

GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL ENGINEERING POWER ELECTRONICS -I SUBJECT CODE: 2150903 B.E. 5th SEMESTER

Type of course: NA

Prerequisite: Basic Electronics and Concept of DC Machines

Rationale: The power electronic devices and converters employing power electronics devices 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 aimed to act as a foundation block and to provide exposure about various aspects (construction, characteristics, operation, ratings etc.) of power electronic devices. It also covers power electronic converters that provide variable DC voltage.

Teaching and Examination Scheme:

Teaching Scheme			Credits C	Examination Marks						Total Marks
L	T	P		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	100

Content:

Sr. No.	Content	Total Hrs	% Weightage
1	Power Semiconductor Devices Construction and Characteristics of Power diodes, Power Transistors, Power MOSFET, Insulated Gate Bipolar transistors (IGBTs) Introduction to Thyristor family : SCR, DIACs, TRIACs, Light Activated SCRs (LASCRs), Reverse Conducting Thyristor , (RCT), Asymmetrical SCR (ASCR), Gate turn-off Thyristors (GTOs), Integrated Gate- Commutated Thyristors (IGCTs), MOS controlled Thyristors (MCTs) Power Integrated circuits (PICs), Intelligent Modules	4	8
2	Thyristor Fundamentals Construction of SCR, Operating modes, Two transistor analogy, Static & dynamic characteristics, Gate characteristics, Turn on & turn off methods (Commutation methods), Series and Parallel operations of SCRs : Need, String efficiency, Issues, Static and Dynamic Equalizing circuit and Means to minimize the effect of mis-match Isolation of gate and base drive using pulse transformer and Opto-couplers Gate Drive/Triggering circuits: R trigger, RC trigger, Cosine Triggering, UJT and Programmable UJT as an oscillator and triggering circuit based on them Ratings, Cooling and Heat sinks, Thermal Modeling, di/dt and dv/dt	13	32

	protection, Design of Snubber Circuit, Over Voltage and Over Current protections, Gate protections, Electro Magnetic Interference(EMI) and Shielding.		
3	Phase Controlled (AC to DC) Converters Review of half-wave and full-wave diode rectifier (with RL load); Principle of phase controlled converter operation; Operation of 1-phase half wave converter with R, RL and RLE load; Significance of free-wheeling diode ; 1- phase full wave converter : Center-tapped and Bridge Configuration; Operation and analysis with R,RL, RLE load; Analysis; Gating Requirements; Conversion (Rectification) and Inversion mode of operation; Operation and analysis of 1-phase Semi-converter/ Half-controlled converter: Asymmetric and Symmetric Configurations; 3-phase converters : Operation of half wave converter; Full wave fully controlled converters: Analysis and operation with different type of loads; Rectification and Inversion Mode; Semi-controlled converter; Dual Converter: Principle and operation; 1-phase and 3-phase configurations; Simultaneous and Non-simultaneous operation Effect of source and load inductances, Power factor improvement techniques, Applications of AC-DC converters	9	22
4	DC to DC Converters The chopper, Basic principle of DC chopper, Classification of DC choppers, Control strategies Basic DC-DC converter (switch regulator) topologies : Principle, operation and analysis for Step-down (Buck), Step-up (Boost), Step up/down (Buck-Boost), Continuous conduction and Discontinuous conduction operation Chopper configurations: Voltage Commutated, Current Commutated, Load Commutated Chopper Multi-phase chopper, Application of DC to DC converters	8	20
5	DC Drives with phase controlled converters Basic characteristics of DC motors, Two zone operation, Four quadrant operation (Operating modes), Principles of DC motor speed control Single phase separately excited drives: Half Wave converter, Semi-converter and Fully Controlled converter based drives; Braking operation of separately excited drive Single phase Series DC motor drive: Semi-converter and Fully Controlled coverter based drives 3-phase separately excited drives: Half Wave converter, Semi-converter and Fully Controlled converter based drives;	4	9
6	DC drives with dc-dc converters Principle of power control (motoring control) of separately excited and series motor with DC-DC Converter; Steady- state analysis Principle of Regenerative Braking; Chopper configuration for Regenerative braking; Analysis for minimum and maximum speed for Regenerative Braking; Combined regenerative and rheostatic brake control; Two and four quadrant DC-DC converter drives	4	9

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. Vedom 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. Explain the construction and characteristics of Power semiconductor devices and fundamental of thyristors and family.
2. Analyze, operate and design ac-to-dc converters.
3. Analyze, operate and design dc-to-dc converters.
4. Apply the knowledge of power electronic converter for speed control of DC motors.
5. Simulate power electronic converters and their control scheme.

List of Experiments:

Some experiments/practical are suggested as the guideline to study

1. Static and dynamic characteristics of an SCR.
2. Output characteristics and transfer characteristics of Power MOSFET.
3. R and RC triggering scheme and to determine the firing angle control range.
4. Principle of voltage commutation and current commutation to turn off an SCR.
5. Line synchronized UJT triggering and its use for firing the SCRs of ac-dc converter
6. Use of Triac as a Fan regulator
7. Performance 1- Φ semi-converter & 1- Φ fully controlled (bridge) converter with R and RL load.
8. Time ratio control for regulating the output voltage of a step-down chopper
9. Time ratio control for regulating the output voltage of a step-up chopper
10. Effect of inductance, switching frequency, duty cycle, load current on the output ripple voltage of a step-down chopper (using simulation platform like MATLAB/Simulink)
11. Performance of three phase fully controlled and half-controlled converter with R and R-L load
12. Speed control of DC separately excited motor with phase controlled converter or DC-DC converter.

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, choke coil, load bank, voltage and current probes, 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.