DEPARTMENT OF EEE

QUESTION BANK

(As Per AUC 2008 REGULATION)

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SUB NAME: SOLID STATE DRIVES

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UNIT – I

PART-A

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 are the requirements of an electric drive?

Stable operation should be assured.

The drive should have good transient response

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) Multimotor drive

5. List the different types of electrical drives.

1) dc drives 2) 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.

1) 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.

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

3) 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.

4) 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?

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 fro 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?

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

• Paper mills
• Electric traction Cement mills
• Steel mills

15. Mention the types of enclosures
Screen projected type
Drip proof type
Totally enclosed 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. Define cooling time constant
It is defined as the ratio between C and A. Cooling time constant is denoted as Tau.
Tau = C/A
Where C=amount of heat required to raise the temp of the motor body by 1 degree Celsius
A=amount of heat dissipated by the motor per unit time per degree Celsius.

24. What are the methods of operation of electric drives?
Steady state
Acceleration including starting
Deceleration including starting

25. Define four quadrant operations.
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 the motion. Motor can provide motoring and braking operations for both forward and reverse directions.

26. What is meant by mechanical characteristics?

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

27. Mention the types of braking

Regenerative braking

Dynamic braking Plugging

28. 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.

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

The applications of D.C. drives are,

a. Rolling mills b. Paper mills c. Mine winders d. Hoists

e. Machine tools f. Traction g. Printing presses h. Excavators

i. Textile mils j. Cranes

30. 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.

PART- B

1. (a) Discuss briefly the factors involved in the selection of drives. (8)

   (b) Compare AC and DC drives (8)

2. (a) Discuss in detail the thermal model of a motor for heating and cooling(8)

   (b) Draw the characteristics of different types of loads (8)

3. (a) Explain in detail the multi quadrant dynamics in the

   speed-torque plane(8)

   (b) Explain briefly the eight standard classes of motor duty. (8)

4. Derive the expressions to find the equivalent load torque and equivalent inertia of loads in Translational and Rotational motion. (16)

5. (a) State essential parts of electrical drives. Write a note on

   speed sensing devices. (8)

   (b) 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.The other load has translational motion and consists of 1000 kg weight to be lifted up at a uniform speed of 1.5 m/sec. Coupling between this load and the motor has an efficiency of 85%.Motor has an inertia of 0.2 kg-m2 and runs at a

constant speed of 1420 r.p.m. Determine the equivalent inertia

referred to the motorshaft and power delivered by the motor. (8)

6.(a)What do you understand by constant torque drive and constant power   drive? (8)

(b)Explain the different types of motors and the key issues considered in the selection of drives. (8)

7. (a)(i)Develop the mechanical characteristics of a separately excited dc motor. (4)

(ii)show that the motor can be operated both in constant torque and constant horse power modes. (4)

(iii)Explain about closed loop control of electric drives. (8)

8. (a)Explain how the rating of a motor is determined when it is subjected to continuous duty and variable load. (8)

(b)A constant speed drive has the following duty cycle:

(i)Load rising from 0 to 400 Kw - 4 minutes.

(ii)Uniform load of 500 Kw - 4 minutes.

(iii)remaining idle for 2 minutes.

Estimate the Power rating of the motor. Assume the losses to be proportional to (power)2 (8)

9.(a)Explain about the selection of motor power rating and determination of motor rating? (8)

(b)Explain about speed control and drive classifications. (8)

10. (a) (i)Give the reason for using electrical braking in DC motor. (4)

(i)Give the regenerative braking in separately excited DC motor. (6)

(iii) A dc shunt motor is connected to a constant voltage main.It drives the load torque which is independent of speed. Prove that if $E < \frac{1}{2}V$,increasing the air gap flux pole decreases the speed.While if $E < \frac{1}{2}V$, decreases the air gap flux increases the speed.(E-Induced emf,V-Supply voltage.) (6)

UNIT II

PART A

1. 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.
2. What are the advantages of series motor?
The advantages of series motors are,
a. High starting torque
b. Heavy torque overloads.
3. Define and mention different types of braking in a dc motor?
In breaking 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.
4. 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 top limit the current to a safe value during starting.
5. 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.

6. 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.

7. What is aline 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.

8. 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

**9. 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 seriesdelta
to parallel-star. Regenerative braking takes place during changeover from higher to
lower speeds.

10. 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.

11. Write the expression for average o/p voltage of full converter fed dc drives?

Vm=(2Vm/pi)cospi .... continuous conduction

Vm=[Vm(cos alpha-cos beta)+(pi+alpha+beta)]/pi] discontinuous conduction

12. 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

13. Mention the drawbacks of rectifier fed dc drives?

Distortion of supply. Low power

factor. Ripple in motor current

14. 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.

15. 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 low power control signal and don't need commutation circuit.

16. 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.

17. 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.

18. What are the types of control strategies in dc chopper?
• Time ratio control.
• Current limit control.

19. What are the adv. of using PI controller in closed loop ctrl. 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 are the different methods of braking applied to the induction motor?
Regenerative braking Plugging, Dynamic braking.

21. What are the different methods of speed control of IM?
Stator voltage control, Supply frequency control, Rotor resistance control, Slip power
recovery control.

22. 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.

23. 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.

24. 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.

25. 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.

26. 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 ctrl.

27. 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.

28. List the adv 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

29. 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 gn by,

%slip s=[(Ns-N)/Ns]x 100

30. Define base speed.

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

PART B

1.(a)Explain in detail the chopper control of separately excited dc motor under motoring mode and Regenerative breaking mode . (10)

   (b)Speed of a separately excited dc motor is controlled by means of two 3Ø full converters one in the armature circuit and the other in the field circuit and both are fed from 3Ø,400v ,50 Hz supply. Resistance of the armature and field circuits is 0.2   and 320   respectively. The motor torque constant is 0.5 V.S /A.rad. Field converter has zero degree firing angle delay. Armature and field currents have negligible ripple. For rated load torque of 60N.m at 2000 rpm, calculate the rated armature current. (6)

2. (a)Explain the operation of four quadrant dc chopper drive. (8)

(b)A dc chopper is used to control the speed of a separately excited dc motor.The DC voltage is 220 V,Ra = 0.2   and motor constant keØ=0.08V/rpm.The motor drives a constant load requiring an average armature current of 25 A, Determine.(1)The range of speed control.(2)The range of duty cycle. Assume –continuous conduction. (8)

3. Explain the motoring operation of a single phase fully controlled converter fed Separately excited DC motor in continuous and discontinuous modes with steady state analysis and wave forms. (16)

4. (a)Explain the operation of four quadrant chopper fed dc separately excited motor drive with necessary diagrams. (8)

(b) A 220V, 1500 rpm, 50 A separately excited motor with armature resistance of 0.5   . It is fed from a three phase fully controlled rectifier. Available ac source has a line voltage of 440 V at 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. (1)calculate transformer turns ratio. (2)Determine the value of firing angle when (a)motor is running at 1200 rpm and rated torque.(b)When motor is running at 800 rpm and twice the rated torque. Assume continuous conduction. (8)

5. Explain how three phase converter controlled dc motor drive can be operated in dual quadrant mode. Draw the relevant wave forms. (16)

6.(a) Explain closed loop speed control scheme of dc drives with a block

diagram. (8)

(b)A 220 V separately excited dc motor has an armature resistance of 2.5 .When driving a load at 600 r.p.m.with constant torque,the armature takes 20A.This motor is controlled by a chopper circuit with a frequency of 400 Hz. and an input voltage of 250V.

(1)What should be the value of the duty ratio if one desires to reduce the speed from 600 to 540r.p.m.with the load torque maintained constant.

(2)Find out the value of duty ratio for which the per unit ripple current will be maximum. (8)

7(a)Explain using a power circuit the working of a single phase full converter fed d.c series motor drive. (8)

(b)The speed of a d.c series motor is controlled by a single phase full converter connected to a 230v,50 hz source. The motor constant is 0.4 Vs/ A radians. The total field and armature resistance is 2 ohms. Assuming continuous and ripple free armature current,at a firing angle of 600 and speed of 1200 rpm,determine (1)the motor current and motor torque and (2)the power delivered to the motor. (8)

8. (a)Describe how a separately dc motor can be made to both run as a motor and operate in the braking mode using a chopper. (8)

(b)A 230 V,1100 rpm,220 Amps separately excited dc motor has an armature resistance of 0.02 ohms. The motor is fed from a chopper ,which provides both motoring and braking operations. calculate

(1)the duty ratio of the chopper for motoring operation at rated torque and 400 rpm.

(2)the maximum permissible motor speed obtainable without field weakening ,if the maximum duty ration of the chopper is limited to 0.9 and the maximum permissible motor current is twice the rated current. (8)

9.(a) The speed of a 10hp, 220V, 1200 rpm separately excited dc Motor is controlled by a single – phase fully controlled converter the rated armature current is 40A. The armature resistance is 0.25 .The ac supply voltage is 230V.The motor constant Ka = 0.18V/rpm.

Assume that the motor current is constant and ripple free. For a firing Angle of 30deg and rated motor current, determine the following:

(i)speed of the motor,

(ii) motor torque,

(iii) power supplied to the motor (8)

(b) A 220V, 1500 rpm, 10 A separately excited dc motor has an armature resistance of 10 . It is fed from a single phase fully controlled bridge rectifier with an ac source voltage of 230 V at 50 Hz. Assuming continuous load current, compute

i) the motor speed at a firing angle of 30 deg and torque of 5 N-m,

ii) developed torque at a firing angle of 45 deg and speed 1000rpm. (8)

10.(a) A 200V, 875 rpm, 150 A separately excited dc motor has an armature Resistance of 0.06 . It is fed from a single phase fully controlled rectifier with an ac source voltage of 220 V at 50 Hz. Assuming continuous conduction, calculate
(i) Firing angle for rated motor torque and 750rpm.
(ii) Firing angle for rated motor torque and (-500)rpm.
(iii) Motor speed for =160deg and rated torque (8)
(b). A 220V, 1200 rpm, 15 A separately excited dc motor has an armature Resistance and inductance of 1.8 and 32 mH respectively. This motor is controlled by single phase fully controlled bridge rectifier with an ac source voltage of 230 V at 50 Hz. Identify modes and calculate speeds for
(a) = 45 deg and torque = 40 Nm.

UNIT III

PART A

1. 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.
2. What is meant by V/F control l?
When the freq 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 behavior is similar to the working of dc series motor.
3. What are the advantages of V/F control?
   Smooth speed ctrl
   Small i/p current and improved power factor at low freq. start
   Higher starting torque for low case resistance
4. 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.

5. What are the 3 modes of region in the adjustable-freq IM drives characteristics?
   Constant torque region
   Constant power region
   High speed series motoring region
6. 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.
7. How will you select the motor rating for a specific application?
When operating for a specific application motor rating should be carefully chosen that the insulation temperature never exceed the prescribed limit. Otherwise either it will lead to its immediate thermal breakdown causing short circuit and damage to winding, or it will lead

to deterioration of its quality resulting into thermal breakdown in near future.

8. 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,

a. Regenerative braking.

b. Dynamic or rheostat braking.

c. Plugging or reverse voltage braking.

9. 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.

10. 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.

11. 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.

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

The drawbacks of Ward . Leonard drive are.

a. High initial cost

b. Low efficiency

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

13. Give some advantages of Ward-Leonard drive.

The advantages of Ward-Leonard drive are,

a. Inherent regenerative barking capability

b. Power factor improvement.

14. 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.

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

The rectifiers provide control of D.C. voltage in either direction and therefore, allow motor control in quadrants I and IV. They are known as fully-controlled rectifiers. The rectifiers allow D.C. Voltage control only in one direction and motor control in quadrant I only. They are known as half-controlled rectifiers.

16. What is called continuous and discontinuous conduction?

A D.C. motor is fed from a phase controlled converter the current in the armature may flow in discrete pulses in called continuous conduction.

A D.C. 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.

17. 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 intervals.

18. What is called inversion?

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

19. What are the limitations of series motor? Why series motor is not used in traction applications now a days?

1. The field of series cannot be easily controlled. If field control is not employed, the series motor must be designed with its base speed equal to the highest desired speed of the drive.

2. Further, there are a number of problems with regenerative braking of a series motor. Because of the limitations of series motors, separately excited motors are now preferred even for traction applications.

20. 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, more efficient, require lower maintenance and can operate in dirty and explosive environments.

21. 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.

22. 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 a constant rotor frequency.

23. 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 cyclconverter in the rotor circuit.

24. Mention the effects of variable voltage supply in a cage induction motor.
When a cage induction motor is fed from a variable voltage for speed control the following observations may be made.
a. The torque curve beyond the maximum torque point has a negative shape.
A stable operating point in this region is not possible for constant torque load.
b. The voltage controlled must be capable of withstanding high starting currents. The range of speed control is rather limited.
c. The motor power factor is poor.

25. Classify the type of loads driven by the motor.
The type of load driven by the motor influences the current drawn and losses of the motor as the slip various. The normally occurring loads are
a. Constant torque loads.
b. Torque varying proportional to speed.
c. Torque varying preoperational to the square of the speed.

26. What are the disadvantages of constant torque loads?
The constant torque loads are not favored 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 ad poor power factor at low speeds.

27. In which cases, torque versus speed method is suitable.
Torque versus speed method is suitable only for the following cases.
a. For short time operations where the duration of speed controls ids defined.
b. For speed control of blowers or pumps having parabolic or cubic variations of torque with speed. This is not suitable for constant torque loads due to increases and heating.

28. How is the speed of a squirrel cage induction motor controlled?
The speed of a squirrel cage induction motor can be controlled very effectively by varying the stator frequency. Further the operation of the motor is economical and efficient, if it operates at very small slips. The speed of the motor is therefore, varied by varying the supply frequency and maintaining the rotor frequency at the rated value or a value corresponding to the required torque on the linear portion of the torque-speed curve.

29. Why the control of a three-phase indication motor is more difficult than D.C. motors.
The control of a three-phase induction motor, particularly when the dynamic performance involved is more difficult than D.C. motors. This is due to a. Relatively large internal resistance of the converter causes voltage fluctuations following load fluctuations because the capacitor cannot be ideally large.
b. In a D.C. motor there is a decoupling between the flux producing magnetizing current and torque producing armature current. They can be independently controlled. This is not the case with induction motors.
c. An induction motor is very poorly damped compared to a D.C. motor.

30. 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.

PART – B

1. Explain in detail the static rotor resistance control in Induction motor. (16)

2. (a) Explain in detail about the closed loop control scheme of three phase VSI fed induction motor? (8)

(b) A three phase 56kw,4000 rpm,460 v ,60 hz,2 pole star connected induction motor has the following parameters: Rs =0, Rr=0.28 ,
Xs=0.23 , Xr=0.23 and Xm=11 . The motor is controlled by varying the supply frequency.If the break down torque requirement is 70 Nm.Calculate
(i)The supply frequency.
(ii)The speed Wm at the maximum torque. (8)

3. Explain the principle of operation of static Scherbius system. (16)

4. (a)A three phase induction motor at rated voltage and frequency has maximum torque of 225% and starting torque of 150 percent of full load torque. Neglect stator resistance and rotational losses. Assume constant rotor resistance. Calculate the following
(i)Slip at maximum torque.
(ii)Slip at full load. (8)

(b) (i)Describe the closed loop control with CSI fed induction motor (6)
(ii)Compare CSI and VSI fed induction motor. (2)

5. (a)Explain the operation of the constant slip speed control of an induction motor drive. (8)

(b) Draw and explain voltage/frequency control. (8)

6. A three phase ,star connected ,60 Hz ,4 pole induction motor has the following parameters for its equivalent circuit. Rs=Rr=0.024 and Xs=Xr=0.12 .The motor is controlled by the variable frequency control with a constant (v/f)ratio.For an operating frequency of 12 Hz.
calculate:
(i)The breakdown torque as a ratio of its value at the rated frequency for both monitoring and braking.
(ii)The starting torque and rotor current in terms of their values at the rated frequency. (16)

7. Explain the voltage source inverter (VSI) fed induction motors drive operated as (i)Stepped wave inverter (ii)PWM inverter. (16)

8. (a) A 400 V star connected three phase ,6 pole ,50 hz induction motor has following parameters referred to the stator: Rs=Rr=1 ohm,Xs=Xr'=2 ohm.For regenerative braking operation of this motor determine the maximum overhauling torque it can hold and range of speed for safe operation. (8)

(b)Explain the V/f speed control scheme of three phase induction motor. (8)

9. Explain the advantages of variable frequency induction motor drives State and explain the various schemes for induction motor speed control by VSI's. (16)

10. (a)Explain using a power circuit how the speed of a diode bridge based voltage source inverter fed induction motor drive can be controlled. (10)

(b) Bring out the advantages of CSI over VSI fed induction motor drives.(6)

11. (a)Describe using a circuit a scheme for regeneratively braking a three

phase induction motor. (8)

(b) A three phase 440V ,50 HZ ,6 pole star connected induction motor has the following parameters referred the stator R1=0.5 ohms,R2=0.6 ohms,X1=X2=1 ohm.The stator to rotor turns ratio is 2.If the motor is regenratively braked, determine

(i)the maximum overhauling torque, it can hold and the range of speed in which it can safely operate.

(ii)the speed at which it will hold load with a torque of 160 N-M (8)

12 .(a)Explain in detail about the stator voltage control of an induction motor? (8)

(b).A 400 V, 4 pole, 50 Hz , three phase star connected induction motor has r1 = 0, x1 = x2 = 1   , r2 = 0.4   , Xm = 500   . The induction motor is fed from (1) A constant voltage source of 231 V/phase (2) A constant current source of 28 A. For both the cases calculate the slip at which maximum torque occurs and the starting and maximum torques. (8)

13 .(a)A 3 KW , 400 V , 50 Hz, 4 pole ,1370 rpm, delta connected squirrel cage induction motor has the following parameters referred to stator .R1 = 2   , X1 = X2 = 5   , R2 = 5   , Xm = 90   . Motor speed is controlled by stator voltage control. When driving a fan load it runs at rated speed at rated voltage. Calculate (1) Motor terminal voltage, current and torque at 1200 rpm

(2) Motor speed, current and torque for the terminal voltage of 300 V. (8)

(b)A 3-Phase , 20 KW, 4 pole , 50 Hz, 400 V, delta connected induction motor has rotor leakage impedance of 0.5 + j2.0   . Stator leakage impedance and rotational losses are assumed negligible. If this motor is energized from a source of 3-Phase, 400 V, 90 Hz, then compute

(a) The motor speed at rated torque

(b) The slip at which maximum torque occurs and

(c) the maximum torque.

UNIT IV

PART A

1. 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 deepens on the load on the motor and hence on rotor frequency.

2. 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.

3. What is voltage source inverter?

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

4. What is the purpose of inductance and capacitance in the D.C. link circuit?

The inductance in the D.C. link circuit provides smoothing whereas the capacitance maintains the constancy of link voltage. The link voltage is a controlled quality.

5. What are the disadvantages of square wave inverter in induction motor drive?
Square wave inverters have commutation problems at very low frequencies, as the D.C. link voltage available at these frequencies cannot charge the commutating capacitors sufficiently enough to commutate the thrusters. Those puts a limit on the lower frequency of operation. To extend the frequency towards zero, special charging circuits must be used.

6. 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 enrolled 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.

7. What are the effects of harmonics in VSI fed induction motor drive?
The motor receives square wave voltages. These voltage has 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 rang of operating frequencies of the inverter.

8. What is a current source inverter?
In a D.C. 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 a low impedance to harmonic currents and have unity p.f.

9. Explain about the commutation of the current source inverter.
The commutation of the inverter is load dependent. The load parameters form a part of the commutation circuit. A matching is therefore required between the inverter and the motor. Multimotor operation is not possible. The inverter must necessarily be a force commutated one as the induction motor cannot provide the reactive power for the inverter. The motor voltage is almost sinusoidal with superimposed spikes.

10. Give the features from which a slip controlled drive is developed.
The stator current of an induction motor operating on a variable frequency, variable voltage supply is independent of stator frequency if the air gap flux is maintained constant. However, it is a function of the rotor frequency. The torque developed is also a function of rotor frequency. The torque developed is also a function of rotor frequency only. Using these features a slip controlled drive can be developed employing a current source inverter to feed an induction motor.

11. How is the braking action produced in plugging?
In plugging, the barking torque is produced by interchange any two supply terminals, so that the direction of rotation of the rotating magnetic field is reversed with respect to the rotation of the motor. The electromagnetic torque developed provides the braking action and brings the rotor to a quick stop.

12. Where is rotor resistance control used?
Where the motors drive loads with intermittent type duty, such as cranes, ore or coal

unloaders, skip hoists, mine hoists, lifts, etc. slip-ring induction motors with speed control by variation of resistance in the rotor circuit are frequently used. This method of speed control is employed for a motor generator set with a flywheel (Ilgner set) used as an automatic slip regulator under shock loading conditions.

13. What are the advantages and disadvantages of rotor resistance control?
Advantage of rotor resistance control is that motor torque capability remains unaltered even at low speeds. Only other method which has this advantage is variable frequency control. However, cost of rotor resistance control is very low compared to variable frequency control.
Major disadvantage is low efficiency due to additional losses in resistors connected in the rotor circuit.

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16. How is the resistance in the output terminals of a chopper varied?
The resistance connected across the output terminals of a chopper can be varied form O to R by varying the time ratio of the chopper. When the chopper is always OFF, the supply is always connected to the resistance R. The time ratio in this case is zero and the effective resistance connected in R. Similarly when the chopper is always ON, the resistance is short circuited. The time ratio in the case is unity and the effective resistance connected is 0. Hence by varying the time ratio from 0 to 1, the value of resistance can be varied from R to O.

17. What is the function of inductance L and resistance R in the chopper resistance circuit?
A smoothing inductance L is used in the circuit to maintain the current at a constant value. Any short circuit in the chopper does not become effective due to L.
The value of R connected across the chopper is effective for all phases and its value can be related to the resistance to be connected in each phase if the conventional method has been used. The speed control range is limited by the resistance.

18. What are the disadvantages and advantages of chopper controlled resistance in the rotor circuit method?
The method is very inefficient because of losses in the resistance. It is suitable for intermittent loads such as elevators. At low speeds, in particular the motor has very poor efficiency. The rotor current is non-sinusoidal. They harmonics of the rotor current produce torque pulsations. These have a frequency which is six times the slip frequency.
Because of the increased rotor resistance, the power factor is better.

19. How is the range of speed control increased?
The range of speed control can be increased if a combination of stator voltage control and rotor resistance control is employed. Instead of using a high resistance rotor, a slip ring rotor with external rotor resistance can be used when stator voltage control is used for controlling the

speed.

20. Why the static scherbius drive has a poor power factor?

Drive input power is difference between motor input power and the power fed back.
Reactive input power is the sum of motor and inverter reactive power. Therefore, drive has a poor power factor throughout the range of its options.

21. 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 cycloconverter. A cycloconverter allows power flow in either direction making the static sherbets drive operate at both sub and supper synchronous speeds.

22. Give the features of static scherbius drive

The torque pulsations and other reactions are minimal. The performance of the drive
improves with respect to additional losses and torque pulsations. A smooth transition is possible from sub to super synchronous speeds without any commutation problems. Speed reversal is not possible. A step up transformer may be interposed between the lines and the converter, to reduce the voltage rating of the converter.

23. Where is Kramer electrical drive system used?

Some continuous rolling mills, large air blowers, mine ventilators, centrifugal pumps and
any other mechanisms including pumps drives of hydraulic dredgers require speed adjustment in the range from 15 to 30% below or above normal. If the induction motor is of comparatively big size (100 to 200 KW) it becomes uneconomical to adjust speed by mean's pf external resistances due to copper losses as slip power is wasted as heat in the retort circuit resistance. In these case , the Kramer electrical drive system is used , where slip power recovery takes places.

24. What is the use of sub synchronous converter cascades?

Sub synchronous converter cascades have been used, till now, in applications requiring
one quadrant operation. These can be employed for drives where at least one electrical barking is required. A four quadrant operation can also be made possible in these cascades, using suitable switching.

25. How is the speed control obtained in static Kramer drive?

For speed control below synchronous speed, the slip power is pumped back to the supply,
where as for the case of speed above synchronous speed, additional slip power is injected into the rotor circuit.

26. What is static Kramer drive?

Instead of wasting the slip power in the rotor circuit resistance, it can be converted to 60
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 know as static Kramer drive.

27. What is the use and functions of step down transformer is static Kramer drive?

For a restricted speed range closer to synchronous speed, the system power factor can be
further improved by using a step -down transformer.
The step-down transformer has essentially two functions: besides improving the line power factor, it also helps to reduce the converter power ratings.

28. What are the advantages of static Kramer drive?

The static Kramer drive has been very popular in large power pump and fan-type drives,
where the range of speed control is limited near, but below the synchronous speed. The drive system is very efficient and the converted power rating is low because t has to handle only the slip power, In fact, the power rating becomes lower with a more restricted range of speed control. The additional advantages are that the drive system has D.C. machine like characteristics and the control is very simple.

29. What are the causes of harmonic currents in static Kramer drive?
The rectification of slip power causes harmonic currents in the rotor, and these harmonics
are reflected to the stator by the transformer action of the machine. The harmonic currents are also
injected into the A.C. line by the inverter. As a result, the machine losses are increased and some
amount of harmonic torque is produced. Each harmonic current in the rotor will create a reading
magnetic filed and its direction of rotation will depend on the order pf the harmonic.

PART B

1. With necessary diagram explain the closed loop speed control of load commutated inverter synchronous motor drive. (16)

2. Draw the open loop volts/Hz speed control of multiple PM synchronous motors and volts/Hz speed control characteristics in torque –speed plane. (16)

3. Explain in detail the construction ,principle of operation and applications of Permanent Magnet Synchronous Motor. (16)

4. (a) Explain in detail about PMSM drives (8)
(b)Explain power factor control of Synchronous Motor with relevant vector diagram. (8)

5. A 3 phase, 400 V , 50 Hz, 6 pole star connected round- rotor synchronous motor has Zs = 0+j2 . Load torque, proportional to speed squared, is 340 N-m 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 at 600 rpm, calculate a) supply voltage b) armature current c) excitation angle d) load angle e) the pull – out torque. Neglect rotational losses. (16)

6. (a) State and explain the role of damper winding in a synchronous motor? (8)
(b) Write short note on cycloconverter fed synchronous motor. (8)

7. Describe the self control of synchronous motor fed from VSI. Discuss about the separately controlled synchronous motor fed from VSI. (16)

8. Write brief notes about
(a)Constant margin angle control. (8)
(b)Synchronous motor fed from cycloconverter. (8)

UNIT – V

PART – A

1. 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

2. 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, servo drives, etc.

3. 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.

4. 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.

5. 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. Hysterias motors.

6. 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'.

7. 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.

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

8. 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.

9. Mention the two modes employed in variable frequency control

Variable frequency control may employ and of the two modes.

a. True synchronous mode b. Self-controlled mode

10. Define load commutation

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

11. 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.

12. 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, main-line traction and aircraft test facilities.

13. 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 relaised by making frequency of voltage induced in the armature. Firning pulses are therefore generated either by comparison of motor terminal voltages or by rotor position sensors.

14. 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 f the thyristor.

15. 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.

16. How is PNM 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 form a diode rectifier. In this case an additional phase controlled converter is required on the line side.

17. What is D.C. link converter and cycloconverter?
D.C. link converter is a two stage conversion device which provides a variable voltage, variable frequency supply.
Cycloconverter is a single stage conversion device which provides a Variable voltage, variable frequency supply.

18. What are the disadvantages of cycloconverter?
A cycloconverter requires large number of thyristors and ts control circuitry is complex. Converter grade thyristors are sufficient but the cost of the converter is high.

19. What are the applications of cycloconverter?
A cycloconverter 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.

20. Give the application of CSI fed synchronous motor.
Application of this type of drive is in gas turbine starting pumped hydroturbine starting, pump and blower drives, etc.

21. 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.

22. 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.

23. 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.

24. When can the synchronous motor be load commutated?

When the synchronous motor operates at a leading power factor thyristors of 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.

25. What are the characteristics of self controlled mode operated synchronous motor?

a) It operates at like dc motor also commutator less motor.

b) These machines have better stability behavior.

c) Do not have oscillatory behavior.

26. What are the characteristics of true synchronus mode operated synchronous motor?

The motor behaves like conventional synchronous motor i.e) hunting oscillations exists.

The change in frequency is slow enough for rotor to truck the changes.

Multi motor operation is possible here.

27. What is meant by sub synchronous speed operation?

The sub synchronous speed operation means the SRIM speed can be controlled below the synchronous speed. i.e) the slip power is fed back to the supply.

28. What is meant by super synchronous speed operation?

The super synchronous speed operation means the SRIM speed can be controlled above the synchronous speed. i.e) the supply is fed back to the rotor side.

29. What are the two types of static scherbius system?

a) DC link static scherbius system b) Cyclo converter scherbius system

PART – B

1. **Describe the operation of variable reluctance stepper motor. (16)**

2. **With a neat diagram describe the working of switched reluctance motor. (16)**

3. **(a)Compare the permanent magnet stepper motor with variable reluctance stepper motor (8)**
    (b)Discuss the advantages and disadvantages of using stepper motor (8)
4. **Explain the operation of Brushless DC motor drives and its applications. (16)**
5. **Explain the operation of permanent magnet stepper motor drives. (16)**
6. **Explain about modern trends in industrial drive and its applications (16)**
7. **What is stepper motor? Explain in detail and its types. (16)**