed loop operation of armature voltage control method with field weakening mode control in detail. **(7)**
15. Define the VSI fed induction motor drives **(7)**
16. Define the CSI fed induction motor drives **(8)**

UNIT IV
SYNCHRONOUS MOTOR DRIVES

PART-A
(2 MARK QUESTIONS WITH ANSWERS)

1. Give the use of synchronous motors.

Synchronous motors were mainly used in constant speed applications. The development of semiconductor variable frequency sources, such as inverters and cyclo-converters, has allowed their use in draft fane, main line traction and servo drives, etc.

2. How are the stator and rotor of the synchronous motor supplied?

The stator of the synchronous motor is supplied from a thyristor power converter capable of providing a variable frequency supply. The rotor, depending upon the situation, may be constructed with slip rings, where it conforms to a conventional rotor. It is supplied with D.C. through slip rings. Sometimes rotor may also be free from sliding contacts (slip rings), in which case the rotor is fed from a rectifier rotating with rotor.

3. What is the difference between an induction motor and synchronous motor?

An induction motor operates at lagging power factor and hence the converter supplying the same must invariable is a force commutated one. A synchronous motor, on the other hand, can be operated at any power factor by controlling the field current.

4. List out the commonly used synchronous motors.

Commonly used synchronous motors are,

- Wound field synchronous motors.
- Permanent magnet synchronous motors
- Synchronous reluctance synchronous motors.
- Hysteresis motors.

5. Mention the main difference between the wound field and permanent magnet motors.

When a wound filed motor is started as an induction motor, D.C. field is kept off. In case of a permanent magnet motor, the field cannot be 'turned off'.

6. Give the advantages and applications of PMSM.

The advantages of PMSM are,

- High efficiency
- High power factor
- Low sensitivity to supply voltage variations.

The application of PMSM is that it is preferred of industrial applications with large duty cycle such as pumps, fans and compressors.

7. Give the uses of a hysteresis synchronous motor.

Small hysteresis motors are extensively used in tape recorders, office equipment and fans. Because of the low starting current, it finds application in high inertia application such as gyrocompasses and small centrifuges.

8. Mention the two modes employed in variable frequency control

Variable frequency control may employ and of the two modes.

- True synchronous mode
- Self-controlled mode

9. Which synchronous machine is said to be self-controlled?

A machine is said to be self-controlled if it gets its variable frequency from an inverter whose thrusters are freed in a sequence, using the information of rotor position or stator voltages. In the former a rotor

position sensor is employed which measures the rotor position with respect to the stator and sends pulses to the thyristors. Thus frequency of the inverter output is decided by the rotor speed.

10. What is Commutator Less Motor (CLM)?

The self-controlled motor has properties of a D.C. Motors both under steady state and dynamic conditions and therefore is called commutator less motor(CLM). These machines have better stability behaviours. They do not fall out of step and do not have oscillatory behaviours, as in normal synchronous motors.

11. Give the application of self-controlled synchronous motor.

A self-controlled synchronous motor is a substitute for a D.C. motor drive and finds application where a D.C. motor is objectionable due to its mechanical commutator, which limits the speed range and power output.

12. Define load commutation

Commutation of thyristors by induced voltages of load is known as load commutation.

13. List out the advantages of load commutation over forced commutation.

Load commutation has a number of advantages over forced commutation

- It does not require commutation circuits
- Frequency of operation can be higher
- It can operate at power levels beyond the capability of forced commutation.

14. Give some application of load commutated inverter fed synchronous motor drive.

Some prominent applications of load commutated inverter fed synchronous motor drive are high speed and high power drives for compressors, blowers, conveyers, steel rolling mills and main-line traction and aircraft test facilities.

15. How the machine operation is performed in self-controlled mode?

For machine operation in the self-controlled mode, rotating filed speed should be the same as rotor speed. This condition is realized by making frequency of voltage induced in the armature. Firing pulses are therefore generated either by comparison of motor terminal voltages or by rotor position sensors.

16. What is meant by margin angle of commutation?

The difference between the lead angle of firing and the overlap angle is called the margin angle of commutation. Safe commutation is assured if this angle has a minimum value equal to the turn off angle of the thyristor.

17. What are the disadvantages of VSI fed synchronous motor drive?

VSI synchronous motor drives might impose fewer problems both on machine as well as on the system design. A normal VSI with 180° conduction of thyristors required forced commutation and load commutation is not possible.

18. How is PWM inverter supplied in VSI fed synchronous motor?

When a PWM inverter is used, two cases may arise the inverter may be fed from a constant D.C. source in which case regeneration is straight forward. The D.C. supply to the inverter may be obtained from a diode rectifier. In this case an additional phase controlled converter is required on the line side.

19. What is D.C. link converter and cyclo-converter?

D.C. link converter is a two stage conversion device which provides a variable voltage, variable frequency supply. Cyclo-converter is a single stage conversion device which provides a Variable voltage, variable frequency supply.

20. What are the disadvantages of cyclo-converter?

A cyclo-converter requires large number of thyristors and its control circuitry is complex. Converter grade thyristors are sufficient but the cost of the converter is high.

21. What are the applications of cyclo-converter?

A cyclo-converter drive is attractive for law speed operation and is frequently employed in large, low speed reversing mils requiring rapid acceleration and deceleration. Typical applications are large gearless drives, e.g. drives for reversing mills, mine heists, etc.

22. Give the application of CSI fed synchronous motor.

Application of this type of drive is in gas turbine starting pumped hydro-turbine starting, pump and blower drives, etc.

23. What are the disadvantages of machine commutation?

The disadvantages of machine commutation are,

- Limitation on the speed range.

- The machine size is large
- Due to overexciting it is underutilized.

24. What are the advantages of brushless D.C. motor?

The brushless D.C. motor is in fact an inverter-fed self-controlled permanent synchronous motor drive. The advantages of brushless D.C. motor are low cost, simplicity reliability and good performance.

PART-B
(13 MARK QUESTIONS)

1. Discuss briefly separate controlled mode of synchronous motor in detail **(8)**
2. Explain self control of synchronous motor drive in detail **(8)**
3. Explain margin angle control of synchronous motor drive. **(8)**
4. Describe briefly the power factor angle control of synchronous motors with relevant vector diagram. **(8)**
5. Explain commutator less Dc motor. **(8)**
6. Describe closed loop speed control of load commutated inverter synchronous motor drive and explain it. **(8)**
7. Describe the open loop v/f control of VSI fed synchronous motor in detail **(8)**
8. Describe the CSI fed synchronous motor drive in detail. (8)
9. Describe the closed loop operation of permanent magnet synchronous motor drive in details. **(13)**
10. Discuss the construction and working of permanent magnet synchronous motor with neat diagram **(13)**
11. Name the various types of permanent magnet synchronous motor and explain it . **(8)**
12. Describe the vector control of sinusoidal SPM in constant torque region. **(8)**
13. A 3phase, 400V, 50Hz, 6pole star connected round rotor synchronous motor has Zs=0+j2Ω Load torque proportional to speed squared is 340Nm at rated synchronous speed. The speed of the motor is lowered by keeping v/f constant and maintaining unity pf by field control of the motor. For the motor operation www.Vidyarthiplus.com www.Vidyarthiplus.com at 600 rpm, calculate a) supply voltage b) armature current c) excitation angle d) load angle e) pull out torque. Neglect rotational losses. **(13)**
14. A 7MW, three phase 12 kV star connected 6 pole 50Hz 0.9 leading power factor synchronous motor has Xs= 10Ω and Rs=0. The rated field

current is 40A. The machine is controlled by variable frequency control at constant V/f ratio up to the base speed and at constant V above base speed. Evaluate(i) Torque (ii) The field current for the rated armature current 750rpm and 0.8 leading power factor. **(13)**

15.A 500kW, 3 phase, 3.3 kV, 50 Hz, 0.8 lagging power factor, 4 pole, star connected synchronous motor has the following parameters Xs=15Ω, Rs=0.Rated field current s 10A. Calculate armature current and power factor at half the rated torque and field current **(13)**

UNIT V
DESIGN OF CONTROLLERS FOR DRIVES

PART-A
(2 MARK QUESTIONS WITH ANSWERS)

1. What is a closed loop control system?

A closed loop system is mainly used to maintain constant speed operation. It is a system in which the output has control over the input.

2. What are the advantages of closed loop system?

- System protection.
- Greater accuracy
- Improved dynamic response
- Reduced effects of disturbances such as loading.

3. What are the basic blocks of a closed loop system of a dc motor?

The system consists of a dc motor, power converter, feedback path, comparator and speed controller.

4. What are the two types of feedback in dc drive?

- Current feedback
- Speed feedback

5. What is speed feedback?

The motor speed can be sensed by any one speed sensor and this signal is compared with reference speed. This error signal is given to speed controller. The speed controller produce control signal to the power converter.

6. How is the speed of a motor sensed?

The speed of a motor can be sensed by using a tacho-generator.

7. What are the two types of speed controller?

- Proportional controller
- Proportional Integral controller

8. What is current feedback?

The motor current can be sensed by current transducer. This signal is compared with reference signal. The error signal is fed to the current controller produces a control signal. This signal is fed to the power converter for controlling the output.

9. What is armature voltage control?

The dc motor sped can be varied by varying armature voltage and field voltage is constant. This voltage can be varied by using power converter. This method is only applicable for below base speed.

10. What is field weakening control?

The dc motor speed can be varied by varying the field current and armature voltage is kept constant. The field current can be controlled by using power converter. By using this method the motor field flux decreases i.e., field weakening mode. This method is only applicable foe speeds above base speed because speed is inversely proportional to flux.

11. What is the purpose of current control in dc drives?

The current control loop is used for the purpose of limiting the transient over current.

12. What happens if the control loop is without current loop?

If inner current loop is not added in the control circuitry, transient over current is produced which is undesirable from the standpoint of converter rating and protection. This is particularly in case of starting or other large changes.

13. What is the advantage of using simulation package?

Simulation packages are used for studying the nature of the system developed without being practically implementing it.

14. What are the main disadvantages of phase controlled converter fed dc motor drives?

The phase controlled rectifiers always consume reactive power. Due to this, they are expensive to operate where the reactive power is to be paid for. It also generates harmonics.

15. What is the advantage of using PI type speed controller?

The addition of an integral feedback can be used to eliminate the steady-state error and to reduce the forward gain required.

16. Which type of converter can be selected if the input is ac?

When the input is ac, the dc motor can be operated from rectifiers. If the motor ratings are low, we can use single phase controlled rectifiers and for high ratings, three phase controlled rectifiers are used.

17. What is the advantage of closed torque control scheme?

It finds application in battery operated vehicles such as electric trains.

18. What is the use of current limiter in the closed loop control system?

It saturates and sets current reference for inner current loop at a value corresponding to the maximum allowable current.

19. What are the advantages of using PI controller in closed loop controller of dc drive?

- Stabilize the drive
- Adjust the damping ratio at the desired value
- Makes the steady state speed error close to zero by integral action and filters out noise again due to the integral action.

20. What is the use of an auxiliary motor?

Sometimes when the power is small an auxiliary motor can be used to run up the synchronous motor to the desired speed.

PART-B
(13 MARK QUESTIONS)

1. Derive and explain from basic principles the transfer function for separately excited DC motor load system with converter fed armature voltage control. **(13)**
2. Explain the closed loop operation of armature voltage control method and field weakening mode control for Dc drive. **(13)**
3. Describe the step by step procedure for the design of current controller. **(13)**
4. Give the design procedure for speed controller of an electrical drive system with necessary diagrams **(13)**

5. Discuss the use of simulation software package for design of controller for drives **(13)**

6. List the factors involved in converter selection and equations involved in controller characteristics. **(13)**

7. A 50KW, 240V, 1700 rpm separately excited DC motor is controlled by a converter. The field current is maintained at If=1.4A and the machine back EMF constant is Kv=.91VA rad/sec.The armature resistance is Rm=0.1Ω and thev is constriction constant is B=0.3Nm/rad/sec. The amplification of the speed sensor is K1=95mV/rad/sec and the gain of the power controller is K2=100. Calculate (i) the reference voltage Vr to drive the motor at the rated speed. (8) (ii)If the reference voltage is kept unchanged, determine the speed at which the motor develops rated torque. **(8)**

8. Discuss the current controller design using (i) P controller and (II) PI controller for a separately excited dc motor drive systems. **(13)**

9. Design a speed controller Dc motor drive maintaining the field flux constant. The motor parameters and ratings are as follows. 220V, 8.3A, 1470 rpm, Ra = 4Ω, J = 0.0607 kg-m2, La = 0.072H,Bt = 0.0869 Nm/rad/sec, Kb = 1.26V/rad/sec The converter is supplied from 230V, 3phase AC at 60 Hz. The converter is linear and its maximum control input voltage is ±10 V. The tacho generator has the transfer www.Vidyarthiplus.com www.Vidyarthiplus.com function Gw(s) =(0.065)/(1+0.002s). The speed reference voltage has a maximum of 10V. The maximum current permitted in the motor is 20A **(13)**

10. Using suitable block diagram explain the following controls. (i)Current limit control (ii) Closed loop torque control (iii) Closed loop speed control **(13)**