DHANALAKSHMI SRINIVASAN COLLEGE OF ENGINEERING AND TECHNOLOGY

MAMALLAPURAM, CHENNAI -603104

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

QUESTION BANK

VII SEMESTER

EE6501-Power system Analysis

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Course Code & Name : EE6703 / Special Electrical Machines
Semester / Year : VII / 2018-2019 (ODD)

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
1.	What are the applications of synchronous reluctance motors?	BTL1	Remember
2.	Draw the voltage and torque characteristics of synchronous reluctance motor.	BTL6	Create
3.	Describe the principle of operation of synchronous reluctance motor.	BTL2	Understand
4.	Compare synchronous reluctance motor and induction motor.	BTL5	Evaluate
5.	Express and explain the voltage and torque equation of synchronous reluctance motor.	BTL2	Understand
6.	Write the different types of controllers used for synchronous reluctance motor.	BTL4	Analyze
7.	Classify the different types of synchronous reluctance motor.	BTL4	Analyze
8.	List the merits of 3-phase brushless permanent magnet synchronous motor.	BTL3	Apply
9.	What are the types of rotor available in synchronous reluctance motor?	BTL1	Remember
10.	What are SYNREL motors?	BTL2	Understand
11.	Give some potential applications of synchronous reluctance machine.	BTL3	Apply
12.	Examine the various design parameters of synchronous reluctance motor.	BTL1	Remember
13.	Give the operating principle of radial flux motor.	BTL2	Understand
14.	List out any four properties of reluctance motors.	BTL1	Remember
15.	Define reluctance torque with reference to synchronous reluctance motor.	BTL1	Remember
16.	Define cogging.	BTL1	Remember
17.	Why the power factor of synchronous reluctance motor is much lower than permanent magnet motor?	BTL3	Apply

18.	Compare synchronous reluctance motor with conventional synchronous motor.	BTL5	Evaluate
19.	Mention any two advantages of synchronous reluctance motors.	BTL4	Analyze
20.	Draw the phasor diagram of synchronous reluctance motor.	BTL6	Create

PART – B

1.	(i) Generalize the expression for the torque equation for the synchronous reluctance motor. (7) (ii) Investigate the performance of the synchronous reluctance motor with neat phasor diagram. (6)	BTL6	Create
2.	(i) Draw 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)	BTL5	Evaluate
3.	(i) Derive the torque equation of a synchronous reluctance motor and draw the torque angle characterisitcs. (7) (ii) Derive the expression for d-axis synchronous reactance of a permanent magnet synchronous reluctance motor (6)	BTL2	Understand
4.	(i) Discuss the various stator current modes in a synchronous reluctance motor in detail. (7) (ii) Write a detailed technical note on the variable reluctance motor and the advantages. (6)	BTL2	Understand
5.	Derive the voltage and torque equations of synchronous reluctance motor. (13)	BTL3	Apply
6.	Describe the constructional features and operation of variable reluctance synchronous reluctance motor. (13)	BTL2	Understand
7.	Explain with neat diagram, the construction, working principle and types of synchronous reluctance motor. (13)	BTL1	Remember
8.	Explain the torque speed characteristics of synchronous reluctance motor in detail. (13)	BTL1	Remember
9.	Derive the open circuit emf of synchronous reluctance motor. (13)	BTL3	Apply
10.	(i) Draw the steady state phasor diagram of synchronous reluctance motor and derive the expression for torque of synchronous reluctance motor. (13)	BTL1	Remember
11.	Differentiate between axial and radial airgap synchronous reluctance motors. Compare the performance of synchronous reluctance motor with switched reluctance motor. (13)	BTL4	Analyze
12.	Explain circle diagram and torque–speed characteristics of synchronous reluctance motor. (13)	BTL1	Remember
13.	Summarize the design considerations of synchronous reluctance motor. (13)	BTL4	Analyze
14.	(i) Discuss the main advantages and disadvantages of synchronous reluctance motor. (7) (ii) Discuss the various applications of synchronous reluctance motor. (6)	BTL4	Analyze

Part - C

1.	A 3Φ,230 Volts,60 HZ,4 pole Star Connected Reluctance Motor has Xd=22.5Ω and Xq=3.5Ω.The Armature Resistance is negligible. The Load torque is TL=12.5Nm.The Voltage to Frequency ratio is Maintained constant at the rated value. If the Supply frequency is 50 HZ. Determine i) The Torque Angle δ ii) The Line current iii) The Input Power Factor. (15)	BTL5	Evaluate
2.	Relate the constructional features of axial and radial gap synchronous reluctance motor. (15)	BTL4	Evaluate
3.	What is saliency ratio of SynRM and how it can be improved? (15)	BTL6	Create
4.	Compare Reluctance Motor with Induction Motor and Synchronous motor. (15)	BTL6	Create

UNIT II - STEPPER MOTORS

Constructional features – Principle of operation – Variable reluctance motor – Hybrid motor - Single and multi stack configurations – Torque equations – Modes of excitation - Characteristics – Drive circuits – Microprocessor control of stepper motors – Closed loop control-Concept of lead angle – Applications.

PART – A

1.	Analyze the various driver circuits used in stepped motor.	BTL4	Analyze
2.	Define stepping angle.	BTL1	Remember
3.	Name the various modes of excitation in stepping motor.	BTL4	Analyze
4.	Define the terms holding and detent torques as referred to stepper motor.	BTL1	Remember
5.	Distinguish the half step and full step operations of a stepper motor.	BTL5	Evaluate
6.	Summarize the principle of operation of a variable reluctance stepper motor.	BTL2	Understand
7.	Point out the difference between single and multi-stack stepping motors.	BTL4	Analyze
8.	Write the principle of operation of stepping motors.	BTL1	Remember
9.	Explain the features of stepper motor which are responsible for its wide spread use.	BTL5	Evaluate
10.	What is the function of drive circuit in stepping motor?	BTL1	Remember
11.	Define torque constant of a stepper motor.	BTL1	Remember
12.	Calculate the stepping angle for a 3phase, 24 pole permanent magnet stepper motor.	BTL3	Apply
13.	Mention the various applications of micro stepping VR stepper motor.	BTL2	Understand
14.	What is the need of suppressor circuits in stepper motor.	BTL3	Apply
15.	Draw the block diagram of the drive systems of a stepping motor.	BTL6	Create

16.	Illustrate the principle of hybrid stepping motors.	BTL3	Apply
17.	What is meant by lead angle in stepper motors?	BTL2	Understand
18.	Draw the equivalent circuit of a winding in stepper motor	BTL6	Create
19.	What are the applications of the stepper motor?	BTL2	Understand
20.	Define slewing.	BTL1	Remember

PART – B

1.	(i) Explain microprocessor based control of stepper motor with an example. (10) (ii) What are the advantages of closed loop control of stepper motor? (3)	BTL1	Remember
2.	Describe the operation of variable reluctance type stepper motor with different modes of operation. (13)	BTL1	Remember
3.	Construct and evaluate the operation of single stack and multi-stack stepper motor with a neat diagram. (13)	BTL5	Evaluate
4.	(i) Compare the static and dynamic characteristics of stepper motor with necessary diagrams. (7) (ii) Explain closed loop control of stepper motor. (6)	BTL4	Analyze
5.	Discuss the construction and working principle of hybrid stepper motor with neat diagrams. (13)	BTL4	Analyze
6.	Draw and explain the drive circuits and their performance characteristics for stepper motor. (13)	BTL6	Create
7.	Discuss the following : (i) Modes of excitations of stepping motors. (7) (ii) Characteristics of stepping motors. (6)	BTL2	Understand
8.	(i) Explain the mechanism of static torque production in a variable reluctance stepping motor. (10) (ii) Calculate the stepping angle for a 3 phase 24 pole permanent magnet type stepper motor. (3)	BTL3	Apply
9.	With a neat block diagram explain microprocessor control of stepping motor. (13)	BTL1	Remember
10.	(i) Discuss in detail, about the construction and working principle of Variable reluctance stepper motors. (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)	BTL2	Understand
11.	(i) What is the motor torque Tm required to accelerate an initial load of $2*10^{-4}$ kgm^2 from 500Hz to 1500Hz in 50ms. The frictional torque is 0.03Nm and step angle is1.18˚. (7) (ii) Write a detailed technical note on the bipolar drives for stepper motors. (6)	BTL3	Apply
12.	(i) Explain with a neat diagram the multi-stack configuration in 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)	BTL1	Remember
13.	Discuss the principle of operations of permanent magnet stepper motor with torque Vs angle characteristics. (13)	BTL4	Analyze

14.	Discuss 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. (13)	BTL2	Understand

PART – C

1.	A stepper motor has a step angle of 2.5, Determine, i)Resolution. ii)Number of steps per shaft to make 25 revolutions iii)Shaft speed if Starting stepping frequency is 3600pulse/sec. (15)	BTL5	Evaluate
2.	Discuss about unipolar and bipolar driver circuits of stepping motor. (15)	BTL6	Create
3.	Explain the working of single and multistack configured stepping motors. Also comment on microstepping. (15)	BTL5	Evaluate
4.	Discuss the principle of operations of permanent magnet stepper motor with torque Vs angle characteristics. (15)	BTL6	Create

UNIT III - SWITCHED RELUCTANCE MOTORS (SRM)

Constructional features – Rotary and Linear SRM - Principle of operation – Torque production – Steady state performance prediction- Analytical method -Power Converters and their controllers – Methods of Rotor position sensing – Sensor less operation – Characteristics and Closed loop control – Applications.

PART – A

1.	What is the significance of closed loop control in switched reluctance motor?	BTL1	Remember
2.	List out the advantages of switched reluctance motors.	BTL1	Remember
3.	Point out the different power controllers used for the control of switched reluctance motor.	BTL 4	Analyze
4.	Illustrate the different modes of operation of switched reluctance motor.	BTL3	Apply
5.	Compare the advantages and disadvantages of the converter circuit with two power semiconductor devices and two diodes per phase.	BTL4	Analyze
6.	Give the advantages of sensorless operation of switched reluctance motor.	BTL2	Understand
7.	Discuss the principle of operation of switched reluctance motor.	BTL2	Understand
8.	Generalize the voltage and torque equation of switched reluctance motor.	BTL6	Create
9.	Mention some position sensors in switched reluctance motor.	BTL4	Analyze
10.	Analyze why SR machines popular in adjustable speed drives.	BTL3	Apply
11.	What is the need of shaft position sensor for switched reluctance motor?	BTL2	Understand
12.	List the methods of rotor position sensing in switched reluctance motor.	BTL1	Remember
13.	Illustrate the applications of switched reluctance motor.	BTL3	Apply
14.	Define energy ratio.	BTL1	Remember

15.	Differentiate switched reluctance motor with variable reluctance stepper motor.	BTL5	Evaluate
16.	Draw the torque speed characteristics of switched reluctance motor.	BTL6	Create
17.	Define voltage pulse width modulation control.	BTL1	Remember
18.	What is hysteresis current control?	BTL1	Remember
19.	Summarize the disadvantages switched reluctance motor.	BTL2	Understand
20.	Differentiate the merits & demerits of converter having phase winding with bifilar wires.	BTL2	Understand

PART – B

1.	(i) Explain 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)	BTL2	Understand
2.	Draw the cross sectional view of switched reluctance motor and explain the principle of operation. State the advantages of switched reluctance motor. (13)	BTL1	Remember
3.	(i) Along with circuit diagrams explain the hysteresis type and PWM current regulator for one phase of a switched reluctance motor. (10) (ii) Explain briefly the various modes of excitation of variable reluctance motor. (3)	BTL3	Apply
4.	(i) Explain the role of microprocessors in control of switched reluctance motor. (7) (ii) Derive the torque equations of the variable reluctance motor and illustrate the various dependent parameters. (6)	BTL3	Apply
5.	Summarize the steady state performance analysis of switched reluctance motor. (13)	BTL5	Evaluate
6.	Explain the closed loop control analysis of switched reluctance motor. (13)	BTL1	Remember
7.	(i) Compare and contrast the performances of SR motor and VR stepper motors. (3) (ii) Explain the importance of closed loop control in SR motor. (10)	BTL4	Analyze
8.	Discuss the following in switched reluctance motor (i) Methods of rotor position sensing (7) (ii) Sensorless operation. (6)	BTL2	Understand
9.	Draw and explain four converter topologies for a three phase SRM. Write the merits and demerits of each topology. (13)	BTL1	Remember
10.	(i) Explain the torque-speed characteristics of switched reluctance motors. (7) (ii) Derive the expressions for voltage and torque of SR machines. (6)	BTL6	Create
11.	Discuss the necessity of power electronic circuit in SR motor. Explain its different types of converter circuits.(13)	BTL4	Analyze
12.	(i) Explain the shaft position sensing of SR motor. (7) (ii) Explain the nonlinear analysis of SRM. (6)	BTL1	Remember

13.	Discuss the various converter topologies for a 3 phase switched reluctance motor with merits and demerits of each. Explain any two of them. (13)	BTL2	Understand
14.	(i) Discuss the main advantages and disadvantages of switched reluctance motor. (7) (ii) Discuss the various applications of switched reluctance motor. (6)	BTL4	Analyze

PART – C

1.	Sketch the general speed-torque curve of SR motor and discuss the type of control strategy used for different regions of the curve. Sketch the typical phase current waveforms of low speed operation. (15)	BTL6	Create
2.	Compare and contrast the features of Rotary and Linear switched reluctance motors. (15)	BTL5	Evaluate
3.	Explain the closed loop control of SRM using sensorless operation. (15)	BTL5	Evaluate
4.	With a neat block diagram, describe in detail the microprocessor based controller in switched reluctance motor. (15)	BTL6	Create

UNIT IV - PERMANENT MAGNET BRUSHLESS D.C. MOTORS

Permanent Magnet materials – Minor hysteresis loop and recoil line-Magnetic Characteristics – Permeance coefficient -Principle of operation – Types – Magnetic circuit analysis – EMF and torque equations –Commutation - Power Converter Circuits and their controllers – Moto characteristics and control– Applications.

PART – A

1.	List the permanent magnet materials used in PMBLDC motors.	BTL 1	Remember
2.	Compare conventional DC motor and PMBLDC motor.	BTL 4	Analyze
3.	Compare PMBLDC motor with PMSM.	BTL 5	Evaluate
4.	Define Permeance coefficient.	BTL 1	Remember
5.	Comment on demagnetization in PMBLDC motor.	BTL 4	Analyze
6.	Describe the principle of operation of PMBLDC motor.	BTL 2	Understand
7.	List out the different classifications of BLPM DC motor?	BTL 3	Apply
8.	Draw the magnetic equivalent circuit of 2 pole PMBLDC motor.	BTL 6	Create
9.	How the permanent magnet motors are named based on the wave shape of emf?	BTL 3	Apply
10.	Express the torque and Emf equation of square wave brushless motor.	BTL 2	Understand
11.	Justify the statement: PMBLDC motor is called electronically commutated motor.	BTL 5	Evaluate
12.	Compare and contrast mechanical and electronic commutator.	BTL 4	Analyze
13.	What are the merits of the brushless DC motor drives?	BTL 2	Understand

14.	List out the power controllers used in permanent magnet brushless DC motor.	BTL 1	Remember
15.	Give short note on hall & optical sensors and its uses?	BTL 1	Remember
16.	Name the position sensors that are used for PMBLDC motor.	BTL 1	Remember
17.	How are the directions of rotations reversed in PMBLDC motor?	BTL 2	Understand
18.	Sketch the ideal phase voltage and current waveform of PMBLDC machine.	BTL 6	Create
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
20.	Mention some of the applications of PMBLDC Motor.	BTL 1	Remember

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)	BTL2	Understand
2.	Illustrate B-H hysteresis loop of permanent magnet material. (13)	BTL3	Apply
3.	Explain the construction PMBLDC also compare conventional DC motor and PMBLDC motor. (13)	BTL1	Remember
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)	BTL1	Remember
5.	Discuss in detail about magnetic circuit analysis of PMBLDC motor. Also draw its characteristics. (13)	BTL4	Analyze
6.	Derive the expression for emf and torque of a PMBLDC motor. Draw the relevant characteristics. (13)	BTL2	Understand
7.	Analyze the operation of electronic commutator in PMBLDC motor with necessary diagrams. Explain the operation of the same. (13)	BTL4	Analyze
8.	Write a note on power controllers used for PMBLDC motor and explain the each blocks associated in it. (13)	BTL1	Remember
9.	Discuss the hysteresis type current regulation of PMBLDC motor with neat diagram? (13)	BTL2	Understand
10.	Discuss the use of Hall sensors for position sensing in PMBLDC motor with necessary block diagram. (13)	BTL6	Create
11.	(i) Explain the speed-torque characteristics of PMBLDC motor.(7) (ii) Differentiate between Mechanical and Electronic Commutators. (6)	BTL4	Analyze
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)	BTL5	Evaluate

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 is 0.15 Ω/phase & drop in controller transistor is 2 V. (6)	BTL3	Apply
14.	Explain the closed loop control scheme of a PMBLDC motor drive with a suitable schematic diagram. (13)	BTL1	Remember

PART – C

1.	Draw IGBT based inverter circuit for delta connected PMBLDC Motor and sketch the firing sequence and phase current waveform for 120° mode. (15)	BTL6	Create
2.	Deliberate the operation of power controllers for PMBLDC Motor with neat diagram. (15)	BTL5	Evaluate
3.	Confer in detail about the operation of an electronic commutator. (15)	BTL6	Create
4.	Convene the use of Hall sensors for position sensing in PMBLDC motors. (15)	BTL5	Evaluate

UNIT V - PERMANENT MAGNET SYNCHRONOUS MOTORS (PMSM)

Principle of operation – Ideal PMSM – EMF and Torque equations – Armature MMF – Synchronous Reactance – Sine wave motor with practical windings - Phasor diagram – Torque/speed characteristics - Power controllers - Converter Volt-ampere requirements– Applications.

PART – A

1.	Compare and contrast Ideal PMSM with practical PMSM.	BTL4	Analyze
2.	List out the merits and demerits of PMSM?	BTL1	Remember
3.	State two classifications of PM synchronous machines with its associated types.	BTL3	Apply
4.	Express the torque and EMF equation of PMSM.	BTL5	Evaluate
5.	Enumerate the assumptions to be made in deriving the EMF equation of PMSM?	BTL3	Apply
6.	Briefly explain about synchronous reactance. Also write the expression for self and synchronous reactance of PMSM.	BTL6	Create
7.	Define load angle.	BTL1	Remember
8.	State the power controllers for PM synchronous machines.	BTL2	Understand
9.	Summarize load commutation? Mention its advantages.	BTL2	Understand
10.	Describe the features of closed loop speed control of loaded commuted Inverter fed synchronous motor drive?	BTL2	Understand
11.	Define pulsated mode?	BTL1	Remember
12.	Distinguish between self control and vector control PMSM.	BTL2	Understand

13.	Explain in brief about field oriented control of PMSM?	BTL4	Analyze
14.	What is self-control in PMSM?	BTL1	Remember
15.	Clearly explain the difference between SYNREL motor and PM synchronous motor.	BTL6	Create
16.	Write the important features of permanent magnet synchronous motor.	BTL1	Remember
17.	What is meant by slot less motor?	BTL1	Remember
18.	Explain the distribution factor for PMSM.	BTL4	Analyze
19.	Examine the Volt-ampere requirements of PMSM.	BTL3	Apply
20.	List few applications of PMSM?	BTL1	Remember

PART – B

1.	Explain the construction and working principle of operation of PMSM. (13)	BTL1	Remember
2.	For an ideal sinewave permanent magnet motor derive the torque and EMF equations. (13)	BTL3	Apply
3.	Deduce the expression for synchronous reactance of PM synchronous motor. (13)	BTL4	Analyze
4.	Describe the construction of phasor diagram of surface magnet sinewave motor. (13)	BTL3	Apply
5.	With necessary phasor diagram and circle diagram, describe the torque speed characteristics of PMSM. (13)	BTL4	Analyze
6.	Derive the expression for power input and torque of a PMSM. Explain how its torque speed characteristics are obtained. (13)	BTL4	Analyze
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)	BTL6	Create
8.	Analyze and Justify, the power output of PMBLDC motor is more than PMSM for the same size. (13)	BTL5	Evaluate
9.	With necessary diagrams, discuss about various power controllers used for PMSM. (13)	BTL2	Understand
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)	BTL2	Understand
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)	BTL1	Remember
12.	With a neat sketch, explain the microprocessor based speed control of PMSM. (13)	BTL1	Remember
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

14.	(i) State the applications of PMSM. (3) (ii) Discuss in detail about Volt-ampere requirements of PMSM. (10)	BTL 1	Remember

PART – C

1.	Discuss self control model of PM synchronous motor with revelent diagram. (15)	BTL 4	Analyze
2.	Elucidate in detail the vector control of permanent magnet synchronous motor. (15)	BTL 5	Evaluate
3.	A three phase, four pole, brushless PM rotor has 36 stator slots. Each phase winding is made up of three coils per pole with 20 turns per coil. The coil span is seven slots. If the fundamental component of magnet flux is 1.8 Mwb. Calculate the open circuit phase emf (Eq) at 3000 rpm. (15)	BTL 5	Evaluate
4.	Enumerate the construction and performance of a permanent magnet synchronous motor with necessary diagrams. (15)	BTL 6	Create