OBJECTIVE:

This subject deals with the importance of power electronics equipments, different a.c and d.c machines speed control techniques

GROUP-I (SHORT ANSWER TYPE QUESTIONS)

S.No	QUESTION	BLOOMS TAXONOMY	COURSE OUTCOME
UNIT-I CONTROL OF DC MOTORS BY SINGLE PHASE CONTROLLED CONVERTERS			
1	What are the advantages of electrical drives	Understand	1
2	State essential parts of electrical drives. What are the function of a power modulator	Analyse	1
3	Write a brief note on the motors employed in variable speed drives	Remember	1
4	State and explain the functions of various converters	Understand	1
5	List out the drawbacks of rectifier fed DC drive.	Remember	1
6	Explain the different converters used for speed control of DC series motor	Understand	1
7	What are the use of phase controlled rectifier in DC drives	Understand	1
8	Give a simple circuit for the speed of a DC separately excited motor	Remember	1
9	Write a brief note on the sources employed in electrical drives	Understand	1
10	What are the main factors which decide the choice of electrical drive for a given for application	Understand	1
UNIT-II CONTROL OF DC MOTORS BY THREE PHASE CONTROLLED CONVERTERS			
1	A separately – excited dc motor is require to be controlled from a 3-phase source for operation in the first quadrant only. The most preferred converter would be	Remember	2
2	A 3-ϕ semi converter is connected to 400 v, 3- ϕ, 50Hz ac supply is delivering 20 A to dc motor. If the firing angle $\alpha = 30°$, the power input to the motor is	Analyse	2
3	A 3ϕ semi converter connected to 400 V, 3ϕ supply delivering 10A continuous current with firing angle $\alpha = 60°$ The r m s value of the line current is	Analyse	2
4	A 3ϕ semi converter is	Analyse	2
5	The speed a separately excited dc motor is controlled by 3ϕ semi converter. Input voltage 4154 V,R_a =0.9 Ω, K_m = 1.5 V/rad/s. $I_{a\,=}$ 10A. The motor developed torque is	Remember	2

6	The speed of a separately excited dc motor is controlled by semi converter. V=415 V,R_a = 0.9 Ω, K_m = 1.5V/rad/s. I_a = 33.3 A, α = 45°. The motor speed is	Understand	2
7	A 3ϕ full converter is	Remember	2
8	A3ϕ fully controlled bridge rectifier is connected to 400 V AC supply. The load current is continuous. If the firing angle is 60°, the average output voltage is	Remember	2
9	The average output voltage equation of the 3-ϕ full converter is	Understand	2
10	A dc separately excited dc motor speed is controlled by3ϕ full converter V=400V,R_a =0.1 Ω, K_m = 1.6V-s/rad, I_a = 200 A, α = 30°. The motor speed is given by	Remember	2
UNIT-III **FOUR QUADRANT OPERATION OF DC DRIVES**			
1	What is 4-quadrant operation and explain with converters	understand	3
2	What is a dual converter	understand	3
3	What is braking	understand	3
4	What is plugging	Analyse	3
5	What is dynamic braking	Analyse	3
6	What is regenerative braking	Analyse	3
7	What is the operation of converter in third and fourth quadrants	Analyse	3
8	What is the operation of converter in first and second quadrants	Analyse	3
9	What is circulating current mode operation	Analyse	3
10	What is counter current braking	Apply	3
UNIT-1V **CONTROL OF DC MOTORS BY CHOPPERS**			
1	What are the types of the DC chopper drives	remember	4
2	What is motoring control in choppers	understand	4
3	What is régénérative in choppers	analyse	4
4	What is dynamic braking in choppers	analyse	4
5	Draw the circuit of type A choppers	analyse	4
6	What are the control stratagies in choppers	analyse	4
7	What is time ratio control	remember	4
8	What is currently limit control	analyse	4
9	Define constant frequency system	remember	4
10	Define variable frequency system	remember	4
UNIT-V **CONTROL OF INDUCTION MOTOR OF STATOR SIDE**			
1	What are advantages of induction motor	analyse	5
2	What are the application of slip ring induction motor	Understand	5
3	Define rotor current frequency	Remember	5
4	Draw the equivalent circuit of an induction motor	Apply	5
5	Write torque equation of an induction motor	Remember	5
6	Define stating torque	Create	5
7	Define maximum torque	Remember	5
8	Define full load torque	Evaluate	5
9	Draw the speed torque characteristics of induction motor	Remember	5

10	What are the conventional methods for stator voltage control	remember	5
UNIT-VI **CONTROL OF INDUCTION MOTOR BY STATOR FREQUENCY**			
1	Draw the speed torque characteristics of induction motor with variable frequency	Analyse	6
2	What is dynamic braking induction motor	Understand	6
3	What regenerative braking in induction motor	Remember	6
4	What are the advantages of variable frequency control	Apply	6
5	What are the disadvantages of variable frequency control	Remember	6
6	What are the limitation of v/f control	Create	6
7	What is constant torque mode operation	Apply	6
8	What is constant power mode operation	Evaluate	6
9	What is constant slip mode operation	Remember	6
10	What are the application of variable frequency drives	remember	6
UNIT-VII **CONTROL OF INDUCTION MOTOR OF ROTOR SIDE**			
1	What are the different types of rotor resistances control in induction motor	Analyse	7
2	Draw the speed torque characteristics of rotor resistances control	Understand	7
3	What are the advantages of rotor resistance control	Remember	7
4	What are the disadvantages of rotor resistance control	Apply	7
5	What is the equation for affective resistance in static rotor resistance control	Remember	7
6	What is slip power recovery system	Create	7
7	What are the types of slip power recovery system	Apply	7
8	What are the advantages of Kramer system	analyse	7
9	What are the advantages of static scherbius drive	Remember	7
10	What are the applications of static scherbius drive	remember	7
UNIT-VIII **CONTROL OF SYNCHRONOUS MOTORS**			
1	Write torque equation of synchronous motor	Remember	8
2	What are the different methods for variable frequency control in synchronous motor	Understand	8
3	What are the advantages of voltage source inverter	Remember	8
4	What are the advantages of current source inverter	Apply	8
5	What are the possible methods to provide variable voltage variable frequency to synchronous motor fed from VSI	Remember	8
6	What is square wave inverter	Create	8
7	What is PWM inverter	Apply	8
8	What is chopper with square wave inverter	Understand	8
9	Define torque angle	Remember	8
10	What is the advantage of constant margin angle control	Remember	8

GROUP-II (LONG ANSWER QUESTIONS)

S.No	QUESTION	BLOOMS TAXONOMY LEVEL	COURSE OUTCOME

UNIT-I **CONTROL OF DC MOTORS BY SINGLE PHASE CONTROLLED CONVERTERS**			
1	What are the assumption made while doing the steady-state performance of the converter fed DC drives? Justify your answers.	analyse	1
2	Derive an expression relating speed and torque of a single phase full converter fed separately excited DC motor drive operating in the continuous current mode	analyse	1
3	Explain the use of freewheeling diode in the converter fed DC drives. Take an example of 1-phase fully controlled converter fed for explanation. How it is going to affect the machine performance.	Understand	1
4	A single phase fully controlled thyristor converter is supplying a DC separately excited DC motor. Draw the neat waveforms diagrams and explain various operating modes of the drive Both in motoring and regenerative braking for (a) $\gamma < \alpha$ (b) $\gamma < \alpha$ Where α is the firing angle, γ is the angle at which the source voltage equal to the motor back emf. Assume the armature of the separately excited dc motor can be replaced by simple R-L and back emf load	analyse	1
5	Derive an expression for an average output voltage of a 1-phase semi-converter. Assuming a very highly inductive load, draw the waveforms of output voltage, load current and voltage across thyristors	Analyse	1
6	Describe the operation of single phase fully controlled rectifier control of DC separately excited motor and obtain the expression for motor speed for continuous mode of operation	Apply	1
7	Describe the operation of single phase half controlled rectifier control of DC separately excited motor and obtain the expression for motor speed for continuous mode of operation	Understand	1
8	Describe the operation of single phase Semi controlled rectifier control of DC separately excited motor and obtain the expression for motor speed for continuous mode of operation	Analyse	1
9	A separately excited dc motor is driving a centrifugal pump whose =torque is proportional to the square of the speed. The armature current is 30 A AT speed of 1000 rpm. The armature current at the speed of 500 rpm is	Apply	1
10	Derive the back emf equation of a dc series motor	Analyse	1
UNIT-II **CONTROL OF DC MOTORS BY THREE PHASE CONTROLLED CONVERTERS**			
1	What are the advantages of three phase drives over single phase drives	Understand	2
2	Explain the motoring 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 speed.	Understand	2
3	Draw the power circuit diagram and explain the operation of a three phase full converter fed separately excited dc motor.	analyse	2
4	Draw the power circuit diagram and explain the operation of a three phase half controlled converter fed separately excited dc motor.	analyse	2
5	Explain the operation of three phase full controlled rectifier fed dc series motor drives	analyse	2
6	Explain the operation of three phase half controlled rectifier fed dc series motor drives	analyse	2
7	Draw the power circuit diagram and explain the operation of a three phase full converter fed dc series motor.	analyse	2
8	Draw the power circuit diagram and explain the operation of a three phase half converter fed dc series motor.	analyse	2
9	Compare three phase drives and single phase drives	Understand	2

10	Explain the motoring and braking operation of three phase half controlled rectifier control of dc separately excited motor with aid of diagrams and waveforms. Also obtain the expression for motor terminal voltage speed	Understand	2
UNIT-III **FOUR QUADRANT OPERATION OF DC DRIVES**			
1	What is a dual converter? Explain the principle of operation of a dual converter in a circulating current mode. How the same is used for speed control of DC drive	analyse	3
2	What is 4-quadrant operation and explain with converters.	remember	3
3	Describe the relative merits and demerits of the following types of braking for DC motors, mechanical braking, dynamic braking and regenerative braking with neat diagram.	remember	3
4	Draw the circuit diagram and explain the operation of closed loop speed control with inner-current loop and field weakening.	Analyse	3
5	Explain how four-quadrant operation is achieved by dual converter each of 3ϕ full wave configuration for DC separately excited motor.	Analyse	3
6	Distinguish between circulating current and non-circulating current mode of operation.	Analyse	3
7	Explain the principle of closed-loop control of a DC drive using suitable block diagram.	Analyse	3
8	Draw and explain the torque-speed characteristics for dynamic braking operation of DC series motor. Why torque becomes zero at finite speed	Analyse	3
9	With a neat diagram, explain the operation of a DC drive in all four quadrants when fed by a single phase dual converter with necessary waveforms and characteristics.	Understanding	3
10	What are the advantages of electric braking over mechanical braking of DC motors? Explain with proper circuit diagram speed-torque characteristics of DC motor dynamic braking, for the following types a) Separately excited DC motor b) Series motor	Understanding	3
UNIT-1V **CONTROL OF DC MOTORS BY CHOPPERS**			
1	Deduce the mathematical expression for minimum and maximum currents for a class A chopper operated DC motor with back emf.	Understand	4
2	Discuss with the suitable diagrams I quadrant and II quadrant choppers.	Analyse	4
3	Distinguish between class A and class B choppers with suitable examples of speed control of motors	Analyse	4
4	List the advantages offered by DC chopper drives over line commutated converter controlled DC drives.	Analyse	4
5	Explain the operation of the two quadrant chopper fed DC drive system	Analyse	4
6	Draw the diagram of regenerative chopper fed separately excited DC motor drive	Analyse	4
7	Describe the working of a single quadrant chopper fed DC series motor drive	Understand	4
8	Explain the different types of control strategies of DC chopper.	Evaluate	4
9	Explain the operation of four quadrant DC chopper drive	Evaluate	4
10	Explain regenerative braking and dynamic braking of separately excited DC motor by chopper control	Analyse	4
UNIT-V **CONTROL OF INDUCTION MOTOR OF STATOR SIDE**			
1	Why stator voltage control is an inefficient method of induction motor speed control	Analyse	5

2	Draw the speed-torque characteristics which are obtained by stator voltage variation of 3-phase induction motor.	Evaluate	5
3	Derive the torque equation of three phase induction motor from equivalent circuit	Evaluate	5
4	What are the different methods of speed control of induction motors	Evaluate	5
5	What is a stator voltage control	Apply	5
6	Mention some applications of stator voltage control of three phase induction motor	Analyse	5
7	What happens to the performance of AC motor if the stator voltage control technique is adopted with frequency being constant	Apply	5
8	Constant torque loads are not suitable for AC voltage controller fed induction motor drive. Why?	Apply	5
9	Using 3-phase solid state AC voltage controllers explain clearly how it is possible to achievef4-quadrant operation of 3-phase induction motors	Analyse	5
10	Draw a closed loop block diagram for the above speed control technique. Mention the merits of the above method of speed control	Apply	5
UNIT-VI **CONTROL OF INDUCTION MOTOR BY STATOR FREQUENCY**			
1	When is an induction motor said to be working in the field weakening mode	understand	6
2	Explain the mechanical characteristics of a three phase induction motor with stator current control	Evaluate	6
3	Why the speed control of a three phase induction motor with constant supply voltage and reduced supply frequency is not preferred	Analyse	6
4	Explain the mechanical characteristics of a three phase induction motor with stator frequency control.	Evaluate	6
5	Explain in detail the speed control scheme for a three phase induction motor using PWM inverter.	Apply	6
6	Sketch the mechanical characteristics of a there phase induction motor with V/f method	Analyse	6
7	Explain how voltage and frequency are varied in voltage source inverter fed induction motor drives	Apply	6
8	Describe the stator frequency control scheme for the speed control of three phase induction motors	Apply	6
9	Explain the induction motor operation when the V/f ratio ois held constant. Also drive the expression for maximum torque	Analyse	6
10	Explain the operation of closed loop control of induction motor dirves/	Apply	6
UNIT-VII **CONTROL OF INDUCTION MOTOR OF ROTOR SIDE**			
1	What are the assumption made in the static resistance control of wound rotor induction motors	Apply	7
2	Draw the speed-torque characteristics of a rotor resistance controlled induction motor and explain the effect of rotor resistance variation	Analyse	7
3	Why rotor resistance control is preferred in low power crane drives	Analyse	7
4	Draw and explain al closed loop operation for a static Kramer controlled drive	Analyse	7
5	In which way a static Kramer control is different from static scherbius drive	Apply	7
6	What are the disadvantages of static rotor resistance control	Analyse	7
7	Name the methods of speed control applicable on the motor side of a three phase induction motor	Apply	7
8	Describe using a schematic the working of a static DC link scherbius drive	Apply	7
9	Explain using a power circuit how static rotor resistance control serves to vary	Analyse	7

	the speed of a three phase induction motor.		
10	Explain how slip power recovery scheme help to achieve sub synchronous speed control of slip ring induction motor with an improvement in overall efficiency.	Apply	7
UNIT-VIII **CONTROL OF SYNCHRONOUS MOTORS**			
1	Draw the block diagram of a closed loop synchronous motor drive fed from VSI and explain	Apply	8
2	Describe the open-loop and closed loop methods of speed control of a synchronous motor using VSI	Evaluate	8
3	Discuss the VSI method of speed control of synchronous motor describe the operation of the converter with waveforms.	understanding	8
4	How is the output voltage of a VSI improved by PWM techniques? Explain how you will use this converter for speed control of a synchronous motor.	Evaluate	8
5	Describe self-controlled and a loop commutated inverter controlled synchronous motor drives in detail and compare them	Apply	8
6	Describe separate controlled mode and self-controlled mode of operation of a synchronous motor drive in detail and compare them	Analyse	8
7	Explain how three phase synchronous motor fed by a three phase inverter can be make to behave like a simple dc motor. Hence is it proper to call them as a commutator less DC motor	Apply	8
8	Explain the operation of a open loop V/f control of multiple synchronous motor with schematic diagram	Apply	8
9	Describe the converter used for low frequency high power synchronous motor drives with relevant waveforms.	Analyse	8
10	a) Derive the torque equation of synchronous b) What is the necessary of damper winding	Analyse	8

GROUP-III (ANALYTICAL QUESTIONS)

S.No	QUESTIONS	BLOOMS TAXONOMY LEVEL	PROGRAM OUTCOME
UNIT-I **BASIC CONCEPTS**			
1	A separately –excited dc motor, operating from a single-phase half-controlled bridge rectifier at a speed of 1400 rpm, has an input voltage of 330 sin 314t and a back emf 80V. The SCRs are fired symmetrically at $\alpha=30°$ in every half cycle and the armature has a resistance of 4Ω. Calculate the average armature current and the motor torque.	Understand	1
2	The speed of a 15hp, 220V, 1000 rpm dc series motor is controlled using a single-phase half controlled bridge rectifier. The combined armature and field resistance is 0.2 Ω. Assuming continuous and ripple free motor current and speed of 1000 rpm and K=0.03 Nm/Amp2 determine a) motor current, b) motor torque for a firing angle $\alpha=30°$ AC source voltage is 250 V.	Understand	1
3	A 1ϕ semi converter is operated from 220 V, 50 Hz supply. it is used for controlling the speed of a separately excited dc motor whose armature resistance is negligible. when the firing angle is 60° the motor is rotating at a speed of 800 rmp. The armature is coupled to constant torque load. The firing angle for a speed of 600 rpm is	Understand	1
4	A 220 V, dc series motor has armature resistance of 0.2 Ω and field resistance of 0.3 Ω. It runs at a speed of 1000 rpm when the armature current is 10 A. When the armature current is 20A, the speed is	Understand	1

5	A single phase full converter connected to 220 V, 50 Hz at supply is supplying power to a dc series motor. The combined armature resistance and field resistance is 0.5 Ω. The firing angle os the converter is 45°. The back emf is 100 V. The average current drawn by the motor is	Remember	1
6	A 220 V, 1500 rpm, 10 A separately excited dc motor has an armature resistance of 1 Ω. It is fed from a single phase full converter with an ac source voltage of 230 V, 50 Hz. The motor emf constant is 1.337 N-m/A. Assume continuous load current at the firing angle of 30° and torque of 5 N-m, the motor speed is	Evaluate	1
7	A 220 V, 1000 rpm, 60 A separately excited dc motor has an armature resistance fof 0.1 Ω. It is fed from a single phase full converter withan ac source voltage of 230 V, 50Hz. Assuming continuous conduction. For 600 rpm and rated torque, the firing angle is	Apply	1
8	A separately excited dc motor connected to 220 V dc supply is developing a torque of 50N-m, when running at a speed of 500 rpm and drawing a current of 20 A. If the current drawn is 40A, the torque developed is	Analyse	1
9	A 1ϕ semi convertor connected to 220 V, 50 Hz ac supply is operating with firing angle of 60° . It is supplying continuous current of 10 A to a separately excited dc motor. The armature resistance is 0.1 Ω . The back emf is	Apply	1
10	A separately excited dc motor is operating from a single phase half – controlled bridge rectifier. The input voltage is 300 sin 314t, back emf80 V firing angle 45° and $R_a = 4\Omega$. The motor armature current is	Apply	1
UNIT-II **CONTROL OF DC MOTORS BY THREE PHASE CONTROLLED CONVERTERS**			
1	The speed of a separately excited dc motor is controlled by means of a 3 phase semi converter from a 3 phase, 415V, 50 Hz supply. The motor constants are inductance 10mH, resistance 0.9Ω and armature constant 1.5V-sec/rad . Calculate the speed of this motor at a torque of 5oN-M when the converter is fired at 45 degrees.	Remember	2
2	A 220V, 1500rpm, 50A separately excited motor with an armature resistance of 0.5ohm 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. (i) Calculate the transformer turns ratio. (ii) Determine the value of firing angle when motor is running at 1200rpm and rated torque.	Understand	2
3	The speed of a 10hp, 230V, 1000rpm dc series motor is controlled using a three phase fully controlled converter. The combined armature and field resistance is 0.2Ω. Assuming continuous and ripple free motor current and speed of 1000rpm and $k=0.03Nm/A^{2,}$ determine a) motor current b) motor torque for a firing angle $\alpha=30^{0.}$ Ac voltage is 250V. Derive the formula used.	Remember	2
4	A 220V DC series motor runs at 1000rpm and takes an armature current of 100A when driving a load with constant torque. The resistances of the armature and field windings are 0.05ohm each. Find the magnitude and direction of motor speed and armature current if the motor terminal voltage is reversed and the number of turns in field winding is reduced to 80%. Assume linear magnetic circuit	Understand	2

5	The speed of a separately excited dc motor is controlled by means of a 3-phase half controlled bridge rectifier from a 3-phase, 415V, 50Hz supply. The motor constants are: inductance 10mH, resistance 0.9 Ω and armature constant 1.5V rad/sec(N-m-A) Calculate the speed of this motor at a torque of 50N-m when the converter is fired at 45^0. Neglect losses in the converter.	Apply	2
6	A 600V, 1500rpm, 80A separately excited dc motor is fed through a three-phase semi converter from 3-phase400supply. Motor armature resistance is 1 Ω the armature current assumed constant. For a firing angle of 45^0 at 1200rpm ,compute the rms value of source and thyristor currents, average value of thyristor current and the input supply power factor	Remember	2
7	A 100kW,500 V, 2000 rpm separately excited dc motor is energised from 400 V, 50Hz, 3-phase source through a 3-phase full converter. The voltage drop in conducting thyristors is 2V. The dc motor parameter are as under: Ra =0.1Ω,Km=1.6V-s/rad,La=8mH. Rated armature current=21A. No-load armature current =10% of rated current. Armature current is continuous and ripple free. a) Find the no-load speed at firing angle of 30^0 b) Find the firirng angle for a speed of 2000 rpm at rated armature current. Determine also the supply power factor.	Apply	2
8	A 230V,1500 rpm,20A separately excited dc motor is fed from 3-phase full converter. Motor armature resistance is 0.6 Ω. Full converter is connected to 400V, 50Hz source through a delta-star transformer. Motor terminal voltage is rated when converter firing angle is zero. Calculate the transformer phase turns-ratio from primary to secondary	Remember	2
9	The speed of a 20HP, 300V, 1800rpm separately excited dc motor is controlled by a three phase full converter drive. The field current is also controlled by a three phase full converter and is set to the maximum possible value. The ac input is a three phase star connected 208V, 60Hz supply. The armature resistance	Apply	2
10	The speed of a separately excited dc motor is controlled by 3ϕ semiconverter. In put voltage 415 V, R_a=0.9 Ω ,K_m = 1.5V/rad/s. I_a = 10A. Calculate the motor speed	Apply	2
UNIT-III **FOUR QUADRANT OPERATION OF DC DRIVES**			
1	A 220V, 970rpm, 100A DC separately excited motor as an armature resistance of 0.05ohm. It is braked by plugging from an initial speed of 1000rpm. Calculate i) Calculate the resistance to be placed in armature circuit to limit breaking current to twice the full load value. ii) Breaking torque and iii) Torque when the speed has fallen to zero.	Understand	3
2	A 200V, 100A DC series motor runs at 1000rpm is operated under dynamic breaking at twice the rated torque and 800rpm. The resistance of armature and field winding is 0.1 ohm. Calculate the value of breaking current and resistance.	Understand	3
3	A 200V, 1500rpm, 50A separately excited motor with armature resistance of 0.5 ohm is fed from a circulating current dual converter with AC source voltage 165V. Determine converter firing angle for the following operating points i) Motoring operation at rated motor torque and 1000rpm. ii) Breaking Operation at rated motor torque and 1000rpm	Understand	3

4	A220V DC series motor runs at 1200 rpm and takes an armature current of 100 A when driving a load with a constant torque. Resistances of the armature and field windings are 0.05 Ω each. DC series motor is operated under dynamic braking at twice the rated torque and 1000 rpm. Calculate the value of braking current and resistor. Assume linear magnetic circuit.	Understand	3
5	A 220 V,200A, 800 rpm dc separately excited motor has an armature resistance of 0.05Ω. The motor armature is fed from a variable voltage source with an internal resistance of 0.03 Ω . Calculate internal voltage of the variable voltage source when the motor is operating in regenerative braking at 80% of the rated motor torque and 600rpm.	Analyze	3
6	A 220V, 750 rpm, 200A separately excited motor has an armature resistance of 0.05 Ω. Armature is fed from a three phase non-circulating current dual converter consisting of fully controlled rectifiers A AND b. Rectifier A provides motoring operation in the forward direction and rectifier Vin reverse direction. Line voltage of ac source is 400V. Calculate filering angles of rectifiers for the following assuming continuous conduction. a) Motoring operation at rated torque and 600rpm b) Regenerative braking operation at rated torque and 600 rpm.	Apply	3
7	Discuss in detail counter current and dynamic braking operations of DC shunt motors	Apply	3
8	Electrical braking of series motor is not straight forward as that of a separately excited DC motors – Justify	Understand	3
9	A230 V,1000rpm, 105 A separately excited dc motor has an armature resistance of 0.06 Ω. Calculate the value of flux as a percent of rated flux for motor speed of 1500 rpm when load is such that the developed motor power is maintained constant at rated value for all speeds above rated speed	Apply	3
10	Speed of a dc series motor coupled to a fan load is controlled by variation of armature voltate. When armature voltage is 400V, motor takes 20 A and the fan speed is 250 rpm. The combined resistance of armature and field is 1.0 Ω. Calculate a) Motor armature voltage for the fan speed of 350 rpm. b) Motor speed for the armature voltage of 250V	Apply	3
UNIT-1V **CONTROL OF DC MOTORS BY CHOPPERS**			
1	A DC series motor is fed from 600V DC source through a chopper. The DC motor has the following parameters. Ra = 0.04 ohm, Rs = 0.06 ohm, $k=4x10^{-3}$ NM/A^2 . Average armature current of 300A is ripple free. For a chopper duty cycle of 60% determine (a) input power from the source, (b) Motor speed and (c) Motor torque.	Understand	4
2	The chopper used for on-off control of a DC separately excited motor has supply voltage of 230V DC and on-time of 10ms and off-time of 15ms. Assuming continuous conduction calculate the average load current when the motor speed is 1500rpm and has a voltage constant of 0.5V-sec/Rad and the armature resistance is 3 ohm.	Apply	4
3	A DC chopper is used to control the speed of a separately excited DC motor. The DC supply voltage is 220V, armature is 0.2 ohm and motor constant is 0.08V/rpm. This motor drives a constant torque requiring an average armature current of 25A. Determine the (a) the range of speed control, (b) the range of duty cycle.	Apply	4
4	A DC chopper is used for regenerative breaking of a separately excited DC motor. The supply voltage is 400V. The motor has Ra=0.2 ohm, k=1.2V-Sec/Rad. The average armature current during regenerative breaking is kept constant at 300A with negligible ripple. For a duty cycle of 60% determine (i) Power returned to the DC supply	Remember	4

	(ii) Min and Max permissible breaking speeds and (iii) Speed during regenerative breaking.		
5	A d.c. series motor, fed from 400 V dc source through a chopper, has the following parameters. Ra = 0.05 Ω, Rs = 0.07 Ω, k = 5* 10-3 Nm/amp2 The average armature current of 200a ripple free. or a chopper duty cycle of 50%. Determine i) Input power from the source ii) Motor speed and	Creating	4
6	A chopper used for ON and OFF control of a dc separately excited motor has supply voltage of $230V_m$ T_{on} = 10ms, T_{off} = 15ms. Neglecting armature inductance and assuming continuous conduction of motor current, Calculate the average load current when the motor speed is 1500 rpm, has a voltage constant Kv = 0.5 V/rad/sec. The armature resistance is 2 Ω.	Remember	4
7	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 $K_e\varphi$ = 0.08 V/rpm. The motor drives a constant load requiring an average armature current of 25 A. Determine a) The range of speed control b) The range of duty cycle, Assume – continuous conduction	Remember	4
8	A 230V, 960 rpm and 200 A separately excited dc motor has an armature resistance of 0.02 Ω. Calculate the duty ratio of the chopper for mototing operation at rated torque and 350 rpm	Remember	4
9	A 220V, 24A, 1000 rpm, separately excited DC motor having an armature resistance of 2 Ω is controlled by a chopper. The chopping frequency is 500Hz and the input voltage is 230V. Calculate the duty ratio for a motor torque of 1.2 times rated torque at 500 rpm	Remember	4
10	A DC chopper controls the speed of DC series motor. The armature resistance Ra = 0.04 Ω, field circuit resistance R_f = 0.06 Ω, and back emf constant K_v = 35M v/RAD/SEC. The DC input voltage of the chopper V_s = 600V. If it is required to maintain a constant developed torque of Td = 547 N-m, plot the motor speed against the duty cycle K of the chopper.	Apply	4
UNIT-V **CONTROL OF INDUCTION MOTOR OF STATOR SIDE**			
1	A three phase SCIM drives a blower type load. No load rotational losses are negligible. Show that rotor current is maximum when the motor runs at a slip of 1/3. Find also an expression for maximum rotor current	creating	5
2	If three phase SCIM runs at a speed of (i) 1455rpm (ii) 1350rpm, determine the maximum current in terms of rated current at these speeds. The induction motor drives a fan and no load rotational losses are ignored.	remember	5
3	A 2.8Kw, 400V,50Hz,4 pole ,1370rpm, delta connected squirrel cage induction motor has following parameters referred to stator R_s=2Ω,R_r'=5 Ω, X_s=$X_{r'}$=5 Ω, X_m=80 Ω. Motor speed is controlled by stator voltage control. When driving a fan load it runs at rated speed and rated voltage. Calculate (i) motor terminal voltage, current and torque at 1200rpm and (ii) motor speed, current and torque for the terminal voltage of 300V.	remember	5
4	A 400V, star connected 3 phase, 6 pole , 50Hz induction motor has following parameters referred to stator: R_s=$R_{r'}$=1 Ω, X_s=$X_{r'}$=2Ω.For regenerative braking operation of this motor determine (i) Maximum overhauling torque it can hold and range of speed for safe operation. (ii) Speed at which it will hold an overhauling load with a torque of 100Nm.	remember	5
5	A 400V, 60 Hz, 6-pole, 3-ϕ induction motor runs at a speed of 1140 rpm	apply	5

	when connected to a 440 V line. Calculate the speed if voltage increases to 550V.		
6	A 3-phase, 400V, 50Hz, 4-pole, 1440 rpm delta connected squirrel cage induction motor has a full load torque of 48.13 N-m. Motor speed is controlled by stator voltage control. When driving a fan load it runs at rated speed at rated voltage. Calculate the motor torque at 1200rpm.	remember	5
7	A 400V, 50Hz, 3-phase squirrel cage induction motor develops full load torque at 1470 rpm. If supply voltage reduces to 340 V, with load torque remaining constant, calculate the motor speed. Assume speed – torque characteristics of the motor to be linear in the stable region. Neglect stator resistance.	Apply	5
8	A three-phase squirrel cage IM drives a fan-type load. No load rotational losses are negligible. Show that rotor current is maximum when motor runs at a slip s = 1/3. Fine also an expression for maximum rotor current. B) If three-phase squirrel cage IM runs at speed of i) 1450 rpm and ii) 1300 rpm, determine the maximum current in terms of rated current at the speeds. The IM drives a fan and no – load rotational losses are ignored.	evaluate	5
9	A 440V, 3- ϕ, 50Hz, 6-pole, 945rpm, Δ-connected induction motor has the following parameters referred to stator: R_s = 2 Ω,R_r = 2 Ω, X_s = 3 Ω, X_r =4 Ω. When driving a fan load at rated voltage it runs at rated speed. The motor speed is controlled by stator voltage control. Determine i) Motor terminal voltage, current and torque at 800 rpm ii) Motor speed, current and torque for the terminal voltage of 280V	Understand	5
10	Repeat the above problem for a voltage torque varies linearly with speed.	apply	5

UNIT-VI

CONTROL OF INDUCTION MOTOR BY STATOR FREQUENCY

1	A 3-ph 20KW, 4-pole, 50Hz, 400V delta connected induction motor has the following parameters per phase R1=0.6 ohm, R2=0.4 ohm, X1=X2=1.6 ohm. If magnetising reactance is neglected and operated at 200V, 25Hz with DOL starting. Calculate the current and power factor at the instant of starting and under the maximum torque conditions. Compare the results with normal values.	creating	6
2	A 3-ph 20KW, 4-pole, 50Hz, 400V delta connected induction motor has the following parameters per phase R1=0.6 ohm, R2=0.4 ohm, X1=X2=1.6 ohm. If magnetising reactance is neglected and operated at 200V, 25Hz with DOL starting. Calculate the starting and maximum torques and compare with normal values.	remember	6
3	A 400V, 4 pole, 50Hz, 3-ph star connected induction motor has R_1=0, X_1=X_2=1 ohm, R_2=0.4 ohm, X_m=50 ohm. This induction motor is fed from (i) a constant voltage source of 231V/ph and (ii) a constant current source of 28A. for both parts (i) & (ii) calculate (a) Slip for maximum torque (b) Starting and maximum torques (c) The supply voltage required to sustained the constant current at the maximum torque.	remember	6
4	A star connected squirrel cage induction motor has following ratings and parameters. 400V, 50Hz, 4 pole 1370rpm, R_s=2 ohm, R'_r=3 ohm, X_s=$X_{r'}$=3.5 ohm. Motor is controlled by voltage source inverter with constant v/f ratio calculate motor breakdown torque for a frequency of 60Hz as a ratio of its value at 50Hz.	remember	6
5	A 3phase, 460V, 60Hz, 6 pole star connected induction motor has Rs = 0,R_r=0.18 Ω, X_s =1.04 Ω,X_r = 1.6 Ω,X_m= 18.8 Ω. The no load loss is negligible. The induction motor speed is 1180 rpm. Calculate	apply	6

6	A three phase squirrel cage induction motor is developing torque of 1500 synchronous watts at 50 Hz and 1440 rpm (synchronous speed is 1500 rpm). If the motor frequency is increased to 75Hz using constant power mode, determine the new value of torque developed by the motor at constant slip.	remember	6
7	At 50 Hz the synchronous speed and full load speed are 1500 rpm and 370 rpm respectively. Calculate the approximate value speed for a frequency of 30 Hz and 80% of full load torque for inverter fed induction motor drive.	Apply	6
8	An inverter supplies a 4 pole, 220V 50 Hz cage induction motor. Determine the approximate required output of the inverter for speeds i) 900 rpm ii) 1200 rpm and iii) 1500 rpm	evaluate	6
9	A400V, 4 pole, 50Hz, three phase, star connected induction motor has r1 = 0,$x_1 = x_2 = 1\Omega$, $r_2 = 0.4\ \Omega$,x_m=500 Ω. The induction motor is fed from i) a constant voltage source of 231 V per phase ii) a constant current source of 28A. For both the cases calculate the slip at which maximum torque occurs and the staring and maximum torques.	Understand	6
10	A star connected squirrel cage induction motor has following ratings and parameters: 400V,50Hz,4 pole, 1370 rpm, R_s=2 Ω, R_r = 3 Ω, $X_s = X_r = 3.5$ Ω, X_m = 55 Ω. It is controlled by a CSI at a constant flux. Calculate: i) motor torque, speed and stator current for 30 Hz and rated slip speed. Ii) inverter frequency and stator current for rated motor torque motor speed of 10200 rpm.	apply	6
UNIT-VII **CONTROL OF INDUCTION MOTOR OF ROTOR SIDE**			
1	A three phase, 400V, 6 pole, 50Hz, delta connected, slip-ring induction motor has rotor resistance of 0.2 ohm and leakage reactance of 1 ohm/ph referred to stator. When driving a fan load it runs at full load at 4% slip. What resistance must be inserted in the rotor circuit to obtain a speed of 850 rpm. Neglect stator impedance and magnetising branch. Stator to rotor turns ratio is 2.2.	Apply	7
2	**A** 440V, 50Hz, 6 pole star connected wound rotor motor has the following parameters. R_s=0.5 ohm, R'r=0.4 ohm, X_s=X_r'=1.2 ohm, Xm=50 ohm, stator to rotor turns ratio is 3.5. Motor is controlled by static rotor resistance control. External resistance is chosen such that the breakdown torque is produced at standstill for a duty ratio of zero. Calculate the value of external resistance. How duty ratio should be varied with speed so that the motor accelerates at maximum torque.	Evaluate	7
3	**A** 440V, 50Hz, 6 pole, 970rpm star connected 3-ph wound rotor motor has the following parameters referred to stator. Rs=0.1 ohm, R'r=0.08 ohm, Xs=0.3 ohm, Xr'=0.4 ohm, stator to rotor turns ratio is 2. Motor speed is controlled by static scherbius drive. Drive is designed for a speed range of 25% below the synchronous speed. Max. value of firing angle 165 deg, calculate (i) transformer turns ratio, (ii) torque for a speed of 780rpm and α=140 deg.	remember	7
4	**A** 440V, 50Hz, 6 pole, 970rpm star connected 3-ph wound rotor motor has the following parameters referred to stator. Rs=0.1 ohm, R'r=0.08 ohm, Xs=0.3 ohm, Xr'=0.4 ohm, stator to rotor turns ratio is 2. Motor speed is controlled by static scherbius drive. Drive is designed for a speed range of 25% below the synchronous speed. Max. value of firing angle 165 deg, calculate the firing angle for half the rated motor torque and speed of 800rpm	Evaluate	7
5	The rotor of a 4-pole, 50 Hz wound – rotor induction motor has a resistance of 0.30 Ω per phase and runs at 1440 rpm at full load. Calculate the external resistance per phase which must be added to lower the speed to 1320 rpm,	Apply	7

	the torque being the same as before		
6	A 440V, 50Hz, 6 pole, star connected slip ring induction motor has the following parameters referred to stator: Rs = 0.5 Ω, Rr = 0.4 Ω,Xs=Xr= 1.2 Ω, resistance control. External resistance is chosen such that the breakdown torque is produced at standstill for a futy cycle of zero. Calculate the value of external resistance. How duty cycle should be varied with speed to that the motor accelerates at maximum torque	Analyse	7
7	Speed of a 400 V, 6 pole, 50 Hz, star connected slip ring induction motor is controlled by static Kramer drive. the effective phase turns ratio from I.v to h.v as 0.4. The inductor current is ripple free. Losses in diode rectifier, inductor, Inverter and transformer are neglected. The load torque is proportional to speed squared and its value is 250 Nm at 800rpm. For a motor operating speed of 700 rpm, Calculate a) Rotor rectified voltage b) inductor current	Apply	7
8	Speed of a 400 V, 6 pole, 50 Hz, star connected slip ring induction motor is controlled by static Kramer drive. the effective phase turns ratio from I.v to h.v as 0.4. The inductor current is ripple free. Losses in diode rectifier, inductor, Inverter and transformer are neglected. The load torque is proportional to speed squared and its value is 250 Nm at 800rpm. For a motor operating speed of 700 rpm, Calculate a) Delay angle of the inverter b) Efficiency in case inductor resistance is 0.01 Ω and per phase resistance for stator and rotor are 0.015 Ω and 0.02 Ω respectively. c) For the firing angle obtained in part d) The load torque is increased to 350 Nm. Find the motor speed	Apply	7
9	Repeat problem (10) in case there is an overlap angle of 12° in the frectifier and 5° in the inverter.	Analyse	7
10	A 600 V, 50Hz, 30kW, 3-phase induction motor is used as the drive motor in an SER system. It is required to deliver constant (rated) motor torque over the full range from 100 rpm to the rated speed of 1000 rpm. The motor equivalent circuit parameters are R_1 = 0.05Ω, R_2=0.07 Ω,R_0 =53 Ω, X_0 = 23 Ω, $X_1 + X_2$ = 0.1153 Ω. Stator to rotor turns ratio 1.3 Calculate the motor currents, efficiency and power factor at 300 rpm	Apply	7
UNIT-VIII CONTROL OF SYNCHRONOUS MOTORS			
1	A 500KW, 3-ph, 3.3KV, 50Hz, 0.8(lag) pf, 4 pole star connected synchronous motor has a following parameters. Xs=15 ohm, Rs=0, rated field current is 10A calculate (i) Armature current and pf at half the rated torque and rated field current (ii) Field current to get upf at the rated torque.	Apply	8
2	A 6MW, 3-ph, 11KV,Y connected, 6 pole, 50Hz, 0.9(lead) pf synchronous motor has Xs=9ohm, Rs=0, rated field current is 50A. Machine is controlled by variable frequency control at constant V/F ratio upto the base speed and at constant V above base speed determine the Torque and field current for the rated armature current, 750rpm and 0.8 leading pf.	Analyse	8
3	A 6MW, 3-ph, 11KV,Y connected, 6 pole, 50Hz, 0.9(lead) pf synchronous motor has Xs=9ohm, Rs=0, rated field current is 50A. Machine is controlled by variable frequency control at constant V/F ratio upto the base speed and at constant V above base speed determine the armature current and power factor for half the rated motor torque, 1500rpm and rated field current.	Analyse	8

4	A3 phase, 400V, 50Hz, 6 pole, star connected round-rotor synchronous motor has Z_s=0+j2Ω. Load torque, proportional to speed squared, is 340N-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 600rmp, calculate a) supply voltage b) armature current.	Analyse	8
5	A 6MW, 3-phase, 11KV, star connected, 6-Pole, 50Hz, 0.9 (leading) power factor synchronous motor has Xs = 8 Ω and Rs = o. Rated field current is 45A. Machine is controlled by variable frequency control at constant (v/f) ratio up to the base speed and at constant V above base speed. Determine, i) Torque and field current for the rated armature current, 700 rpm and 0.58 leading power factor. ii) Armature current and power factor for half the rated motor torque, 1400 rpm and rated field current,	Apply	8
6	A 6MW, 3-phase, 11KV, star connected, 6-Pole, 50Hz, 0.9 (leading) power factor synchronous motor has Xs = 8 Ω and Rs = o. Rated field current is 45A. Machine is controlled by variable frequency control at constant (v/f) ratio up to the base speed and at constant V above base speed. Determine, i) Armature current and power factor for regenerative braking power output of 4.2MVA at 700 rpm and rated field current, ii) Torque and field current for regenerative braking operation at rated armature current, 1400 rpm and unity power factor	Analyse	8
7	A synchronous motor is controlled by a load commutated inverter, which in turn is fed from a line commutated converter . Source voltage is 6.6kV, 50Hz. Load commutated inverter operates at a constant firing angle α1 of 130° and when rectifying α_γ = 0° dc li nk inductor resistance Rd = 0.2 Ω. Drive operates in self control mode with a constant (V/f) ratio. Motor has the details; 8MV, 3 phase 6600V, 6pole, 50Hz unity power factor, star connected, Xs = 2.6 Ω, Rs = o. Determine source side converter firing angles for the following i) Motor operation at the rated and 500rpm. What will vbe the power developed by motor	Apply	8
8	A synchronous motor is controlled by a load commutated inverter, which in turn is fed from a line commutated converter . Source voltage is 6.6kV, 50Hz. Load commutated inverter operates at a constant firing angle α1 of 130° and when rectifying α_γ = 0° dc link inductor resistance Rd = 0.2 Ω. Drive operates in self control mode with a constant (V/f) ratio. Motor has the details; 8MV, 3 phase 6600V, 6pole, 50Hz unity power factor, star connected, Xs = 2.6 Ω, Rs = o. Determine source side converter firing angles for the following ii) Regenerative braking operation at 600 rpm and rated motor current. Also calculate power supplied to the source	Apply	8
9	A3 phase, 400V, 50Hz, 6 pole, star connected round-rotor synchronous motor has Z_s=0+j2Ω. Load torque, proportional to speed squared, is 340N-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 600rmp, a) Excitation angle b) load angle c) the pull-out torque. Neglect rotational losses	Analyse	8
10	A synchronous motor is controlled by a load commutated inverter, which in frorn is fed from a line commutated converter,. Source voltage is 606KV, 50Hz. Load commutated inverter operates at a constant firing angle α of 140 ° and when rectifying α = 0° dc link inductor resistance Rd = 0.1Ω. Drive operates in self control mode with a constant (V/f) ratio. Motor hs the details; 8MW, 3-phase, 6600V, 6pole, 50Hz, unity power factor, star connected, Xs = 2.8Ω Rs = 0. Determine source side converter firing angles for the following.	Apply	8

	i)	Motor operation at the rated and 500rpm. What will be the power developed by motor.		