GUJARAT TECHNOLOGICAL UNIVERSITY

BRANCH NAME: POWER ELECTRONICS (24)
SUBJECT NAME: Industrial Drives and Control – II
Subject Code: 2172402
BE SEMESTER VII

Type of course: Engineering Science (Electronics)

Prerequisite: **1.** 2140906 (AC Machine)
2. 2162409 (Power Electronics Circuit – II**)**
3. 2162404 (Industrial Drives and Control – I)

Rationale:

Today's industrial and domestic loads demands precise and smooth variable speed control. The development of compact thyristor power converters has made this possible by smooth speed control of both AC and DC motors which are employed for several applications such as DC/AC drives, Vehicles and renewable energy. This course enables to develop the basics of electric drives and maintain different types of AC drives in industries. The competency in this area is highly required in diploma pass outs working in most of the industries since these industries employ large number of motors and drives and their smooth operation and maintenance requires lot of competent man power. Thus this course is must for students who want to work in industries.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		ESE (V)		PA (I)	
					PA	ALA	ESE	OEP		
4	0	2	6	70	20	10	20	20	10	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1.	**Introduction to Induction Motor Drives:** Analysis and performance of 3-Ø induction motor - Operation of induction motor on unbalanced source voltage & single phasing, comparison of IM operation with balanced source voltage and unbalanced source voltage- Operation with unbalanced rotor impendence - Analysis of Induction Motor with Non Sinusoidal source Voltages - Starting, Braking and Transient analysis of drives, Drive selection	06	10-15
2.	**Induction Motor drives:** Types of Induction Motor Control - Stator voltage control of induction motor: Torque slip characteristics, operation with different types of loads, closed loop control of Stator voltage through power electronics modulator - Stator frequency control: variable frequency operation, V/F control, controlled current and controlled slip operation, Effect of harmonics and control of harmonics, PWM inverter drives, Multi-quadrant drives, closed loop control of stator frequency through Power Electronics Modulator - Rotor resistance control: slip - torque characteristics, rotor choppers, torque equations, constant torque operation, closed loop control of Rotor Resistance through Power Electronic Modulator - Slip power recovery scheme: torque equation, torque slip characteristics, power factor, methods of improving power factor, limited sub synchronous speed operation, super synchronous speed operation, closed loop control of slip power recovery scheme.	12	20-25

3.	**Synchronous motor drives:** Speed control of synchronous motors, adjustable frequency operation of synchronous motors, principles of synchronous motor control , Voltage Source Inverter Drive with open loop control , self controlled synchronous motor with electronic commutation , self controlled synchronous motor drive using load commutated thyristor inverter. Principle of Vector control.	10	15-20
4.	**Dynamics and Modeling of AC Machine:** Dynamic modeling of induction machines – 3-phase to 2-phase transformation – power equivalence – generalized model in arbitrary reference frame – electromagnetic torque – derivation of stator reference frame model, rotor reference frame model, synchronously rotating reference frame model – equations in flux linkages - dynamic d-q model of synchronous machines, control principle of the induction motor - Modeling of induction machine, Modeling of synchronous machine, Reference frame theory and per unit system	08	10-20
5.	**Vector Control of Induction Motor Drive:** Basic principle, Direct Rotor flux oriented vector control , Estimation of rotor flux and torque , Implementation with current source and voltage source inverters Stator flux oriented vector control , Indirect rotor flux oriented vector control scheme implementation, tuning, Dynamic simulation. - Parameter sensitivity and compensation of vector controlled induction motors, Selection of Flux level, Flux weakening operation, Speed controller design, Vector control strategies for Synchronous motor.	10	20-30
6.	**Sensor less Control of Induction Motor Drives:** Principles for speed sensor less control, Sensor less methods for scalar control, Sensor less methods for vector control, Introduction to observer based techniques, Basic principle of DTFC.	04	10-15
7.	**Special Machine Drives:** SRM operation and control, Converter circuits, modes of operations - Permanent Magnet AC Motor drives, Sinusoidal PMAC motor drives, Trapezoidal PMAC motor drives.	04	10-15

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
7	**21**	**14**	**14**	**7**	**7**

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. Power Semiconductor controlled Drives,- Gopal K Dubey
2. Electric Motor Drives – Modeling, Analysis and Control, -R.Krishnan
3. Fundamentals of Electrical Drives, -Gobal K.Dubey
4. Power Semiconductor Drives, -S.Sivnagaraju
5. Control of Electrical Drives, 3rd edition, Springer 2001- Werner Leonhard
6. Power Semi conductor controlled Drives, Johnwiley Pub. - S.B.Dewan, G.R.Slemon & A.Stranghan

7. Power Electronics & Motor Control: Cambridge Univ. Press - Shepherd Hullay & Liag,
8. Bimal K Bose, "Modern Power Electronics and AC Drives", Pearson Education Asia 2002
9. Murphy J.M.D and Turnbull, "Thyristor Control of AC Motors", Pergamon Press, Oxford, 1988.

Course Outcome:

The theory should be taught and practical should be carried out in such a manner that students are able to acquire different learning outcomes in cognitive, psychomotor and affective domain to demonstrate following course outcomes.

After learning the course, the students should be able to:

1. Select a drive for a particular application based on power rating.
2. Select a drive based on mechanical characteristics for a particular drive application.
3. Understand various operating regions of the induction motor drives.
4. Understand the speed control of induction motor drive from the rotor side.
5. Understand the field oriented control of induction machine.
6. Understand the control of synchronous motor drives.

List of Experiments:

1. To study the fundamental and block diagram of Electric drive.
2. To study and understand various adjustable parameters in AC drive. (Acceleration time, retardation time, voltage boost, skip frequency, dc braking, local and remote start stop and speed control etc.)
3. To study and perform speed control of IM by using AC drive.
4. MATLAB simulation for the study of spectrum analysis of output voltage and current of unipolar switching for single phase inverter with and without filter.
5. MATLAB simulation for the study of speed control of 1-phase Induction motors with A.C. voltage controllers.
6. To Study of spectrum analysis and speed control of 3-phase Induction motors fed from VSI using v/f strategy using experimental set-up.
7. To Study of torque produced in an induction machine in 'abc' and 'qd0' frames of reference with sinusoidal source and with a 3-Ph VSI with V/f control
8. To compare working of V/f controlled and vector controlled induction motor
9. To study speed control of 1-phase Induction motors with A.C. voltage controllers
10. Spectrum analysis of output voltage and current of unipolar switching for single phase inverter with and without filter using experimental set-up

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. Indentify 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. Digital Multimeter: 4 ½ digit hand held 9 V batteries operated, DC Voltage: 0 to 0.001 mV – 1000 V, AC Voltage: 0 to 0.01 mV – 1000 V, AC Current: 0 to 100 nA – 10 A, DC Current: 0 to 100 nA – 10 A,
2. Digital Tachometer: Hand held, battery operated, 5 digit display contact type, 60 to 50000 RPM
3. Four channel Digital Oscilloscope with isolated ground: Bandwidth :200MHz, Power supply:230V ±

10% tolerance,50 Hz AC supply

4. AC drive trainers
5. Any one simulation software (Open source software preferred) : Scilab/Matlab and Simulink toolbox, Octave, CASPOC

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%3EDC%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?sequence=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

ACTIVE LEARNING ASSIGNMENTS: This includes preparation of presentation including slides, videos, animations, pictures, graphics etc. for better understanding theory and practical work. The faculty should assign chapters/ parts of chapters to groups of students for preparing presentation as part of this. The student should study the topic in details and prepare presentation.