GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3162416

Semester – VI
Subject Name: Advanced Electrical Machines

Type of course: Engineering Science (Power Electronics)

Prerequisite: 1. 3110005 - Fundamental of Electrical Engineering
2. 3110016 – Basic Electronics
3. 3132407 - Electrical Machine and Application

Rationale: Conventional rotating electrical machine like direct current machine, induction machine and synchronous machines are mainly used for bulk energy conversion. There are other types of electrical machine such as stepper motor, Switched Reluctance Motor, Permanent Magnet DC and AC motors, Brushless DC Motor, Linear Electric Machine, Permanent Magnet Axial Flux machine. With rapid developments in semiconductor technology and digital control systems, during past few decades, the implementation of fast and accurate control schemes could be realized. At present large number of institutions and industries are actively involved in research for further improvement in construction and performance of special electrical machine. This subject enables the students to develop the understanding of Brushless DC Machines & Stepper Motors. Understand the concept of Switched Reluctance Motor & Linear Induction Machines and Permanent Magnet DC & AC or PMSM motor.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
				Theory Marks		Practical Marks		
L	T	P	C	ESE (E)	PA (M)	ESE (V)	PA (I)	
3	0	2	4	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs	% Marks
1	Electronic Speed Control of DC Motors: Uncontrolled Rectifiers, Controlled Rectifiers, Thyristor Choppers, Thyristor Inverters, Thyristor Speed Control of Separately-excited D. C. Motor, Thyristor Speed control of D.C. Series Motor, Full-wave Speed Control of a Shunt Motor, Thyristor Speed Control of a Shunt Motor, Thyristor Speed Control of a Series D. C. Motor, Starter and Speed-control Rheostats, Starting and Speed control of Series Motor, Grading of Starting Resistance of Shunt Motors, Series Motor Starter, Thyristor Controller Starters, Electrical Braking for Series and Shunt Motor.	**6**	**15**
2	Behavioral Phenomena of Induction Motor: Torque / speed Curve, Current / Speed Curve, Torque / Speed Characteristic Under Load, Induction Motor operation as a Generator, Complete Torque / speed curve for a 3-phase machine, Measurement of slip, Power Stages, Torque equation, Synchronous Watt, Variations in Rotor Current, Analogy with a Mechanical Clutch, Analogy with a DC Motor, Sector Induction Motor, Linear Induction Motor,	**6**	**10**

	Properties of Linear IM, Magnetic Levitation.		
3	Electrical Machine with Specific Applications: Types Construction working Principle and Applications of Stepper Motors, Variable Reluctance Stepper Motors, Multi-stack VR Stepper Motor, Permanent-Magnet Stepping Motor, Hybrid Stepper Motor, Permanent-Magnet DC Motor, Low-inertia DC Motors, Permanent-Magnet Synchronous Motors, Switched Reluctance Motor, Servo Motors, Synchro and Resolver.	**10**	**15**
4	Stepper and Reluctance Motor: Stepper Motor: Characteristics – Open Loop and Closed Loop Control – Control Strategies -Power Converter Circuit – Microprocessor, DSP and Microcontroller based Control Switched Reluctance Motor: Characteristics – Open Loop and Closed Loop Control – Control Strategies - Power Converter Circuit – Microprocessor, DSP and Microcontroller based Control – Sensor less control Servo Motor: Characteristics – Open Loop and Closed Loop Control – Control Strategies - Power Converter Circuit – Microprocessor, DSP and Microcontroller based Control	**6**	**20**
5	Permanent Magnet Motors: PMDC and BLDC Motor: Characteristics – Open Loop and Closed Loop Control – Control Strategies - Power Converter Circuit – Microprocessor, DSP and Microcontroller based Control PMSM Motor: Characteristics – Open Loop and Closed Loop Control – Control Strategies - Power Converter Circuit – Microprocessor, DSP and Microcontroller based Control PMAF Machine: Characteristics – Open Loop and Closed Loop Control – Control Strategies -Power Converter Circuit – Microprocessor, DSP and Microcontroller based Control	**8**	**20**
6	Linear Electric Machines: Linear Induction Machine: Construction – Types – Working –Feature – Thrust Equation – Control – Application Linear Synchronous Machine: Construction – Types – Working –Feature – Thrust Equation – Control – Application DC Linear Motor: Construction – Types – Working –Feature – Thrust Equation – Control – Application Linear Reluctance Motor: Construction – Types – Working –Feature – Thrust Equation – Control – Application	**6**	**20**

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	35	20	20	10	5

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Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

Note: This specification table shall be treated as a general guideline for students and teachers. The actual distribution of marks in the question paper may vary slightly from above table.

Reference Books:

1. Special Electrical Machine E. G. Janardanan
2. Electric Machinery A.E. Fitzgerald, Charles Kingsley
3. Fundamental of Electrical Drives G. K. Dubey
4. Brushless Permanent-Magnet Motor Design, D. C. Hanselman
5. Analysis of electric machinery and drive systems, - Paul C.Krause, Oleg Wasynnczuk, and S.D. Sudhoff
6. Principles of Power Electronics, P. C. Sen.
7. Brushless Permanent Magnet Motor and Reluctance Motor Drive T. J. E. Miller
8. Permanent Magnet Synchronous and Brushless DC Motor Drives R. Krishnan

Course Outcomes:

Sr. No.	CO statement (Students will be able to:)	CO- Topic Mapping	Marks % weightage
CO-1	Criticize the Electronics Speed Control of DC Motor.	1	20
CO-2	Interpret behavioral phenomena of Induction Motor.	2	20
CO-3	Illustrate the Construction, Working and characteristics of Special Electrical Machine.	3-4-5	25
CO-4	Analyse the different Speed control method for Special Electrical Machine.	3-4-5	25
CO-5	Create block diagram Electric Drive for speed control of the Special Electrical Machine.	3-4-5	10

List of Experiments:
The list is for guideline only. As far as possible, the term work given should be in digitized form.

1. To study and perform microprocessor-based Control of Stepper Motor.
2. To study and perform microprocessor-based Control of Switched Reluctance Motor.
3. To study and perform Sensor Less Control of Switched Reluctance Motor.
4. To study and perform microprocessor-based Control of PMBLDC.
5. To study and perform DSP based Control of PMBLDC.
6. To study and perform sensor less Control of PMBLDC
7. To study and perform Vector Control of PMSM.
8. To study and perform Sensor less and Self Control of PMSM.
9. To study and perform microprocessor and DSP based Control of PMSM.
10. To study constant direct axis current control of scheme for Synchronous Reluctance Motor.

11. To study and perform AC and DC Servo Motor Control Using microprocessor.
12. To study and perform DSP based Control scheme for trapezoidal or sinusoidal PMAF Motor.

Design based Problems (DP)/Open Ended Problem:

1. Develop and analyze a dynamic model of a separately excited dc motor model, its control structure and design current, speed and position controllers for both constant torque and constant power operation.
2. Identify and analyze different chopper topologies for to drive a separately excited dc motor in different quadrants.
3. Develop and analyze an induction motor model suitable for a scalar controller and the different speed control schemes.
4. Develop and analyze dynamic model of an induction motor using space phasor and reference frame theory approach suitable for vector control of induction motor for improved transient performance.
5. Develop and analyze rotor and stator (DTC) control schemes.
6. Analyze field oriented permanent magnet synchronous motor drives.

Major Equipment:

1. 4 ½ digit handheld Digital Multimeter
2. Handheld Digital Tachometer
3. Four channel Digital Oscilloscope
4. Various Trainer boards for AC Drives.
5. V/f control of three-phase induction motor. IGBT inverter power module, 3 phase induction motor0.5HP, V/f controller display meters
6. Micro controller-based speed control of Stepper motor. Stepper motor, PIC Microcontroller, controller circuit, Interface circuit.
7. Speed control of BLDC motor. Power module, BLDC motor(0.5HP) Controller circuit, sensor circuit, display meter.
8. DSP based speed control of SRM motor. SRM motor-0.5 HP, PIC DSP/TMS DSP Processor, speed sensor, Power module, Display meter,
9. Any one simulation software (Open source software preferred): Scilab /Matlab and Simulink toolbox, CASPOC
10. Voltage Regulation of three-phase Synchronous Generator. Synchronous generator – 0.5HP, Power module (MOSFET/IGBT), Controller circuit,

List of Open Source Software/learning website:

1. http://www.electrical4u.com/electrical-drives/
2. http://nptel.ac.in/courses/108104011/
3. http://electrical4u.com/types-of-dc-motor-separately-excited-shunt-series-compound-dc-motor/
4. https://www.wisc-online.com/learn/career-clusters/stem/iau13208/fundamentals-of-a-dc-motor
5. http://www.ni.com/white-paper/3656/en/
6. http://www.minarik.com/drupal/content/products/Electrical%3E%3EControl%3E%3EDrives%3E%3E DC%20Drives/0
7. http://electrical-engineering-portal.com/download-center/books-and-guides/siemens-basics-of- energy/basics-of-dc-drives
8. https://www.joliettech.com/products/dc-variable-speed-drives/dc-drive-fundamentals/
9. http://www.eetimes.com/document.asp?doc_id=1274114&page_number=3
10. http://www.ohioelectricmotors.com/a-guide-to-electric-drives-and-dc-motor-control-688

11. http://www.slideshare.net/psksiva13/63814075-electricaldrivesandcontrollecturenotes
12. http://metalab.uniten.edu.my/~anisa/eeeb443.htm
13. http://www.ijareeie.com/upload/november/18_THREE%20PHASE%20INDUCTION.pdf
14. http://futuronix.in/download/Basics%20of%20AC%20drives.pdf
15. http://www.egr.msu.edu/~fzpeng/ECE320/ECE320-Notes-Part1.pdf
16. http://www.vssut.ac.in/lecture_notes/lecture1424084684.pdf
17. http://ir.nmu.org.ua/bitstream/handle/123456789/132706/6d3772cee6f3501e45cdee4aefb4b028.pdf?seq uence=1
18. http://www.svecw.edu.in/Docs%5CEEEPELNotes2013.pdf
19. http://cdn.intechopen.com/pdfs-wm/35260.pdf
20. http://www.motor-design.com/cmsAdmin/uploads/induction_motor_modelling.pdf
21. http://cache.freescale.com/files/product/doc/AN1930.pdf
22. http://www.drivetechinc.com/articles/IM98VC1.pdf
23. http://ethesis.nitrkl.ac.in/5162/1/211EE2136.pdf
24. http://dspace.thapar.edu:8080/dspace/bitstream/10266/1489/1/Kulraj+Kaur+(800941016).pdf
25. www.sciencedirect.com
26. www.delnet.nic.in