CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
EET426	SPECIAL ELECTRIC MACHINES	PEC	2	1	0	3

Preamble: This course gives an overview of special electrical machines for control and industrial applications.

Prerequisite: EET202 DC Machines and Transformers

EET307   Synchronous and Induction Machines

Course Outcomes: After the completion of the course, the student will be able to:

CO 1	Analyse the performance of different types of permanent magnet motors.
CO 2	Analyse the performance of a stepper motor.
CO 3	Analyse the performance of different types of reluctance motors.
CO 4	Explain the construction and principle of operation of servo motors, single phase motors and linear motors.
CO 5	Analyse the performance of linear induction motors.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	3	2	-	-	-	2	-	-	-	-	-	2
CO 2	3	2	-	-	-	2	-	-	-	-	-	2
CO 3	3	2	-	-	-	2	-	-	-	-	-	2
CO 4	3	2	-	-	-	2	-	-	-	-	-	2
CO 5	3	2	-	-	-	2	-	-	-	-	-	2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	15	15	30
Understand	25	25	50
Apply	10	10	20
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance   : 10 marks
Continuous Assessment Test (2 numbers)   : 25 marks
Assignment/Quiz/Course project   : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contains 10 questions (each carrying 3 marks) with 2 questions from each module. Students should answer all questions. Part B contains 2 questions from each module, out of which students should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

Part A: 10 Questions x 3 marks=30 marks, **Part B:** 5 Questions x 14 marks =70 marks

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain the principle of operation of any motor.[K1, PO1]
2. List the permanent magnets used in motors and explain their magnetization characteristics. [K1, PO1]
3. Problems based on emf and torque of PMBLDC motor and PMSM. [K2, PO2]

Course Outcome 2 (CO2):

1. Explain the working of any type of stepper motor with a neat diagram. [K1, PO1]
2. Explain the different configurations for switching the phases of a stepper motor. [K2, PO1]
3. Numerical problems from stepper motors. [K2, PO2]

Course Outcome 3(CO3):

1. Derive the torque equation of any motor. [K2, PO1]
2. Draw the phasor diagram of a synchronous reluctance motor. [K1, PO1]
3. Explain any two power converter circuits used for the control of SRM. [K1, PO1]

Course Outcome 4 (CO4):

1. Explain the constructional details of any servo motor. [K1, PO1]
2. Discuss the role of servo motors in automation systems. [K2, PO12]
5. Explain the constructional details and working principle of any motor. [K1, PO1]

Course Outcome 5 (CO5):

1. Explain the principle of operation of a LIM. [K1, PO1]
2. What are the different types of Linear motors?. [K1, PO1]
3. Derive the thrust equation of a LIM. [K2, PO1]

Model Question Paper

QP CODE: PAGES:

Reg. No:_____
Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY EIGHTH SEMESTER
B.TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: EET426
Course Name: SPECIAL ELECTRIC MACHINES

Max. Marks: 100 Duration: 3 Hours

PART A (3 x 10 = 30 Marks)
Answer all Questions. Each question carries 3 Marks

1. Explain the constructional details of PMBLDC Motor.
2. Explain the sensor less control of PMSM.
3. Define the following terms as applied to stepper motors (i) Holding Torque (ii) Step accuracy (iii) Detent position.
4. What is meant by micro stepping in stepper motors? What are its advantages?
5. Draw the torque -slip characteristics of a Reluctance motor and explain its shape.
6. Explain the drawbacks of a Switched Reluctance motor.
7. What are the applications of servo motors?
8. Draw and explain the performance characteristics of an ac servo motor.
9. Explain the working principle of a hysteresis motor.
10. Derive the expression for linear force in LIM.

PART B (14 x5= 70 Marks)
Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. (a) Explain the principle of operation of the PMBLDC motor with a neat circuit diagram showing the complete drive circuit. (10 marks)
    (b) Differentiate trapezoidal and sinusoidal back emf permanent magnet motors.
    (4 marks)
12. (a) Explain the demagnetisation characteristics and choice of permanent magnets in a Brushless DC motor. (10 marks)
    (b) Explain the constructional details and working principle of the permanent magnet dc motor. (4 marks)

Module 2

13. (a) With neat sketches, explain the constructional details and working principle of the variable reluctance stepper motor. (10 marks)
    (b) List any four applications of stepper motors. (4 marks)

14. (a) A permanent magnet stepper motor is driven by a series of pulses of duration 20ms. It has 4 stator poles and 6 rotor poles. How long will it take for the motor to make a complete rotation? (4 marks)
    (b) Compare variable reluctance, permanent magnet and hybrid stepper motors.
    (6 marks)
    (c) Explain monofilar and bifilar windings. (4 marks)

Module 3

15. (a) With neat sketches explain the construction and operation of 8/6 SRM. (10 marks)
    (b) Draw and explain n+1 switches and diode configuration power converter for the SRM. (4 marks)

16. (a) Derive the torque equation of a synchronous reluctance motor. (8 marks)
    (b) Explain the basic principle of operation of a synchronous reluctance motor.
    (6 marks)

Module 4

17. (a) With the help of a schematic diagram, explain the working of the field controlled d.c servomotor. (8 marks)
    (b) Explain the working and applications of split field servomotors. (6 marks)

18. (a) Explain the constructional features and working principle of AC Servomotors.
    (10 marks)
    (b) Explain the characteristic difference between AC and DC servomotors. (4 marks)

Module 5

19. (a) Describe the properties of the materials used for the rotor construction of hysteresis motors. (5 marks)
    (b) Why is compensating winding used in AC series motors? Draw a series motor with different types of compensating windings. (5 marks)
    (c) What are the modifications to be made in the DC series motor to operate it in an AC supply? (4 marks)

20. (a) Develop the equivalent circuit of a LIM and describe the main factors affecting its performance. (10 marks)
     (b) Explain the transverse edge effect in LIM. (4 marks)

Syllabus

Module 1 (8 hours)

Permanent Magnet DC Motors – construction – principle of operation.
PM Brushless DC motor- Brushless DC motor-construction - permanent magnets – different types- demagnetization characteristics – arrangement of permanent magnets – magnetization of permanent magnets – axial and parallel magnetizations- principle of operation – Control of BLDC motor - applications.
Permanent Magnet Synchronous Motors-construction - principle of operation –Control of PMSM - Self control - Sensor less Control– applications - Comparison with BLDC motors.

Module 2 (7 hours)

Stepper motors - Basic principle - different types - variable reluctance, permanent magnet, hybrid type - principle of operation – comparison. Monofilar and bifilar windings - modes of excitation- static and dynamic characteristics- open loop and closed loop control of Stepper Motor-applications.

Module 3 (7 hours)

Synchronous Reluctance Motor - Construction, principle of operation- phasor diagram - torque equation - applications.
Switched reluctance motors - principle of operation - torque equation – characteristics - power converter circuits - control of SRM - rotor position sensors- torque pulsations – sources of noise- noise mitigation techniques - applications.

Module 4 (6 hours)

DC Servo motors – DC servo motors – construction– principle of operation - transfer function of field and armature controlled dc servo motors -permanent magnet armature controlled dc servo motor- series split field dc servo motor- applications.
AC Servo motors -Construction – principle of operation- performance characteristics - damped ac servo motors - Drag cup servo motors- applications.

Module 5 (8 hours)

Single Phase Special Electrical Machines- AC series Motor, Repulsion Motor, Hysteresis Motor, Universal Motor- Construction - principle of operation - applications.

Linear Electric Machines: Linear motors – different types – linear reluctance motor- linear synchronous motors – construction – comparison.

Linear Induction Motor – Construction- Thrust Equation, Transverse edge and end effects- Equivalent Circuit, Thrust-Speed characteristics, Applications.

Text Book:
1. E. G. Janardhanan, '*Special Electrical Machines*' PHI Learning Private Limited.

References:
1. R. Krishnan, '*Permanent magnet synchronous and Brushless DC motor Drives*', CRC Press.
2. T. J. E. Miller, '*Brushless PM and Reluctance Motor Drives*', C. Larendon Press, Oxford.
3. Theodore Wildi, '*Electric Machines, Drives and Power Systems*', Prentice Hall India Ltd.
4. Veinott & Martin,' *Fractional & Sub-fractional hp Electric Motors*', McGraw Hill International Edn.
5. R. Krishnan, '*Switched Reluctance Motor Drives*', CRC Press.
6. K. Venkataratnam, '*Special Electrical Machines*', Universities Press.

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Permanent Magnet DC Motors (8 hours)**	
1.1	Permanent Magnet DC Motors – construction – principle of operation.	1
1.2	Brushless DC motor-construction - permanent magnets – different types- demagnetization characteristics	1
1.3	Arrangement of permanent magnets – magnetization of permanent magnets – axial and parallel magnetizations- principle of operation	2
1.4	Control of BLDC motor- applications.	1
1.6	Permanent Magnet Synchronous Motors-construction- principle of operation	1
1.7	Control methods of PMSM-Self control- Sensorless Control -applications-Comparison with BLDC	2
2	**Stepper motors (7 hours)**	
2.1	Stepper motors – construction and principle of operation	1
2.2	different types - variable reluctance , permanent magnet, hybrid type - principle of operation – comparison	2
2.3	Windings - Monofilar and bifilar windings- modes of excitation- Full step on mode, two phase ON mode, Half step mode.	2
2.4	Static and dynamic characteristics	1
2.5	Open loop and closed loop control of Stepper Motor-applications.	1
3	**Reluctance motors (7 Hours)**	
3.1	Synchronous Reluctance Motor - Construction, principle of operation	1
3.2	Phasor diagram - torque equation- torque-slip characteristics- applications	2
3.3	Switched reluctance motors - principle of operation - torque equation-characteristics - power converter circuits .	2
3.4	Control of SRM - rotor position sensors-	1
3.5	Torque pulsations – sources of noise- mitigation techniques -	1

	applications.	
4	**Servo motors (6 Hours)**	
4.1	DC servo motors – construction– principle of operation - transfer function of field and armature controlled DC servomotors	2
4.2	Permanent magnet armature controlled - series split field DC servo motor- applications	2
4.3	**AC Servomotors -**Construction – principle of operation- performance characteristics	1
4.4	Damped AC servo motors - Drag cup servo motors- applications.	1
5	**Single Phase Special Electrical Machines- (8 Hours)**	
5.1	AC series Motor, Repulsion Motor, Hysteresis Motor, Universal Motor- Construction -principle of operation - applications.	3
5.2	**Linear Electric Machines:** Linear motors – different types	1
5.3	Linear reluctance motor , linear synchronous motors – construction – comparison.	1
5.4	Linear Induction Motor – Construction- Thrust Equation, Transverse edge and end effects	2
5.5	Equivalent Circuit, Thrust-Speed characteristics, Applications.	1