QUESTION BANK

NAME OF THE SUBJECT: EE 1403 SOLID STATE DRIVES

YEAR / SEM : IV / VII

UNIT – I

FUNDAMENTALS OF ELECTRIC DRIVES

PART-A ( 2 MARKS)

1. What is meant by electrical drives?
2. Mention the different types of drives.
3. List the different types of electrical drives.
4. What are the advantages of electric drives?
5. Mention the different factors for the selection of electric drives?
6. What are the parts of electrical drives.
7. Mention the applications of electrical drives
8. Mention the types of enclosures
9. Mention the different types of classes of duty
10. Define equivalent current method
11. Define cooling time constant
12. What are the methods of operation of electric drives?
13. Define four quadrant operation.
14. What is meant by mechanical characteristics?
15. What are the Typical elements of an Electric Drive?
PART-B

1. (a) Draw and explain the general electric drive system (8)
   (b) Compare AC and DC drives (8)

2. (a) Explain in detail about dynamics of motor load system (8)
   (b) Draw the characteristics of different types of loads (8)

3. Explain in detail about multiquadrant operation. (16)

4. Explain in detail about regenerative breaking. (16)

5. (a) Explain heating and cooling curves (8)
   (b) Explain the selection of electric drives for particular application. (8)

6. (a) Explain in detail the multi quadrant dynamics in the speed-torque plane. (8)
   (b) Explain the principle of regenerative braking used in four –quadrant industrial drives. (8)

7. (a) Explain the concept of steady state stability condition in Industrial drives. (8)
   (b) Discuss the different modes of operation of an electrical drives. (8)

8. (a) Derive the mathematical expression for the analysis of steady state stability of equilibrium point. (8)
   (b) Explain the multi quadrant operation of low speed hoist drive with neat diagram. (8)

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

10. (a) Explain in detail about the multi quadrant dynamics in the speed-torque plane. (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-m$^2$ 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-m$^2$ and runs at a constant speed of 1420 r.p.m. Determine the equivalent inertia referred to the motor shaft and power delivered by the motor. (8)

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

(b) State essential parts of electrical drives. Write a note on speed sensing devices. (8)

12. What are the main factors which decide the choice of electrical drive for a given application? (16)

13. Explain the four quadrant torque-speed characteristics of a dc motor drive. (16)

14. Explain the different types of motors and the key issues considered in the selection of drives. (16)

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

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

(c) Describe the four quadrant operation of an electric motor driving a hoist load. (8)

16. (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 \((\text{power})^2\).

17. (a) Give the reason for using electrical braking in DC motor. (4)
(b) Give the regenerative braking in separately excited DC motor. (6)
(c) 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

CONVERTER / CHOPPER FED DC MOTOR DRIVE

PART – A (2 MARKS)

1. Mention the types of braking
2. Define and mention different types of braking in a dc motor?
3. List the drawbacks of armature resistance control?
4. What is static Ward-Leonard drive?
5. What is a line commutated inverter?
6. Mention the methods of armature voltage controlled dc motor?
7. Write the expression for average o/p voltage of full converter fed dc drives?
8. What are the disadvantages of conventional Ward-Leonard schemes?
9. Mention the drawbacks of rectifier fed dc drives?
10. What are the advantages in operating choppers at high frequency?
11. Why self commutated devices are preferred over thyristors for chopper circuits?
12. State the advantages of dc chopper drives?
13. What are the advantages of closed loop c of dc drives?
14. What are the types of control strategies in dc chopper?
15. What are the advantages of using PI controller in closed loop control of dc drive?
PART – B

1. (a) Explain the steady state analysis of the single phase fully controlled converter fed separately excited DC motor drive. 
(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 are 0.2Ω and 320 Ω 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.

2. (a) Explain the operation of four quadrant dc chopper drive.
(b) A dc chopper is used to control the speed of a separately excited dc motor. The DC voltage is 220 V, R_a = 0.2 Ω and motor constant k_eØ=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.

3. Explain the operation of a single phase fully controlled converter fed separately excited DC motor with neat waveforms and derive the Speed torque characteristics.

4. 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.

5. (a) Explain the operation of four quadrant chopper fed dc separately excited motor drive with necessary diagrams.
(b) A 220V, 1500 rpm, 50 A separately excited motor with armature resistance of 0.5 Ω. 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.
(i) calculate transformer turns ratio.
(ii) 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.

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


8. (a) Explain the operation of the two quadrant chopper fed dc drive.

    (b) A 220 V separately excited dc motor has an armature resistance of 2.5 Ω. 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. 

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

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

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

    (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 V-s/A radians. The total field and armature resistance is 2 ohms. Assuming continuous and ripple free armature current, at a firing angle of 60° and speed of 1200 rpm, Determine (i) the motor current and motor torque and (ii) the power delivered to the motor.

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

    (ii) 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 (i) the duty ratio of the chopper for motoring operation at rated torque and 400 rpm.
(ii) the maximum permissible motor speed obtainable without field weakening, if the maximum duty ratio of the chopper is limited to 0.9 and the maximum permissible motor current is twice the rated current. (8)

11. Draw the power circuit diagram and explain the operation of a three-phase full converter fed separately excited DC motor. (16)

12. Explain regenerative braking and dynamic braking of separately excited dc motor by chopper control. (16)

13. Explain closed loop speed control scheme of dc drives with a block diagram. (16)

14. (a) Explain regenerative braking and dynamic braking of series motor by chopper control. (8)
   (b) What are the various control strategies for varying duty cycle of the chopper? (8)

15. (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 0.25Ω. The ac supply voltage is 230V. The motor constant \( K_a \Phi = 0.18 \text{V/rpm} \).
   Assume that the motor current is constant and ripple free. For a firing angle of 30 deg 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 Ω. 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 1000 rpm. (8)

16. (a) A DC series motor is fed from 600 V dc source through a chopper. The dc motor has the following parameters: \( R_a = 0.04 \Omega, R_s = 0.06 \Omega, K = 4 \times 10^{-3} \text{Nm/amp}^2 \). The average armature current of 300A is ripple free. For a chopper duty cycle of 60%.
Determine (i) input power from the source, (ii) motor speed (iii) motor torque. (8)

(b). A 220V, 1200 rpm, 15 A separately excited dc motor has an armature resistance and inductance of 1.8 Ω 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 \( \alpha = 45 \text{ deg} \) and torque = 40 Nm. (8)

UNIT – III

INDUCTION MOTOR DRIVES

PART – A (2 MARKS)

1. What are the different methods of braking applied to the induction motor?
2. What are the different methods of speed control of IM?
3. What is meant by stator voltage control?
4. Mention the application of stator voltage control.
5. Mention the applications of ac drives.
6. What are the three regions in the speed-torque characteristics in the IM?
7. What are the advantages of stator voltage control method?
8. What is meant by soft start?
9. List the advantages of squirrel cage IM?
10. Define slip
11. Define base speed.
12. What is meant by frequency control of IM?
13. What is meant by V/F ctrl?
14. What are the advantages of V/F ctrl?
15. What is meant by stator current ctrl?
16. What are the 3 modes of region in the adjustable-freq IM drives char.?
17. What is meant by regenerative braking?
18. What is meant by dynamic braking?
19. What is meant by plugging?
20. What is meant by rotor resistance control?
21. What is meant by slip power recovery system?
22. What are the advantages of slip power recovery system?
23. What are the different types of slip recovery system?
24. What is the function of static Kramer system?
25. The cycloconverter scherbius drive is also called as constant torque drive. Why?
PART – B

1. (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: \( R_s = 0 \), \( R_r = 0.28 \, \Omega \), \( X_s = 0.23 \, \Omega \), \( X_r = 0.23 \, \Omega \), and \( X_m = 11 \, \Omega \). 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 \( W_m \) at the maximum torque. (8)

2. (a) Explain the principle of operation of static Scherbius system. (8)

(b) A three phase, 4 pole, 50 hz slip ring induction motor when fully loaded, run with a slip of 4%. Find the value of the resistance necessary in series per phase of the rotor to reduce the speed by 15%. Assume that the resistance of the rotor per phase is 0.5 ohm. (8)

3. (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. (8)

(ii) Slip at full load.

(b) (i) Describe the closed loop control with CSI fed induction motor (6)

(ii) Compare CSI and VSI fed induction motor. (2)

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

(b) Draw and explain voltage/frequency control. (8)
5. (a) Explain with neat diagram and equations the static scherbius system of slip power recovery scheme.  
(b) A three phase ,star connected , 60 Hz , 4 pole induction motor has the following parameters for its equivalent circuit. Rs=Rr=0.024 Ω and Xs=Xr=0.12 Ω. 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. 

6. Draw and explain the slip power recovery scheme applicable for 
   Three phase slip ring induction motor 

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

8. Explain closed loop speed control scheme of dc drives with a block diagram. 

9. (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. 
    (b) Explain the V/f speed control scheme of three phase induction motor. 

10. Explain the advantages of variable frequency induction motor drives State and explain the various schemes for induction motor speed control by VSI’s. 

11. Explain the operation of v/f control technique of speed control method of Induction motor. List the ways to implement the voltage to frequency ratio.
12. Classify different types of braking Induction motor and explain the regenerative braking method for an induction motor with a suitable sketch. (16)

13. Derive the expression for three phase induction motor using equivalent circuit? Also draw its speed – torque characteristics. (16)

14. (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)

15. (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 $R_1=0.5$ ohms, $R_2=0.6$ ohms, $X_1=X_2=1$ ohm. The stator to rotor turns ratio is 2. If the motor is regeneratively 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)

16. (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 $r_1=0$, $x_1=x_2=1$ Ω, $r_2=0.4$ Ω, $X_m=500$ Ω. 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)

17. A 3-Phase, 20 KW, 4 pole, 50 Hz, 400 V, delta connected induction motor has the following per phase parameters referred to stator. $r_1=0.6$ Ω, $r_1=0.4$ Ω, $x_1=x_2=1.6$ Ω. Its magnetizing reactance is neglected. If this motor is operated at 200 V, 25 Hz with DOL starting, calculate (i) current and power factor at the instant of starting.
and under maximum torque conditions, compare the results with normal values (ii) starting and maximum torques and compare with normal values. (16)

UNIT – IV

SYNCHRONOUS MOTOR DRIVES

PART – A (2 MARKS)

1. What are the different modes of control that exist in a synchronous motor on a variable frequency supply?
2. What are the different classifications of synchronous motor?
3. When can the synchronous motor be load commutated?
4. What are the disadvantages of the VSI (Square wave) fed synchronous motor?
5. What are the major applications of cycloconverter fed synchronous motor?
6. What are the advantages of cycloconverter drive?
7. What is the main advantages of using closed loop control in drives?
8. What are the characteristics of self controlled mode operated synchronous motor?
9. What is the effect of VSI on the line power factor and the synchronous machine power factor?
10. What are the disadvantages of load commutation in the CSI fed synchronous motor drive?

PART – B

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

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

5. (a) Explain self control of Synchronous Motor in detail. (8)  
(b) Explain power factor control of Synchronous Motor with relevant vector diagram. (8)

6. A 3 phase, 400 V, 50 Hz, 6 pole star connected round-rotor synchronous motor has \( Z_s = 0 + j 2 \Omega \). 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)

7. Explain in detail about wound field synchronous motor? (16)

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

9. Explain in detail about the open loop v/f control and self controlled mode of the Synchronous motor? (16)

10. Write brief notes about  
   i) Constant margin angle control. (8)  
   ii) Synchronous motor fed from cycloconverter. (8)

11. Explain in detail about PMSM drives. (16)
UNIT – V
BLDC, STEPPER AND SWITCHED RELUCTANCE MOTOR DRIVES

PART – A (2 MARKS)

1. What are the applications of stepper motors?
2. What are the advantages and disadvantages of stepper motors?
3. What are the important features and applications of brushless DC motor drives?
4. What is the slew range?
5. What is ramping?
6. What are the advantages of switched reluctance motor over other AC motor drives?
7. What is stepper motor?
8. What are the disadvantages of SRM?
9. What is the difference between switched reluctance motor and synchronous reluctance motor?
10. What is BLDC?

PART – B

1. Describe the operation of variable reluctance stepper motor. (16)
2. Explain the operation and control of switched reluctance motor? (16)
3. Explain the operation of brushless DC motor drives and its applications. (16)
4. Explain the operation of permanent magnet stepper motor drives. (16)
5. Explain about modern trends in industrial drive and its applications (16)