GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL ENGINEERING (09)
POWER ELECTRONICS – II
SUBJECT CODE: 2160902
B.E. 6th SEMESTER

Type of course: NA

Prerequisite: Power Electronics - I

Rationale: The power electronic converters are now widely used in domestic applications as well as in industrial applications like Electrical Drives, Power Systems, Renewable Energy based power generation, heating applications etc. The course is designed to provide exposure of power electronic converters and their operation and control to obtain variable AC voltage (magnitude and/or frequency).

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		
3	0	2	5	70	20	10	20	10	20	150

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	DC TO AC CONVERTERS: INVERTERS Performance parameters of Inverters; Classification of Inverters: Voltage source inverters and Current source inverters; Single phase inverters: series, parallel and bridge type (Half wave and Full wave) inverters; Forced Commutated, Line commutated and Self-Controlled Switches based Inverters; Three phase bridge inverters: 180 degree conduction, 120 degree conduction and their comparison PWM Inverters: Principle of PWM control, PWM techniques classifications, Unipolar and Bipolar PWM, Effect of Switching frequency on Harmonic Spectrum, Sinusoidal PWM, Third harmonic PWM, Selective Harmonic Elimination, Hysteresis band current control PWM, Space vector pulse width modulation technique, Comparison of PWM techniques, Voltage and frequency control of single phase and three-phase inverters, Harmonic Cancellation techniques Gating circuits for switches of inverter, Gate driver ICs having high side and low side reference output for driving switches of legs of inverters (like IR25604) Current Source Inverters: single phase and three phase ASCI and self-controlled switch based inverters; Comparison of Voltage and Current source Inverters.	15	38
2	AC VOLTAGE CONTROLLERS	8	20

	Concept of On-Off or integral cycle control and Phase control; Various single phase full wave ac-ac controllers with R, L and RL load; Analysis for phase control and integral cycle control; Gating requirements; Sequence Control of AC regulators; 3-phase full wave converter configurations with Y and Δ connected loads and their analysis with R load; AC Voltage controller with PWM control; Basic principle of matrix converter			
3	CYCLOCONVERTERS Introduction; Basic Principle; Single to single-phase cycloconverters; Three-phase half-wave cycloconverters; Cycloconverters for three phase output; Output voltage equation; Output harmonics in cycloconverter; Comparison between cycloconverter and DC link Converter; Load Commutated cycloconverter.	6	16	
4	Induction Motor Drives Comparison of ac & dc drive; their selection for particular application; Review of Induction Motor fundamentals: Equivalent circuit, Characteristics, Basic Equations and speed control methods; motoring and braking (3 Hrs) Soft starting: Stator voltage control with AC voltage controller; Six-step VSI inverter based drives; PWM-VSI drives; Braking and multi-quadrant operation of VSI drives; Cycloconverter based induction motor drive; Variable frequency control from a current source; Slip power control using Rotor resistance along-with chopper; Closed loop control schemes; Effect of non-sinusoidal wave form on AC machine performance; (6 Hrs)	9	18	
5	Synchronous Motor Drives Three phase synchronous motors; variable speed drives; variable frequency control; self-controlled synchronous motor drive employing load commutated thyristor inverter, self controlled synchronous motor drive employing a cycloconverter.	3	8	

Suggested Specification table with Marks (Theory):

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level

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. M D Singh and K B Khanchandani, "Power electronics", TMH, New Delhi, 2nd ed., 2007.
2. Muhammad H. Rashid, "Power Electronics - Circuits, Devices and Applications", Prentice Hall of India, 3rd ed., 2003.
3. Vedam Subramanyam, "Power Electronics – Devices, Converters and Applications", New Age International Publishers Pvt. Ltd., Bangalore, 2nd ed. 2006.
4. P.S. Bimbhra, "Power Electronics", Khanna Publishers, New Delhi, 2012..
5. Ned Mohan, Undeland and Robbins, "Power Electronics – Converters, Applications and Design", John Willey & sons, Inc., 3rd ed., 2003.
6. V.R.Moorthi, "Power Electronics", Oxford University press, 2005.

7. G..K. Dubey, S.R. Doradla, A. Joshi, and R.M.K. Sinha, "Thyristorised Power Controllers", New Age International Ltd. Publishers, 1986 (Reprint 2008).
8. P.T. Krein, "Elements of Power Electronics", Oxford University Press, 1998.
9. G..K. Dubey, " Fundamentals of Electrical Drives", Narosa Publishing House, New Delhi, 2nd ed. 2001.

Course Outcome:

After learning the course the students should be able to:

1. Analyze, operate and design dc-to-ac inverters.
2. Analyze, operate and design ac-to-ac converters.
3. Apply the knowledge of power electronic converter for speed control of AC motors.
4. Simulate power electronic converters and their control scheme.

List of Experiments:

1. SCR based 1-phase ac voltage controller
2. SCR based 3-phase ac voltage controllers for (i) star connected load with neutral (ii) SCR based 3-phase ac voltage controller (star connected load without neutral)
3. SCR based 1-phase cycloconverter working on the principle of integral half cycle control.
4. SCR based 3-phase to 1- phase cycloconverter
5. Performance of 1-phase bridge inverter with R and R-L load
6. Harmonic spectrum of output voltage for unipolar and bipolar PWM controlled half-bridge and full bridge converter.
7. Performance of 3-phase bridge inverter operating with 120° and 180° conduction mode.
8. Simulation of SVPWM and its effectiveness over SPWM
9. Performance of V/F controlled induction motor drive
10. Closed loop speed control of Induction Motor using stator voltage control
11. Simulation of 1-phase bridge type cycloconverter in MATLAB
12. Coding for selective harmonic elimination technique

Design based Problems (DP)/Open Ended Problem:
Faculty teaching the subject shall provide an application oriented course project. The students can work in a group to design a power electronic converter and its control scheme to target different applications

Major Equipment:

Power semiconductor devices, power electronic converter kits, CRO/DSO, load bank, voltage and current probes, AC load and motors, simulation tools like MATLAB, PSIM etc.

List of Open Source Software/learning website:

http://nptel.iitm.ac.in/coursecontents_elec.php
ocw.mit.edu/courses/electrical.../6-334-power-electronics-spring-2007

ACTIVE LEARNING ASSIGNMENTS: Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ parts of chapters to groups of students so that the entire syllabus to be covered. The power-point slides should be put up on the web-site of the College/ Institute, along with the names of the students of the group, the name of the faculty, Department and College on the first slide. The best three works should submit to GTU.