SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM Nagar, Kattankulathur–603203.

DEPARTMENT OF

ELECTRICAL AND ELECTRONICS ENGINEERING

QUESTION BANK

1905704 – Special Electrical Machines

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DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

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UNIT I - SYNCHRONOUS RELUCTANCE MOTORS				
Constructional features – Types – Axial and Radial flux motors – Operating principles – Variable Reluctance Motors – Voltage and Torque Equations - Phasor diagram - performance characteristics – Applications.				
Part - A				
Q.No.	Questions	BT Level	Competence	Course Outcome
1.	What is synchronous reluctance motor?	BTL 1	Remember	CO1
2.	List the applications of synchronous reluctance motors.	BTL 1	Remember	CO1
3.	Examine the principle of operation Synchronous reluctance Motor.	BTL 4	Analyze	CO1
4.	Develop the voltage and torque characteristics of synchronous reluctance motor.	BTL 6	Create	CO1
5.	Describe in short about SYNREL motors.	BTL 2	Understand	CO1
6.	Compare synchronous reluctance motor and induction motor.	BTL 5	Evaluate	CO1
7.	Give the voltage and torque equation of synchronous reluctance motor.	BTL 2	Understand	CO1
8.	Analyze the effect of cogging.	BTL 4	Analyze	CO1
9.	Order the different types of synchronous reluctance motor.	BTL 4	Analyze	CO1
10.	Identify the advantages of synchronous reluctance motors.	BTL 3	Apply	CO1
11.	Classify the types of rotor available in synchronous reluctance motor.	BTL 2	Understand	CO1
12.	Define reluctance torque with reference to synchronous reluctance motor.	BTL 1	Remember	CO1
13.	Infer potential applications of synchronous reluctance machine.	BTL 3	Apply	CO1
14.	Define the characteristics of synchronous reluctance motor.	BTL 1	Remember	CO1
15.	What are the primary design consideration of synchronous reluctance motor?	BTL 1	Remember	CO1
16.	Define power factor of synchronous reluctance motor.	BTL 3	Apply	CO1
17.	What are the applications of the torque – speed characteristics of synchronous reluctance motor?	BTL 1	Remember	CO1
18.	Summarize the various stator current modes	BTL 2	Understand	CO1

	used in synchronous reluctance motor?			
19.	List out the properties of synchronous reluctance motor.	BTL 6	Create	CO1
20.	Outline the various design parameters of a synchronous reluctance motor.	BTL 2	Understand	CO1
21.	Compare synchronous reluctance motor with conventional Synchronous motor.	BTL 5	Evaluate	CO1
22.	Justify whether skewing is necessary for synchronous reluctance motor.	BTL 4	Analyze	CO1
23.	Construct the advantages of increasing Ld / Lq ratio in Synchronous reluctance motor?	BTL 3	Apply	CO1
24.	Draw the voltage and torque characteristics of Synchronous reluctance Motor.	BTL 5	Evaluate	CO1
	Part – B			
1.	(i) Give a detailed technical note on the variable reluctance motor and the advantages. (7) (ii) Investigate the performance of the synchronous reluctance motor with neat phasor diagram. (6)	BTL 6	Create	CO1
2.	(i) Draw and explain the phasor diagram of synchronous reluctance motor. (3) (ii) Explain the construction and operation of axial and radial flux machines. Discuss the advantages and disadvantages of each construction. (10)	BTL 5	Evaluate	CO1
3.	Differentiate between axial and radial airgap synchronous reluctance motors. Compare the performance of synchronous reluctance motor with switched reluctance motor. (13)	BTL 2	Understand	CO1
4.	Summarize the design considerations of synchronous reluctance motor. (13)	BTL 2	Understand	CO1
5.	A three phase 230V,60Hz,4 pole star connected synchronous reluctance motor with negligible armature resistance has X_{sd} = 22.5ohm and X_{sq} = 3.5ohm.The load torque is 12.5Nm.The voltage frequency ratio is maintained constant at rated value. If the supply frequency is 60Hz,determine (i) torque angle (5) (ii) line current (4) (iii)input power factor (4)	BTL 3	Apply	CO1
6.	Describe the constructional features and operation of variable reluctance synchronous reluctance motor. (13)	BTL 2	Understand	CO1
7.	Explain with neat diagram, the construction, working principle and types of synchronous reluctance motor. (13)	BTL 1	Remember	CO1
8.	Explain the torque speed characteristics of synchronous reluctance motor in detail. (13)	BTL 1	Remember	CO1
9.	(i) Discuss the main advantages and disadvantages of synchronous reluctance	BTL 3	Apply	CO1

	motor. (7) (ii) Discuss the various applications of synchronous reluctance motor. (6)			
10.	Describe circle diagram and torque–speed characteristics of synchronous reluctance motor. (13)	BTL 1	Remember	CO1
11.	Derive the torque equation of synchronous reluctance motor.(13)	BTL 4	Analyze	CO1
12.	Explain the various types of Synchronous reluctance motor based on rotor construction (13)	BTL 1	Remember	CO1
13.	Compare a reluctance motor with an equivalent induction motor and list out the merits and demerits of reluctance motor over induction motor. (13)	BTL 4	Analyze	CO1
14.	(i) Explain the advantages and disadvantages of synchronous reluctance motor. (8) (ii) Explain the characteristics of synchronous reluctance motor. (5)	BTL 5	Evaluate	CO1
15.	(i) Distinguish between Axial and Radial airgap motors. (ii) List out the applications of synchronous reluctance motor.	BTL 4	Analyze	CO1
16.	A three phase 400V, 50Hz, 4 pole, star connected synchronous reluctance motor with negligible armature resistance has $X_{sd} = 8\Omega$ and $X_{sq} = 2\Omega$. Calculate (a) the load angle (b) the line current (c) the input power factor. Neglect rotational losses.	BTL 3	Apply	CO1
17.	Explain the various stator current modes in a synchronous reluctance motor in detail.	BTL 2	Understand	CO1
	Part – C			
1.	Recommend a suitable type of synchronous reluctance motor for rewinding mill. (15)	BTL 5	Evaluate	CO1
2.	Formulate a suitable saliency ratio of synchronous reluctance motor and how it can be improved. (15)	BTL 6	Create	CO1
3.	A three phase, 220Volts, 50Hz, 4 pole Star Connected Reluctance Motor has $X_d=25\Omega$ and $X_q=2.5\Omega$. The Armature Resistance is negligible. The Load torque is $T_L=24.5$Nm.The voltage to frequency ratio is maintained constant at the rated value. If the supply frequency is 50 Hz. Determine i) Torque Angle δ (5) ii) Line current (5) iii) Input Power Factor. (5)	BTL 5	Evaluate	CO1
4.	Derive the expression for the d axis synchronous reactance of the PM synchronous reluctance motor. (15)	BTL 6	Create	CO1
5.	A three phase, 230V, 60Hz, 4 pole, star	BTL 5	Evaluate	CO1

	connected reluctance motor has X_{sd} = 22.5Ω and X_{sq} = 3.5Ω. The armature resistance is negligible. The load torque is T_l = 12.5 N-m. The voltage to frequency ratio is maintained constant at rated value. If the supply frequency is 60 Hz, determine (a) torque angle δ (b) the line current (c) the input power factor.			
UNIT II - STEPPER MOTORS				
Constructional features – Principle of operation – Types – Torque predictions – Linear Analysis – Characteristics – Drive circuits – Closed loop control – Concept of lead angle – Applications of Stepper motor in robotics, CNC, Computer peripherals, 3D printers.				
1	What is stepper motor?	BTL 4	Analyze	CO2
2	Define step angle.	BTL 1	Remember	CO2
3	Define slewing.	BTL 4	Analyze	CO2
4	Classify the different types of stepping motor.	BTL 2	Understand	CO2
6	Summarize the principle of operation of a variable reluctance stepper motor.	BTL 2	Understand	CO2
7	Distinguish the half step and full step operations of a stepper motor.	BTL 5	Evaluate	CO2
8	Generalize single stack and multi stack configurations in stepping motors.	BTL 6	Create	CO2
9	Define the terms holding and detent torques as referred to stepper motor.	BTL1	Remember	CO2
10	What is the relationship between the step number and step angle in a stepper motor?	BTL 1	Remember	CO2
11	The stepper motor has a step angle of 1.8º and is driven at 4000rps. Determine (a) Resolution (b) Rotor speed.	BTL 5	Evaluate	CO2
12	Define torque constant of a stepper motor.	BTL 1	Remember	CO2
13	Calculate the stepping angle for a 3phase, 24 pole permanent magnet stepper motor.	BTL 3	Apply	CO2
14	Draw the block diagram of the drive system of a stepping motor.	BTL 6	Create	CO2
15	What is the function of drive circuit in stepping motor?	BTL 1	Remember	CO2
16	Name the various driver circuits used in stepped motor.	BTL 2	Understand	CO2
17	Illustrate the need of suppressor circuits in stepper motor.	BTL 3	Apply	CO2
18	Examine the advantages of closed loop operation of stepper motor.	BTL 4	Analyze	CO2
19	What is meant by Lead angle in stepper motors?	BTL 2	Understand	CO2
20	List the applications of stepper motor.	BTL 4	Analyze	CO2
21	Outline the limitations of stepper motor?	BTL 2	Understand	CO2
22	With the characteristics, Define Pull in torque	BTL 3	Apply	CO2
23	What is meant by pull out range?	BTL 1	Remember	CO2
24	Justify the application of stepper motor in 3D printers.	BTL 5	Evaluate	CO2
Part – B				

1	Describe in detail the construction and working of variable reluctance stepper motor. (13)	BTL 1	Remember	CO2
2	Explain the construction and working principle of hybrid stepper motor with neat diagrams. (13)	BTL 4	Analyze	CO2
3	Explain the operation of single stack and multi-stack stepper motor with a neat diagram. (13)	BTL 5	Evaluate	CO2
4	Discuss the principles of operation of permanent magnet stepper motor torque Vs angle characteristics. (13)	BTL 4	Analyze	CO2
5	Draw and explain in detail the static and dynamic characteristics of stepper motor. (13)	BTL 1	Remember	CO2
6	i) Explain the mechanism of static torque production in a variable reluctance stepping motor. (7) ii) Describe the dynamic characteristics of a variable reluctance stepper motor. (6)	BTL 2	Understand	CO2
7	i) Explain with a neat diagram the multi-stack construction of stepper motors. (7) ii) A stepper motor has a resolution of 180 steps per revolution. Find the pulse rate required in order to obtain a rotor speed of 2400 rpm. (6)	BTL 6	Create	CO2
8	Explain in detail, linear analysis of stepper motor. (13)	BTL 2	Understand	CO2
9	Draw and explain drive circuits and their performance characteristics for stepper motor. (13)	BTL 1	Remember	CO2
10	A stepper motor driven by a bipolar drive circuit has following parameters: Winding inductance = 30mH, rated current = 3A, DC supply = 45V, total resistance in each phase = 15ohm. When the transistors are turned off, determine the time taken by the phase current to delay to zero and the proportion of the stored inductive energy returned to the supply. (13)	BTL 4	Analyze	CO2
11	(i) Explain briefly closed loop control of stepper motor. (7) (ii) A single stack 3 phase variable reluctance motor has a step angle of 15˚.Find the number of stator and rotor poles. (6)	BTL 2	Understand	CO2
12	Explain in detail the concept of lead angle in stepper motor. (13)	BTL 1	Remember	CO2
13	(i) What is the motor torque T_m required to accelerate an initial load of $2*10^{-4}$ kgm^2 from f_1=500 Hz to f_2=1500 Hz during 50ms. The frictional torque T_f is 0.03Nm and step angle is 1.18˚. (7) (ii) Write a detailed technical note on the bipolar drives for stepper motors. (6)	BTL 3	Apply	CO2
14	Enumerate the various applications of stepper	BTL 3	Apply	CO2

	motor. (13)			
15	A stepper motor has a step angle of 1.8^0 and it is driven at 4000 pps. Determine (a) Resolution (b) Motor speed (c) Number of pulses required to rotate the shaft through 54^0.	BTL 3	Apply	CO2
16	Summarize about the suppressor circuits for stepper motor.	BTL 2	Understand	CO2
17	Explain dual voltage driver circuit for two phase on drive of a four phase stepper motor and explain the nature of current build up in dual voltage drive.	BTL 5	Evaluate	CO2
	Part-C			
1	Develop single and multi-stack configured stepping motors for mechanical clock application. (15)	BTL 6	Create	CO2
2	A Variable Reluctance stepper motor has a step angle of 3˚, Determine the following: i) Resolution. ii) Number of steps per shaft to make 10 revolutions iii)Shaft speed if stepping frequency is 2400pulse/sec. (15)	BTL 5	Evaluate	CO2
3	Recommend suitable types of stepper motor for textile mill and explain the reason with the mechanical characteristics. (15)	BTL 5	Evaluate	CO2
4	Design a suitable driver circuit which employs unipolar and bipolar wiring arrangements of stepping motor and explain. (15)	BTL6	Create	CO2
5	(i) A variable reluctance stepper motor has 8 poles and they have five teeth in each pole. If the rotor has 50 teeth, calculate the step angle and also resolution. (8) (ii) A stepper motor has a step angle of 2.5, Find (a) Resolution (b) Number of steps required for the shaft to make 25 revolutions (c) Shaft speed if stepping frequency is 3600 pulses/sec. (7)	BTL 5	Evaluate	CO2
	UNIT III - SWITCHED RELUCTANCE MOTORS (SRM)			
Constructional features – Principle of operation - Torque prediction – Characteristics Steady state performance prediction – Analytical Method – Power controllers – Control of SRM drive - Sensor less operation of SRM – Applications.				
1	What is switched reluctance motor?	BTL 1	Remember	
2	Explain the principle of operation of switched reluctance motor.	BTL 2	Understand	CO3
3	List out the advantages of switched reluctance motors.	BTL 1	Remember	CO3
4	Illustrate the different modes of operation of switched reluctance motor.	BTL 3	Apply	CO3
5	Differentiate switched reluctance motor and variable reluctance stepper motor.	BTL 5	Evaluate	CO3
6	Give basic features or characteristics of Switched Reluctance motor	BTL 2	Understand	CO3
7	What are the disadvantages of a switched	BTL 2	Understand	CO3

	reluctance motor?			
8	Give the expression for torque of a switched reluctance motor	BTL 6	Create	CO3
9	Write the relations between the speed and fundamental switching frequency	BTL 1	Remember	CO3
10	Analyze the step angle of a three phase switched reluctance motor having 12stator poles and 8 rotor poles. What is the commutation frequency in each phase of 6000rpm?	BTL 4	Analyze	CO3
11	Write the relations between the speed and fundamental switching frequency	BTL 5	Evaluate	CO3
12	List out the basic requirements of power semiconductor switching circuits employed for switched reluctance motor.	BTL 2	Understand	CO3
13	List out the different power controllers used for the control of switched reluctance motor.	BTL 4	Analyze	CO3
14	What are the merits of classic converter or power controller in SRM?	BTL 2	Understand	CO3
15	What are the merits of Dump C – Converter?	BTL 1	Remember	CO3
16	Illustrate why SR machines popular in adjustable speed drives.	BTL 3	Apply	CO3
17	List out the advantages and disadvantages of the converter circuit with two power semiconductor devices and two diodes per phase?	BTL 1	Remember	CO3
18	Examine the significance of closed loop control in switched reluctance motor?	BTL 4	Analyze	CO3
19	Classify types of current control techniques?	BTL 3	Apply	CO3
20	List the advantages of sensorless operation of switched reluctance motor.	BTL 4	Analyze	CO3
21	Illustrate the applications of switched reluctance motor.	BTL 3	Apply	CO3
22	Why rotor position sensor is essential for the operation of SRM?	BTL 1	Remember	CO3
23	Develop the simple block diagram of SRM.	BTL 6	Create	CO3
24	Evaluate the demerits of Bifilar wires.	BTL 5	Evaluate	CO3
	Part-B			
1.	Draw the cross sectional view of switched reluctance motor and explain the principle of operation. State the advantages of switched reluctance motor. (13)	BTL 1	Remember	CO3
2.	(i) Explain the torque-speed characteristics of switched reluctance motors. (7) (ii) Derive the expressions for voltage and torque of SR machines. (6)	BTL 4	Analyze	CO3
3	i) What is the relationship between torque and current in synchronous reluctance motor? Derive the equation of torque developed in a switched reluctance motor. (7) ii) A switched reluctance motor with 8 stator	BTL 1	Remember	CO3

	poles and 6rotor poles has a stator polar arc of 30^o and rotor pole arc of 33^o. The aligned inductance is 10.5mH and unaligned inductance is 1.5mH. Saturation can be neglected. Calculate the instantaneous torque when the rotor is 30^o before the aligned position and phase current is 6A. Neglect fringing. (6)			
4	Explain the steady state performance analysis of switched reluctance motor. (13)	BTL 5	Evaluate	CO3
5	i) Draw and explain the characteristics of switched reluctance motor in detail. (7) ii) Derive the expression of static torque in SRM. (6)	BTL 3	Apply	CO3
6	A SRM with 6 stator poles and 4 rotor poles has a stator pole arc of 30^o and rotor pole arc is 32^o. The aligned inductance is 10.7mH and unaligned inductance is 1.5mH. Saturation can be neglected. Calculate the instantaneous torque when the rotor is 30^o before the aligned position and phase current is 6A. What is the maximum energy conversion for one stroke, if the current is limited to 7A? Determine the average torque corresponding to this energy conversion. (13)	BTL 3	Apply	CO3
7	Prepare the necessity of power electronic circuit in SR motor. Explain its different types of converter circuits. (13)	BTL 6	Create	CO3
8	Draw and explain four converter topologies for a three phase SRM. Write the merits and demerits of each topology. (13)	BTL 1	Remember	CO3
9	Draw a schematic diagram and explain the operation of a "C"-dump converter used for the control of SRM. (13)	BTL 4	Analyze	CO3
10	Describe the various converter topologies for a 3 phase switched reluctance motor with merits and demerits of each. Explain any two of them. (13)	BTL 2	Understand	CO3
11	(i) Describe with a neat circuit any two configuration of power converters used for the control of switched reluctance motor. (10) (ii) State the advantages of sensorless operation. (3)	BTL 2	Understand	CO3
12	Describe the closed loop control analysis of switched reluctance motor. (13)	BTL 1	Remember	CO3
13	Describe the following: (i) Role of microprocessors in control of switched reluctance motor (7) (ii) Sensorless operation. (6)	BTL 2	Understand	CO3
14	(i) Discuss the main advantages and disadvantages of switched reluctance motor. (7)	BTL 4	Analyze	CO3

	(ii) Discuss the various applications of switched reluctance motor. (6)			
15	(i) Explain the shaft position sensing of SR motor. (9) (ii) Enumerate the necessity of converter circuits for switched reluctance motors. (4)	BTL 2	Understand	CO3
16	Determine the nonlinear analysis of SRM.	BTL 5	Evaluate	CO3
17	Derive the voltage and torque equation of SRM.	BTL 3	Apply	CO3
Part-C				
1.	Assess the features of rotary and linear switched reluctance motors and suggest suitable motor for bottling plant. (15)	BTL 5	Evaluate	CO3
2.	Build a suitable microprocessor based controller for switched reluctance motor. (15)	BTL 6	Create	CO3
3.	Summarize the various stages in sensorless control of SRM. (15)	BTL 5	Evaluate	CO3
4.	Plot the mechanical characteristics of SR motor and discuss the type of control strategy used for different regions of the curve. Also, draw the typical phase current waveforms. (15)	BTL 6	Create	CO3
5	Describe in detail about the λ-i curve.	BTL 5	Evaluate	CO3
UNIT IV - PERMANENT MAGNET BRUSHLESS D.C. MOTORS				
Fundamentals of Permanent Magnets – Types - Principle of operation - Magnetic circuit analysis - EMF and Torque equations - Power Converter Circuits and their controllers - Characteristics and control - Applications.				
Part-A				
1.	List the permanent magnet materials used in PMBLDC motors.	BTL 1	Remember	CO4
2.	Compare conventional DC motor and PMBLDC motor.	BTL 4	Analyze	CO4
3.	Compare PMBLDC motor with PMSM.	BTL 5	Evaluate	CO4
4.	Define permeance coefficient.	BTL 1	Remember	CO4
5.	Write down the torque equation of P.M brush less D.C motor?	BTL 1	Remember	CO4
6.	Describe the principle of operation of PMBLDC motor.	BTL 2	Understand	CO4
7.	List out the different classifications of BLPM DC motor.	BTL 3	Apply	CO4
8.	Plot the magnetic equivalent circuit of PMBLDC motor.	BTL 6	Create	CO4
9.	What are the differences between mechanical and electronic commutator?	BTL 3	Apply	CO4
10.	Give the torque and emf equation of square wave brushless motor.	BTL 2	Understand	CO4
11.	Justify the statement: PMBLDC motor is called electronically commutated motor.	BTL 5	Evaluate	CO4
12.	How the demagnetization occurs in PMBLDC motor?	BTL 4	Analyze	CO4

13.	Summarize the merits of the brushless DC motor drives.	BTL 2	Understand	CO4
14.	List out the power controllers used in permanent magnet brushless DC motor.	BTL 1	Remember	CO4
15.	What are the ways by which demagnetization can be limited in permanent magnet?	BTL 1	Remember	CO4
16.	Name the position sensors that are used for PMBLDC motor.	BTL 1	Remember	CO4
17.	Show how are the directions of rotations reversed in PMBLDC motor?	BTL 2	Understand	CO4
18.	Sketch the ideal phase voltage and current waveform of PMBLDC machine.	BTL 6	Create	CO4
19.	A permanent magnet DC commutator motor has a stalling torque of 2 Nm. The stall current is 5 A.Compute the motor's no-load speed if it is fed with 28 V DC supply.	BTL 3	Apply	CO4
20.	Mention some of the applications of PMBLDC motor.	BTL 5	Evaluate	CO4
21.	List the materials used for making Hall IC Pallet.	BTL 4	Analyze	CO4
22.	Classify types of BLPM motors?	BTL 2	Understand	CO4
23.	Identify the peak recovery current in PMBLDC motor.	BTL 3	Apply	CO4
24.	Define recoil permeability.	BTL 4	Analyze	CO4
	Part-B			
1.	(i) Derive an expression for permeance coefficient of PMBLDC motor. (10) (ii) State the advantages of BLPM DC motor over conventional DC motor. (3)	BTL 2	Understand	CO4
2.	Derive the torque equation and torque ratio of permanent magnet brushless DC motor. (13)	BTL 3	Apply	CO4
3.	Explain the construction PMBLDC also compare conventional DC motor and PMBLDC motor. (13)	BTL 1	Remember	CO4
4.	(i) Elucidate in detail about the operation of PMBLDC motor with 180˚ magnet arcs and 120˚ square-wave phase currents. (7) (ii) Describe the constructional aspects of mechanical and electronic commutators of PMBLDC motors. (6)	BTL 1	Remember	CO4
5.	Discuss in detail about magnetic circuit analysis of PMBLDC motor. Also draw its characteristics. (13)	BTL 4	Analyze	CO4
6.	Derive the expression for emf and torque of a PMBLDC motor. Draw the relevant characteristics. (13)	BTL 2	Understand	CO4
7.	Explain the operation of electronic commutator in PMBLDC motor with necessary diagrams. Explain the operation of the same. (13)	BTL 4	Analyze	CO4
8.	Write a note on power controllers used for PMBLDC motor and explain the each blocks	BTL 1	Remember	CO4

	associated in it. (13)			
9.	Discuss the hysteresis type current regulation of PMBLDC motor with neat diagram? (13)	BTL 2	Understand	CO4
10.	Discuss the use of Hall sensors for position sensing in PMBLDC motor with necessary block diagram. (13)	BTL 6	Create	CO4
11.	(i) Explain the speed-torque characteristics of PMBLDC motor. (7) (ii) Differentiate between mechanical and electronic commutators. (6)	BTL 4	Analyze	CO4
12.	(i) A permanent magnet DC commutator motor has a no-load speed of 6000 rpm when connected to a 120 V supply. The armature resistance is 2. Ω and rotational and iron losses may be neglected. Determine the speed when the supply voltage is 60 V and the torque is 0.5 Nm. (7) (ii) Prove that the torque equation in BLDC motor is similar to that of conventional DC motor. (6)	BTL 5	Evaluate	CO4
13.	(i) Explain in detail about various types of PMBLDC motor with necessary diagrams. (7) (ii) A PMBLDC motor has torque constant of 0.12 Nm/A referred to DC supply. Find the motor's no-load speed when connected to 48 V DC supply. Find the stall current and stall torque if armature resistance is0.15 Ω/phase & drop in controller transistor is 2 V. (6)	BTL 3	Apply	CO4
14.	What is the operation of the closed loop control scheme of a PMBLDC motor drive with a suitable schematic diagram. (13)	BTL 1	Remember	CO4
15.	Explain the following (i) B-H loop (7) (ii) Demagnetization Characteristics (6)	BTL 2	Understand	CO4
16.	(i) Conclude the features of various Permanent magnets used for electrical machines. (6) (ii) Briefly explain the drive circuits of BLPMDC motor. (7)	BTL 5	Evaluate	CO4
17.	Identify the role of rotor position sensors for BLPM motors.	BTL 3	Apply	CO4
	Part-C			
1.	Identify appropriate power controllers for PMBLDC motor and explain with neat diagram. (15)	BTL 5	Evaluate	CO4
2.	Develop a power semiconductor base inverter circuit for star connected PMBLDC Motor and sketch the firing sequence and phase current waveform for any mode. (15)	BTL 6	Create	CO4
3.	Select suitable sensors for position sensing in	BTL 5	Evaluate	CO4

	MBLDC motors and explain the operation with neat sketch. (15)			
4.	Prepare the relationship between magnetising force and flux density by performing the magnetic circuit analysis of a brushless dc motor on open circuit. (15)	BTL 6	Create	CO4
5.	Derive the expression for permeance coefficient.	BTL 5	Evaluate	CO4
UNIT V - PERMANENT MAGNET SYNCHRONOUS MOTORS (PMSM)				
Constructional features - Principle of operation – EMF and Torque equations - Sine wave motor with practical windings - Phasor diagram - Power controllers – performance characteristics - Digital controllers – Applications.				
1.	Distinguish PM synchronous motor from BLPM DC motor.	BTL 4	Analyze	CO5
2.	List out the merits and demerits of PMSM.	BTL 1	Remember	CO5
3.	Classify the different types of PMSM.	BTL 3	Apply	CO5
4.	Express the torque and EMF equation of PMSM.	BTL 5	Evaluate	CO5
5.	Enumerate the assumptions to be made in deriving the EMF equation of PMSM.	BTL 3	Apply	CO5
6.	Briefly explain about synchronous reactance. Also write the expression for self and synchronous reactance of PMSM.	BTL 6	Create	CO5
7.	Define load angle.	BTL 1	Remember	CO5
8.	State the power controllers for PM synchronous machines.	BTL 2	Understand	CO5
9.	Describe load commutation and mention its advantages.	BTL 2	Understand	CO5
10.	Describe the features of closed loop speed control of loaded commuted inverter fed synchronous motor drive.	BTL 2	Understand	CO1
11.	Differentiate square wave and sine wave motor.	BTL 1	Remember	CO5
12.	Distinguish between self-control and vector control PMSM.	BTL 2	Understand	CO5
13.	What are the assumptions made in derivation of emf equation for PMSM?	BTL 4	Analyze	CO5
14.	Define synchronous reactance in PMSM.	BTL 1	Remember	CO5
15.	Explain the difference between SYNREL motor and PM synchronous motor.	BTL 4	Analyze	CO5
16.	Prepare the important features of permanent magnet synchronous motor.	BTL 6	Create	CO5
17.	Differentiate between self control and vector control of PMSM.	BTL 1	Remember	CO5
18.	Summarize the distribution factor for PMSM.	BTL 2	Understand	CO5
19.	Examine the Volt-ampere requirements of PMSM.	BTL 3	Apply	CO5
20.	List few applications of PMSM.	BTL 1	Remember	CO5
21.	State the principle of operation of PMSM.	BTL 4	Analyze	CO5
22.	When does a PMSM operate as synchronous reluctance motor?	BTL 4	Analyze	CO5
23.	Identify the uses of position sensors?	BTL 3	Apply	CO5

24.	Identify the types of power controllers for PMSM.	BTL 5	Evaluate	CO5
	Part-B			
1.	Explain the construction and working principle of operation of PMSM. (13)	BTL 1	Remember	CO5
2.	For an ideal sinewave permanent magnet motor derive the torque and EMF equations. (13)	BTL 3	Apply	CO5
3.	Enumerate the design considerations of permanent magnet synchronous motor. (13)	BTL 6	Create	CO5
4.	Describe the construction of phasor diagram of surface magnet sinewave motor. (13)	BTL 3	Apply	CO5
5.	With necessary phasor diagram and circle diagram, describe the torque speed characteristics of PMSM. (13)	BTL 4	Analyze	CO5
6	Derive the expression for power input and torque of a PMSM. Explain how its torque speed characteristics are obtained. (13)	BTL 4	Analyze	CO5
7.	Discuss PMBLDC and PMSM with respect to torque/ampere and KVA of converter/ kW of power to motor for 4 Pole, 3 Phase motor system. (13)	BTL 5	Evaluate	CO5
8.	Analyze and justify, the power output of PMBLDC motor is more than PMSM for the same size. (13)	BTL 4	Analyze	CO5
9.	With necessary diagrams, discuss about various power controllers used for PMSM. (13)	BTL 2	Understand	CO5
10.	(i) Discuss the current control scheme of permanent magnet synchronous motor in detail. (7) (ii) Derive self and mutual inductance of permanent magnet synchronous motor. (6)	BTL 2	Understand	CO5
11.	(i) What is armature reaction? Discuss its effects on PMSM. (3) (ii) Explain the concept of vector control and how it achieved in PMSM. (10)	BTL 1	Remember	CO5
12.	With a neat sketch, explain the microprocessor based speed control of PMSM. (13)	BTL 1	Remember	CO5
13.	(i) Discuss in detail about various rotor configurations of permanent magnet synchronous machines. (6) (ii) With necessary block diagram explain in detail about FOC for PMSM. (7)	BTL 2	Understand	CO5
14.	(i) State the applications of PMSM. (3) (ii)Discuss in detail about Volt-ampere requirements of PMSM. (10)	BTL 1	Remember	CO5
15.	Compare BLPM SQW motor and BLPM SNW motor.	BTL 2	Understand	CO5
16.	Explain Vector control of BLPM SNW motor in detail.	BTL 3	Apply	CO5
17.	Justify the self control operation of PMSM.	BTL 5	Evaluate	CO5

Part-C				
1.	A brush PM sine wave motor has an open circuit voltage of 173V at its corner point speed of 3000rpm. It is supplied from a PWM converter whose maximum voltage is 200V. Neglecting resistance and all other losses, estimate the maximum speed at which maximum current can be supplied to the motor. (15)	BTL 5	Evaluate	CO5
2.	Integrate a suitable microprocessor for the control of permanent magnet synchronous motor. (15)	BTL 6	Create	CO5
3	A 3 ϕ, 4 pole, brushless PM rotor has 36 stator slots. Each phase winding is made up of three coils per pole with 10 turns per coil. The coil span = 7 slots. If the fundamental component of magnet flux is 1.8mWb. Estimate the open circuit phase emf (E_q) at 3000 rpm. (15)	BTL 5	Evaluate	CO5
4.	Elaborate in detail the field oriented control of permanent magnet synchronous motor. (15)	BTL 6	Create	CO5
5.	Derive an expression for synchronous reactance of PMSM.	BTL 5	Evaluate	CO5

Course Outcomes:

Cos	Course Outcome
CO1	Ability to acquire the knowledge on construction, operation and control of synchronous reluctance motors.
CO2	Ability to acquire the knowledge on construction, operation and control of stepper motors.
CO3	Ability to acquire the knowledge on construction, operation and control of switched reluctance motors.
CO4	Ability to acquire the knowledge on construction, operation and control of permanent magnet brushless D.C. motors.
CO5	Ability to acquire the knowledge on construction and operation of permanent magnet synchronous motors.