EE8601- SOLID STATE DRIVES

2 Marks and 16 Marks-Question Bank

UNIT-I DRIVE CHARACTERISTICS

TWO MARKS

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. What is active load torque? (April/May 2015)

Load torques which has the potential to drive the motor under equilibrium conditions are called active load torque.

3. Specify the functions of power modulator.

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

a. Modulates flow of power form 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.

1) Group drive

2) Individual drive

3) Multi motor drive

5. List the different types of electrical drives.

1) DC drives

2) AC drives

6. What are the advantages of electric drives? (AU 2009)

1) They have flexible control characteristics. The steady state and dynamic Characteristics of electrical drives can be shaped to satisfy load requirements.

2) Drives can be provided with automatic fault detection systems, programmable logic controllers and computers can be employed to automatically control the drive operations in a desired sequence.

3) They are available in which range of torque, speed and power.

4) 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.

5) 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.

a. Driving fans, ventilators, compressors and pumps etc.

b. Lifting goods by hoists and cranes

c. Imparting motion to conveyors in factories, mines and warehouses and

d. 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

a. Electric drives system is tied only up to the electrified area.

b. The condition arising under the short circuits, leakage from conductors and breakdown of overhead conductor may lead to fatal accidents.

c. Failure in supply for a few minutes may paralyses the whole system.

9. What are the advantages of group drive over individual drive? (AU 2008)

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? (AU 2008) (April/May 2015)

1) Steady state operation requirements.
2) Transient operation requirements.
3) Requirements related to the source.
4) Capital and running cost, maintenance needs life.
5) Space and weight restriction.
6) Environment and location.
7) Reliability.

13. Mention the parts of electrical drives.

1) Electrical motors and load.
2) Power modulator
3) Sources
4) Control unit
5) Sensing unit

14. Mention the applications of electrical drives

1. Paper mills
2. Electric traction
3. Cement mills
4. Steel mills

15. What is critical speed?

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

16. Which braking is suitable for reversing the motor?

Plugging is suitable for reversing the motor.

17. 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.

18. What are the methods of operation of electric drives? (AU 2010) (Nov-2013)

1. Steady state
2. Acceleration including starting
3. Deceleration including starting

19. What is multi quadrant dynamics in drive characteristics? (AU 2011)

The motor operates in two mode: 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 th motion. Motor can provide motoring and braking operations for both forward and reverse directions.

20. What is meant by mechanical characteristics?

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

21. Mention the types of braking

1. Regenerative braking
2. Dynamic braking
3. Plugging

22. What is passive load torque? (AU 2009) (April/May 2015)

Load torques which always oppose the motion and change their sign on the reversal of motion are called passive load torque.

23. What are the different types of load torque? (AU 2011)

1. Active load torque
2. Passive load torque

24. Define dynamic torque. (Nov-2013)

Torque component $J(d\omega_m/ dt)$ is called the dynamic torque. Its present only the transient operations.

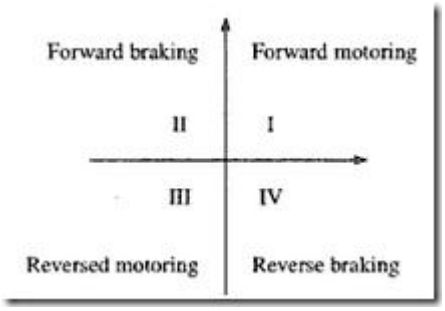
25. Write down the fundamental torque equation of motor load system?
(AU 2011)

Motor Torque Equal To Load Torque Adding With Dynamic Torque (Momemt Of Inertia)

26. What are the different types of load? (AU 2011)

1. Constant torque type load
2. Torque proportional to speed (generator type load)
3. Torque proportional to square of the speed (fan type load)
4. Torque inversely proportional to speed (constant power type load)

27. What is the speed torque conventions used in multi quadrant operation? (AU 2012)



28. Give any one example of active load torque (AU 2012)

Load torques which is independent of the speed typical example would be the load caused by gravitational pull. The load does not change sign even when the direction of motion changes. Torques which are dependent on speed

1. Proportional to the speed – e.g. load torque due to the laminar flow of the lubricant known as viscous friction

2. Proportional to the square of the speed – e.g. fan, blowers and pumps where turbulent flow of liquid or air occurs.

3. Inversely proportional to the speed – this type of load consumes constant power. Large torque required at low speed and small torqued required at high speed. E.g. coiler used in steel strip or paper mills

29. What are the disadvantages of constant torque loads?

The constant torque loads are not favoured due to increase in the losses linearly with slip and becoming maximum at s= 1.0. This is obvious form the variation of flux as the voltage is varied for speed control. To maintain constant torque the motor draws heavy current resulting in poor torque/ampere, poor efficiency and poor power factor at low speeds.

30.What is an electrical drive?(NOV/DEC 2014)

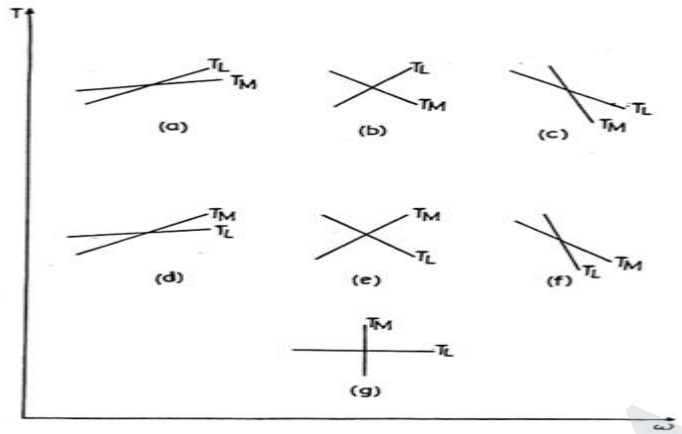
Systems employed for motion control are called drives and they employ any of the prime movers such as diesel or petrol engines, gas or steam turbines, hydraulic motors and electric motors for supplying mathematical energy for motion control. Drives employing electric motion are called electric drives.

31. What is regenerative braking? (NOV/DEC 2014)

Regenerative braking is a system in which the electric motor that normally drives a hybrid or pure electric vehicle is essentially operated in reverse (electrically) during braking or coasting. Instead of consuming energy to propel a vehicle, the motor acts as a generator that charges the onboard batteries with electrical energy that would normally be lost as heat through traditional

mechanical friction brakes. As the motor "acts in reverse," it generates electricity. The accompanying friction (electrical resistance) assists the normal brake pads in overcoming inertia and helps slow the vehicle.

32. State the condition for steady state stability of motor load system. (MAY/JUNE 2014)



$$\frac{dTL}{d\omega m} > \frac{dT}{d\omega m} \quad \text{——(1)}$$

33**. Define active load torque (MAY/JUNE 2014)**

Load torques which has the potential to drive the motor under equilibrium conditions are called Active load torque

SIXTEEN MARKS

1. Give a brief explanation on the selection of drives.
2. Derive the fundamental torque equations for a motor-load system. (AU 2013)
3. Explain the four quadrant operation of electric drives. **(April/May 2015)** (MAY/JUNE 2014)
4. Draw and describe the load torque characteristics of various drives. (AU 2011&2012) **(April/May 2015)**

5. Draw and explain the block diagram of an electric drive and discus the functions of power modulator (AU 2008)

6. Derive the mathematical condition for steady state stability analysis of equilibrium operating point. (AU 2009, 2011, 2012 & 2013)

7. Explain in detail the multi quadrant dynamics in the speed-torque plane. (AU 2009, 2011 & 2012)

8. Discuss the different modes of operation of a hoist load. (AU 2012&2013)

9. Derive the expressions to find the equivalent load torque and equivalent inertia of loads in Translational and Rotational motion. (AU 2009, 2011 & 2012)

10. 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. (AU 2011)

11. Derive and describe the equations governing motor load dynamics. (AU 2011)

12. Discuss the steady state stability characteristics of drives. (AU 2011)

13. A motor is coupled to a load having the following characteristics:

Motor : $T_m=15-0.5w_m$

Load : $T_l=0.5w_m^2$

Find out the stable operating point for this condition. (8) (NOV/DEC 2014)

14. Explain in detail the multi quadrant dynamics in the speed-torque plane (NOV/DEC 2014)

15. Discuss the different modes of operation of an electrical drive. (NOV/DEC 2014)

16. Explain the four quadrant operation of low speed hoist in detail?

17. Derive an equation to find out equivalent load torque in a motor load system with translational and rotational motor. (MAY/JUNE 2014)

18. Derive the mathematical condition to obtain steady state stability of equilibrium point? (MAY/JUNE 2014) **(April/May 2015)**

UNIT II CONVERTER/CHOPPER FED DC MOTOR DRIVE

TWO MARKS

1. What are the applications of chopper fed dc drives? (AU 2012)

1. Subway cars 2. Cranes 3. Traction 4. Battery operated vehicles.

2. What are the merits of 4 quadrant operation of a converter? (AU 2011)

High efficiency, Flexibility in control and Quick response.

3. Define current limit control of a chopper fed dc drives. (AU 2011 & 2013)

The chopper is switched ON and OFF so that the current in the load is maintained between two limits Io min to Io max.

4. Write down the speed torque relation for 1Φ fully controlled converter fed dc motor in continuous conduction mode?

Speed $N \alpha E_b/\Phi$

Here Φ is constant

$N \alpha E_b$

$N = K_m E_b$

Where K_m = Motor constant

Torque $\alpha \Phi I_a$

Here Φ is constant

Torque αI_a

$T = K_m I_a$

5. 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.

6. 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.

7. Mention the drawbacks of rectifier fed dc drives? (April/May 2015)

1. Distortion of supply.
2. Low power factor.
3. Ripple in motor current

8. What are the advantages in operating choppers at high frequency? (AU 2008)

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

9. 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.

10. State the advantages of dc chopper drives? (AU 2009)

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.

11. What are the advantages of closed loop of dc drives?

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

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

1. Time ratio control.
2. Current limit control.

13. 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.

14. What is TRC scheme? (AU 2011)

In the time ratio control the value of Ton/T is varied. This is effective in two ways. 1. Constant frequency system. 2. Variable frequency system.

15. What is the difference between continuous and discontinuous conduction modes? (AU 2012)

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.

16. 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,

a. Duty interval
b. Free, wheeling interval
c. Zero current intervals.

The two intervals present in fully controlled rectifier are

a. Duty interval

b. Zero current interval

17. What is called inversion?

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

18. List out the drawbacks of ac-dc converter fed dc drive. (AU 2011)

1. Distortion of supply.
2. Low power factor.
3. Ripple in motor current.

19. What are the advantages of chopper fed drive over converter fed drive? (NOV/DEC 2014)

DC chopper drives has the advantage of high efficiency of flexibility in control, light weight, small size, quick response and regeneration down to very low speed

20. What is necessity of DC choke coil and freewheeling diode in a converter circuit? (NOV/DEC 2014)

- Input power factor improved
- Make the load current continuous

21. Write down the speed torque equation of single phase fully controlled converter fed separately excited DC motor (MAY/JUNE 2014)

Speed $N \propto E_B/\phi$

Here ϕ is constant

$N \alpha E_B$

$N=K_M E_B$, K_m=motor constant

$T=K_M I_a$

22. Write down the control strategies of chopper. (MAY/JUNE 2014)

- Time ratio control.
- Current limit control.

23. Can semi converter fed DC drive operated in quadrant IV? (April/May 2015)

No, a semi converter conducts only positive half cycle

SIXTEEN MARKS

1. Describe the operation of 1f fully controlled rectifier control of DC separately excited motor and obtain the expression of motor speed for continuous and discontinuous modes of operations. (Nov-2013)

2. A 220V, 1500rpm, 50A separately excited motor with armature resistance of 0.5Ω, is fed from a 3-phase fully controlled rectifier. Available ac source has a line voltage of 440V, 50Hz. A star delta connected transformer is used to feed the armature so that motor terminal voltage equals rated voltage when converter firing angle is zero.(Nov-2013)

(i) Calculate transformer turns ratio.

(ii) Determine the value of firing angle when

(1) Motor is running at 1200rpm and rated torque.

(2) When motor is running at 800rpm and twice the rated torque. Assume continuous conduction.

3. Explain the motoring operation and braking operation of three phase fully controlled rectifier control of dc separately excited motor with aid of diagrams and waveforms. Also obtain the expression for motor terminal voltage and speed. (AU 2011)

4. Explain the operation of chopper for forward motoring and braking control of separately excited dc motor with aid of diagrams, waveforms and speed-torque curves.

5. A 230 V, 960 rpm and 200 A separately excited dc motor has an armature resistance of 0.02W. The motor is fed from a chopper which provides both motoring and braking operations. The source has a voltage of 230V. Assuming continuous conduction, Calculate

i) Duty cycle ratio of chopper for motoring operations at 350 rpm.

ii) Duty cycle ratio of chopper for braking operation at rated torque and 350 rpm.

iii) If maximum duty ratio of chopper is limited to 0.95 and maximum permissible motor current is twice the rated. Calculate the maximum permissible motor speed and power fed to the source.

6. Explain the operation of single phase fully-controlled converter fed dc separately excited motor in continuous and discontinuous modes of operation with necessary waveforms and steady state analysis. (AU 2011) **(April/May 2015)**

7. Explain the different control techniques of chopper in detail. (AU 2011, 2012)

8. Discuss the four quadrant operation of DC-DC converter. (AU 2011, 2012)

9. Discuss the two methods of time ratio control. (AU 2011)

10. Discuss the four quadrant operation of chopper in detail. (AU 2012)

11. A 200 V, 875 rpm, 150 A separately excited motor has an armature resistance of 0.06W. It is fed from a 1 phase fully controlled rectifier with an ac source voltage of 220 V, 50Hz. Assuming continuous conduction, Calculate**(April/May 2015)**

i) Firing angle for rated motor torque and 750 rpm

ii) Firing angle for rated motor torque and (–500) rpm.

iii) Motor speed for a =1600 rpm and rated torque.

12. A 220V, 1500 rpm 50 A separately excited motor with armature resistance of 0.5W, is fed from a 3phase fully controlled rectifier. Available ac source has a line voltage of 440V, 50 Hz. A star-delta connected transformer is used to feed the armature so that motor terminal voltage equals rated voltage when converter firing angle is zero.

(i) Calculate the transformer turns ratio.

(ii) Determine the value of firing angle when

a) Motor is running at 1200 rpm & rated torque

b) When motor is running at (-800) rpm & twice the rated torque.

Assume continuous conduction.

13. Explain in detail the single phase fully controlled rectifier control of dc separately excited motor with neat waveforms **(NOV/DEC 2014)**

14. A220v, 1500rpm, 10A, separately excited dc motor has an armature resistance of 1ohm.its fed from a single phase fully controlled rectifier with a source voltage of 230v, 50hz.Assuming continuous load current .compute (1) motor speed at the firing angle of 30 degree and torque of 5Nm. (2) Developed torque at the firing angle of 45degree and speed of 1000rpm **(NOV/DEC 2014)**

15. Explain in detail the regenerative operation of three phases fully controlled rectifier control of separately excited DC motor. **(NOV/DEC 2014)**

16. Explain in detail the four quadrant operation of chopper fed drive. **(NOV/DEC 2014)** **(April/May 2015)**

17. Explain the operation of single phase fully-controlled converter fed dc separately excited motor in continuous and discontinuous modes of operation with necessary waveforms and steady state analysis(**MAY/JUNE 2014)**

18. Discuss the four quadrant operation of chopper in detail. (**MAY/JUNE 2014)**

UNIT III INDUCTION MOTOR DRIVES

TWO MARKS

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

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

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

1. Stator voltage control
2. Supply freq. control
3. Rotor resistance control
4. 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. (AU 2011)

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?

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

7. What are the advantages of stator voltage control method? (April/May 2015)

1. The control circuitry is simple
2. Compact size
3. Quick response time
4. 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 stepless control of supply voltage from zero to rated voltage. They are used for soft start for motors.

9. 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

10. Define base speed.

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

11. 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.

12. 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.

13. What are the advantages of V/F control? (AU 2011, 2012)

1. Smooth speed ctrl
2. Small i/p current and improved power factor at low freq. start
3. Higher starting torque for low case resistance

14. What is meant by stator current control?

The 3 phase IM speed can be controlled by stator current control. The stator current can be varied by using current source inverter.

15. What are the 3 modes of region in the adjustable-freq IM drives characteristics?

1. Constant torque region Constant power region
2. High speed series motoring region

16. 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.

17. What are the drawbacks of stepped wave inverter fed drives? (Nov-2013)

(i) Due to low frequency harmonics, the motor losses are increased at all speeds causing derating of the motor.

(ii) Motor develops pulsating torque due to fifth, seventh and thirteenth harmonics which cause jerky motion of the rotor at low speeds.

(iii) Harmonic content in motor current increases at low speeds. The machine saturates at light at low speeds due to high (v/f) ratio. These two effects overheat the machine at low speeds, thus limiting lowest speed to around 40% of base speed.

18. What are the three types of speed control?

The three types of speed control as,

a. Armature voltage control

b. Field flux control

c. Armature resistance control.

19. What are the advantages of armature voltage control?

The advantages of armature voltage control are,

a. High efficiency

b. Good transient response

c. Good speed regulation.

20. What are the methods involved in armature voltage control?

When the supply in A.C.

a. Ward-Leonard schemes

b. Transformer with taps and an uncontrolled rectifier bridge.

c. Static ward Leonard scheme or controlled rectifiers when the supply in D.C.

d. Chopper control.

21. What are the advantages of induction motors over D.C. motors?

The main drawback of D.C. motors is the presence of commutate and brushes, which require frequent maintenance and make them unsuitable for explosive and dirty environments. On the other hand, induction motors, particularly squirrel-cage are rugged,

cheaper, lighter, smaller, and more efficient, require lower maintenance and can operate in dirty and explosive environments.

22. 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.

23. How is the speed controlled in induction motor?

The induction motor speed can be controlled by supplying the stator a variable voltage, variable frequency supply using static frequency converters. Speed control is also possible by feeding the slip power to the supply system using converters in the rotor circuit; basically one distinguishes two different methods of speed control.

a. Speed control by varying the slip frequency when the stator is fed from a constant voltage, constant frequency mains.

b. Speed control of the motor using a variable frequency variable voltage motor operating at constant rotor frequency.

24. How is the speed control by variation of slip frequency obtained?

Speed control by variation of slip frequency is obtained by the following ways.

a. Stator voltage control using a three-phase voltage controller.

b. Rotor resistance control using a chopper controlled resistance in the rotor circuit.

c. Using a converter cascade in the rotor circuit to recover slip energy.

d. Using a cycloconverter in the rotor circuit.

25. 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.

26. What are the components of the applied voltage to the induction motor?

The applied voltage to the induction motor has two components at low frequencies. They are

a. Proportional to stator frequency.

b. To compensate for the resistance drop in the stator.

The second component depends on the load on the motor and hence on rotor frequency.

27. 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.

28. What is voltage source inverter?

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

29. What is slip controlled drive?

When the slip is used as a controlled quantity to maintain the flux constant in the motor the drive is called slip controlled drive. By making the slip negative (i.e., decreasing the output frequency of the inverter). The machine may be made to operate as a generator and the energy of the rotating parts fed back to the mains by an additional line side converter or dissipated in a resistance for dynamic barking. By keeping the slip frequency constant, braking at constant torque and current can be achieved. Thus braking is also fast.

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

The motor receives square wave voltages. These voltages have harmonic components. The harmonics of the stator current 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.

31. 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 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.

32. What are the disadvantages of stator voltage control method? (AU 2012)

1. Voltage and current waveforms are highly distorted due to harmonics, which affects the efficiency of the motor.
2. Performance is poor under running condition at low speeds.
3. Operating efficiency is low as resistance losses are high.
4. Maximum torque available from the motor decreases with reduction in stator voltage

33. Define vector control. (AU 2011)

Vector control, also called field-oriented control (FOC), is a variable frequency drive (VFD) control method which controls three-phase AC electric motor output by means of three controllable VFD inverter output variables:

1. Voltage magnitude 2.Voltage angle 3. Frequency.

34. What are the merits and demerits of voltage and current fed inverters controlled drives? (AU 2011)

The stator current draw by the motor when fed square wave inverter has sharp peaks and rich in harmonic content that cause additional losses and heating of the motor. They also produce pulsating torque that is objectionable at low speeds.

1. Limitation on the speed range
2. The machine size is large and due to over excitation. It is under utilized.

35. Give the advantages of vector control method (AU 2011 & 2012)

Brushless DC motors offer several advantages over traditional brushed AC and DC motors, including lower materials costs, greater reliability, and longer lifetime. However, since brushless motors do not self commutate, torque control, which is fundamental to successful operation of any servo system, presents a more complex challenge. Several strategies have evolved for controlling torque in brushless motors, which perform commutation on the motor's behalf as well as calculating the optimal current for each stator to produce the maximum torque.

36. What are the various applications of stator voltage control scheme?

Heating,
Ventilation,
Air conditioning systems,
Waste water treatment plants,
Blowers,
Fans,
Textile mills,
Rolling mills, etc.

37. What are the advantages of static rotor resistance control over conventional rotor resistance control? (Nov-2013)

(i) Smooth and step less control
(ii) Fast response.
(iii) Less maintenance.
(iv) Compact size.
(v) Simple closed loop control.

38. What are the different methods of speed control of induction motor? (NOV/DEC 2014)

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

39. Distinguish between VSI and CSI (NOV/DEC 2014)

CSI	VSI

More reliable	Less reliable
Does not required feedback diodes Less dynamic response Cost is high It's not suitable for multi motor drive	Require feedback diodes high dynamic response Cost is less Its suitable for multi motor drive

40. What are the drawbacks of stator voltage controlled induction motor drive. (MAY/JUNE 2014)

- Voltage and current waveforms are highly distorted due to harmonics, which affects the efficiency of the motor.
- Performance is poor under running condition at low speeds.
- Operating efficiency is low as resistance losses are high.
- Maximum torque available from the motor decreases with reduction in stator voltage

41. Write any two advantages of vector control. (MAY/JUNE 2014)

Brushless DC motors offer several advantages over traditional brushed AC and DC motors, including lower materials costs, greater reliability, and longer lifetime. However, since brushless motors do not self commutate, torque control, which is fundamental to successful operation of any servo system, presents a more complex challenge. Several strategies have evolved for controlling torque in brushless motors, which perform commutation on the motor's behalf as well as calculating the optimal current for each stator to produce the maximum torque.

SIXTEEN MARKS

1. A 3Φ 60KW, 4000rpm, 460v, 60Hz, 2 pole star connected induction motor has the following parameters: Rs=0Ω, Rr=0.28Ω, Xs= 0.23Ω Xr=0.3Ω & X_m=11Ω. Motor speed is controlled by varying the supply frequency. If the breakdown torque requirement is 70NM. Calculate supply frequency and speed ω_m at the maximum torque. (AU 2013)
2. Explain the of operation constant V/f control of induction motor and draw the waveforms. (AU 2011)
3. Describe briefly the PWM inverter fed induction motor drive.
4. Explain the operation of induction motor fed by current source inverter.

5. Derive an expression for the torque-speed characteristics, based on this expression. How does this characteristics change, i) when stator voltage is varied (keeping frequency constant) ii) when the rotor resistance is varied?

6. How dynamic/ regenerative braking is achieved in a variable frequency V.S.I/C.S.I fed induction motor drives?

7. In a pump drive, the fluid flow is to be varied from full down to 50 percent. Stator voltage controlled 3 phase induction motor is used for driving the pump. If full load slip of the motor is 0.15. Evaluate i) the maximum motor current to rated motor current ratio. Also derive the expressions used. Expression for Imax/ Irated

8. Describe with a neat diagram the working of a current fed inverter induction motor drive. (AU 2011)

9. A 3 phase, star connected, 50 Hz, 4 pole induction motor has the following parameters in ohms per phase referred to the stator. Rs =Rr' = 0.034 W & Xs =Xr' = 0.18 W. The motor is connected by the variable frequency control with a constant (V/f). Determine the following for an operating frequency of 15 Hz. i) The breakdown torque as a ratio of its value at the rated frequency for motoring and braking.ii) The starting torque and rotor current in terms of their values at the rated frequency.

10. Explain about VSI induction motor drives and also closed loop control for VSI induction motor drives. (AU 2013)

11. Explain about variable frequency control in induction motor drives. (AU 2013)

12. Discuss in brief about the control of an induction motor by stator voltage variation using 3 phase voltage controller.

13. A 440 V, 50 Hz, 960rpm, star- connected wound rotor Induction Motor has: Rs=0.15W, Xr' =0.6W and Xm=20W. The stator to rotor turns ratio is 2. This motor is controlled by a rotor-chopper scheme. The filter inductor has a resistance of 0.01W. The external resistance is 4W. For a duty cycle of 0.7 and a speed of 600 rpm, evaluate the torque developed.

14. Explain the theory of v/f control in detail. (AU 2011, 2012)

15. Make a comparison between voltage/current fed inverters. (AU 2012)

16. Describe the vector control with a neat block diagram. (AU 2011) **(April/May 2015)**

17. Explain with a neat diagram the field weakening mode control of induction motor drives. (AU 2011)

18. A 2.8 KW, 400V, 50 Hz, 4 pole 1370 rpm, delta connected squirrel cage induction motor has following parameters referred to the stator Rs=2Ω, Rr=5Ω, Xs=Xr=5Ω, X=80Ω. Motor speed is controlled by stator voltage control. When driving a fan load it runs at rated speed at rated voltage. Calculate motor terminal voltage, current and torque at 1200 rpm. (AU 2012)

19. Describe the VSI fed induction motor drive**(NOV/DEC 2014)**

20. Explain in detail the static rotor resistance control in the induction motor drive**(NOV/DEC 2014)**

21. Explain in detail about the vector control for a induction motor**(NOV/DEC 2014)**

22. Explain the theory of v/f control in detail (**MAY/JUNE 2014)**

23. Explain about variable frequency control in induction motor drives in a closed loop with constant air gap flux. (**MAY/JUNE 2014)**

24. Compare VSI and CSI fed induction motor drive. (**MAY/JUNE 2014)**

25. Explain the block diagram of vector control of induction motor drive. (**MAY/JUNE 2014)**

26. Explain the four modes of operation of a static scherbius drive **(April/May 2015)**

. Explain the block diagram of vector control of induction motor drive.

UNIT V SYNCHRONOUS MOTOR DRIVES

TWO MARKS

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 cycloconverters, 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,

a. Wound field synchronous motors.

b. Permanent magnet synchronous motors

c. Synchronous reluctance synchronous motors.

d. 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,

a. High efficiency

b. High power factor

c. Low sensitivity to supply voltage variations, 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 in synchronous motor drives? (AU 2008) (AU 2013)

Variable frequency control may employ and of the two modes.

a. Synchronous mode

b. Self-controlled mode

9. Which synchronous machine is said to be self controlled? (AU 2011, 2012) (April/May 2015)

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

1. It does not require commutation circuits
2. Frequency of operation can be higher
3. 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 realised 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. If this angle of the thyristor, commutation failure occurs. 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 are the disadvantages of machine commutation?

The disadvantages of machine commutation are,

a. Limitation on the speed range.

b. The machine size is large

c. Due to overexciting it is underutilized.

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.

21. 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.

22. Write the advantages of permanent magnet synchronous motor. (AU 2012)

1. Elimination of field copper loss 2. Higher power density 3. Lower rotor inertia
4. Robust construction.

23. Define self control of synchronous motor. (AU 2012)

The self control of a synchronous motor is done using an inverter fed through a dc link. Speed is controlled by varying the output frequency of the inverter by controlling the dc link voltage

24. Which type of control can be used for constant torque operation in synchronous motor? How? (AU 2011)

In self controlled synchronous motor drive the load side converter is operated as an inverter and maximizes motor power factor.

25. What are the different types of control used in synchronous motor drives? (AU 2011)

The speed controller and current controller are the two major controllers used in the closed loop control of drives

26. What is the necessity of delay unit in a open loop v/f control of synchronous motor? (AU 2011)

This is done so that the rotor speed is able to track the changes in frequency. A flux control block is used which changes the stator voltage with frequency so as to maintain constant flux for speed below base speed and constant terminal voltage for speed above base speed.

27. When can the synchronous motor be load commutated? (Nov-2013)

When the synchronous motor operates at a leading power factor thyristors of the load side converter can be commutated by the motor induced voltages same way as the thyristors of a line commutated converter are commutated by line voltages.

28.When can a synchronous motor be load commutated? (NOV/DEC 2014)

When the synchronous motor operates at a leading power factor thyristors of the load side converter can be commutated by the motor induced voltages same way as the thyristors of a line commutated converter are commutated by line voltages.

29. Write down the torque equation of synchronous motor? (NOV/DEC 2014)

$T=3VE/X_S W_S(Sin\alpha)$

30. Define self control technique of synchronous motor. (MAY/JUNE 2014)

The self control of a synchronous motor is done using an inverter fed through a dc link. Speed is controlled by varying the output frequency of the inverter by controlling the dc link voltage

31. Write any two applications of synchronous motor drives? Justify the selection (MAY/JUNE 2014)

High power and high speed compressors

Blowers

Induced and forced draft fans

Main line traction

SIXTEEN MARKS

1. Explain the operation of a 'torque- angle control' based self –controlled synchronous motor drive. (AU 2011&2013)

2. Write short notes on Brushless Excitation system.

3. Explain the working of a self controlled synchronous mode fed from a three phase inverter. Why a self controlled synchronous motor is free from hunting oscillations?

4. i)Describe the self control of synchronous motor fed from VSI. Discuss about separately controlled synchronous motor fed from VSI. ii) Compare the above two schemes.

5. Explain the closed loop control scheme of adjustable speed synchronous motor drive. (AU 2013)

6. Explain the operation of a 'power factor control' based self –controlled synchronous motor drive.

7. Explain the open loop v/f speed control of permanent magnet synchronous motor in detail. (AU 2011, 2012 & 2013)

8. Explain the concept of self controlled synchronous motor drive. (AU 2011, 2012)

9. Explain the construction and working of permanent magnet synchronous motor. (AU 2011, 2012)

10. Describe the marginal angle control of synchronous motor drive. (AU 2011) **(April/May 2015)**

11. Explain self control of synchronous motor drive operated with constant margin angle control **(NOV/DEC 2014)**

12. Explain power factor control of synchronous motor drive**(NOV/DEC 2014)**

13. Write brief notes on different types of permanent magnet synchronous motors**(NOV/DEC 2014)**

14. A 3 phase 400v,50hz,6 pole a star connected round rotor synchronous motor has Zs=0+j2 ohm.loas 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 power factor by field control of the motor.for the motor operation at 600rpm.(1)supply voltage(2)the armature current(3)excitation voltage (4)load angle (5)pullout torque neglect rotational losses**(NOV/DEC 2014)**

15. Explain the open loop v/f speed control of permanent magnet synchronous motor in detail (**MAY/JUNE 2014)**

16. Explain the concept of self control technique. (**MAY/JUNE 2014)**

17. Explain the construction and working of closed loop operation of commutated less permanent magnet synchronous motor (**MAY/JUNE 2014) (April/May 2015)**

UNIT V DESIGN OF CONTROLLERS FOR DRIVES

TWO MARKS

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. Write any two advantages of closed loop control system? (AU 2012)

a. System protection.

b. Greater accuracy

c. Improved dynamic response

d. 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?

a. Current feedback

b. Speed feedback

5. How is speed feedback achieved in speed controller design? (AU 2011)

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?

1. Proportional controller 2. 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 only applicable for below base speed.

10. What is field weakening mode control? (AU 2010, 2011, 2012 & 2013)

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?

a. Stabilize the drive

b. Adjust the damping ratio at the desired value

c. Makes the steady state speed error close to zero by integral action and filters out noise again due to the integral action.

20. What are the functions of feedback loops in an electrical drives?

1. Protection
2. Improvement of speed response
3. To improve steady state accuracy

21. Write the transfer function of converter. (AU 2011)

$G_c(s) = K_c/1+sT_c$

K_c = Converter gain

T_c = Converter time delay S = Laplace operator

22. Write the real and reactive power equations of a balanced 3 phase ac system (AU 2011)

$P_i = P_o = (3)^{1/2} VI_1 \cos\alpha$

$Q_i = Q_o = (3)^{1/2} VI_1 \sin\alpha$

23. Write any two simulation packages used for drive systems? (Nov-2013)

1. MATLAB/SIMULINK
2. PSIM
3. PSPICE
4. EMTP
5. C

24.What is the function of current control loop in closed loop in closed loop speed control system? (NOV/DEC 2014)

- Protection
- Improvement of speed response
- To improve steady state accuracy

25. What are the factors to be considered for the selection of controller? (NOV/DEC 2014)

1) Steady state operation requirements.

2) Transient operation requirements.

3) Requirements related to the source.

4) Capital and running cost, maintenance needs life.

5) Space and weight restriction.

6) Environment and location.

7) Reliability.

26. Write down the advantages of PI Controller. (MAY/JUNE 2014)

- 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

27. Write down the transfer function of converter. (MAY/JUNE 2014)

$G_c(s) = K_c/1+sT_c$

K_c = Converter gain

SIXTEEN MARKS

1. Explain the closed loop speed control of DC drives. (AU 2011)
2. Write short notes on: (AU 2009)

1. Converter selection and characteristics
2. Field weakening mode control (AU2012)

3. With a block diagram discuss the operation of a closed loop scheme for speed control of a DC motor, below and above the base speed (AU 2009)

4. Derive the transfer function of DC motor load system with armature voltage control (AU 2009, 2011)

5. Write down the approximate expression with respect to converter selection and characteristics (AU 2009)

6. Explain in detail the design of current controller of closed loop speed control system of Dc separately Excited motor. (AU 2009, 2011 &2012)

7. Explain the closed loop operation of armature voltage control method with field weakening mode control in detail. (AU 2011)

8. Explain the design procedure of current controller in detail. (AU 2011)

9. Write the step by step procedure and drive the transfer function of the DC motor and load system. (AU 2008 & 2013)

10. Derive the transfer function of the speed controller? (AU 2008)

11. Describe the design of speed controller with necessary diagrams. (8) (AU 2011) (MAY/JUNE 2015)

12. Discuss the use of simulation software package for design of controller for drives. (AU 2011)

13. Discuss the current controller design using (i) P and PI controller for a separately excited dc motor drive system. (Nov-2013)

14. Explain in detail the operation of a closed loop scheme for speed control of a DC motor, below and above base speed. (NOV/DEC 2014)

15. Derive the transfer function of DC motor load system. (NOV/DEC 2014)

16. Derive the transfer function of the speed controller. (NOV/DEC 2014)

17. Explain the closed loop operation of armature voltage control method with field weakening mode control in detail (MAY/JUNE 2014) (MAY/JUNE 2015)

18. Explain in detail the design of current controller of closed loop speed control system of Dc separately Excited motor (MAY/JUNE 2014)