

GUJARAT TECHNOLOGICAL UNIVERSITY

ELECTRICAL ENGINEERING (07)

POWER ELECTRONICS

SUBJECT CODE: 2710702

SEMESTER: I

Type of course: Engineering

Prerequisite: Fundamentals of electromagnetics; concepts of Fourier series, differential equations, Laplace transforms and basics of electrical engineering

Rationale: The power electronic devices and some conventional converters based on the principle of power electronics converters are now widely used in domestic applications as well as in industrial applications like Electrical Drives, Power Systems, Renewable Energy based power generation etc. The course acts as a foundation block and provides exposure operation, design, analysis and control of some of the conventional power electronics converters.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P		Theory Marks		Practical Marks				
			ESE (E)	PA (M)	PA (V)		PA (I)			
					ESE	OEP	PA	RP		
3	2#	2	5	70	30	20	10	10	10	150

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1	Semiconductor Devices Review of Semiconductor devices like Power BJT, SCR, MOSFET, IGBT, GTO, MCT; Static and dynamic characteristics of these devices; Single quadrant, Two quadrant and bid-directional switches.	4	7.5
2	Switching Voltage Regulators Introduction; Linear power supply (voltage regulators); Switching voltage regulators; Review of basic dc-dc voltage regulator configurations -Buck, Boost, Buck-Boost converters and their analysis for continuous and discontinuous mode; Other converter configurations like Flyback converter, Forward converter, Half bridge, Full bridge configurations, , Push-pull converter, C'uk converter, Sepic Converter; Design criteria for SMPS; Multi-output switch mode regulator.	8	20
3	Design of Magnetic Components Design of power transformer; high frequency transformers for flyback, forward, half-bridge – full bridge and push pull converters; Design of inductors for various converter topologies; Design of current transformers; Different types of core materials.	8	15
4	Line Commutated Converters Single phase and three phase half wave and full wave, 1-phase and 3-phase half controlled and fully controlled converters, Analysis with R & RL load, Performance parameters for converters,, Operation in continuous and dis-continuous mode, Operation in conversion and inversion mode, Effect of source inductance, Power factor	8	15

	improvement techniques, Dual Converters		
5	Classification; Review of line commutated inverters, Concept of Unipolar and Bipolar PWM, Sine-triangular PWM, Space Vector Pulse Width Modulation, Other PWM techniques, Harmonic reduction techniques, Current Source Inverters, Impedance source inverters	9	20
6	Gate and Base drive circuits Preliminary design considerations; DC coupled drive circuits with unipolar and bipolar outputs; Importance of isolation in driver circuits; Electrically isolated drive circuits; Some commonly available driver chips (based on boot-strap capacitor); Cascode connected drive circuits; Thyristor drive circuits; Protection in driver circuits; Blanking circuits for bridge inverters.	5	7.5
7	Three phase AC voltage controllers and Cycloconverters AC voltage controllers: Review of On-off and phase control; Single phase full wave controllers and their analysis with resistive loads; Three phase full wave controllers, Analysis with R-load, Three phase bi-directional delta-connected controllers Cycloconverters: single-phase to single-phase cycloconverter, 3-phase to 1-phase cyclo-converter, 3-phase to 3-phase cycloconverter circuits; circulating current operation; non-circulating current operation; mean output voltage and harmonics in supply current waveform	8	15

** Some topics (especially related to design) may be covered as a part of assignments/tutorials.

Reference Books:

1. Mohan, Undeland and Robbins, "Power Electronics – Converters, Applications and Design", John Willey & sons, Inc., 3rd ed., 2003.
2. Muhammad H. Rashid, "Power Electronics - Circuits, Devices and Applications", Prentice Hall of India, 3rd ed., 2003.
3. P.C.Sen, "Modern Power Electronics ", S. Chand and Co. Ltd., New Delhi, 2012.
4. L. Umanand and S. Bhat, "Design of Magnetic Components for Switched Mode Power Converters", New Age International Ltd., New Delhi, 2001.
5. G.K. Dubey, S.R. Doradla, A. Joshi, and R.M.K. Sinha, "Thyristorised Power Controllers", New Age International Ltd. Publishers, 1986 (Reprint 2008).
6. R.W. Erickson, D. Maksimovic, "Fundamentals of Power Electronics", Kluwer Academic Publisher, 2nd ed., 2001.
7. P.T. Krein, "Elements of Power Electronics", Oxford University Press, 1998.
8. B. Jayant Baliga, "Fundamentals of Power Semiconductor Devices", Thomson, 2008.
9. Joseph Vithayathil , "Principles of Power Electronics", Tata Mc-Graw Hill, 2010.
10. William Shepherd, Li Zhang, "Power Converter Circuits", Marcell Dekker, New York, 2005.
11. http://nptel.iitm.ac.in/coursecontents_elec.php

Course Outcome:

After learning the course the students should be able to

1. Analyze the characteristics of Power electronics devices and to determine the suitable device for a particular application
2. Analyze, design and operate DC-DC converters, phase controlled converters, inverters and AC-AC converters.
3. Design inductors and transformers for power electronic converters
4. Design of driver, protection and control circuits for power electronic devices
5. Design the schemes for reduction or elimination of harmonics.

The experiments shall be based on the syllabus. A list suggesting some of the experiments that may be performed using simulation tools and/or experimental set-up are as under:

1. To study the static/dynamic characteristics of power electronics device(s).
2. Design of an inductor for a DC-DC converter configuration. ##
3. Design of a transformer for an isolated DC-DC converter configuration.
4. Design of gate/base driver circuits for power electronic converter. ##
5. To study the closed loop control scheme for dc-dc converters. ##
6. To study the performance of various single-phase ac-dc converters with different types of loads.
7. To study the performance of various three-phase ac-dc converters with different types of loads.
8. To evaluate the performance of unipolar and bipolar pulse width modulation technique.
9. To compare the performance of various PWM techniques for three phase bridge inverter.
10. Write a code to determine the switching positions of the single phase bridge inverter so that the output voltage waveform is free from 3rd, 5th and 7th harmonics.
11. Speed control of 3-phase induction motor using 3-phase inverter
12. To study the performance of 3-phase ac voltage controller(s) with R and RL load.
13. To study the performance of 1-phase and 3-phase cycloconverter circuit(s).

Power Electronic Converter configuration can be specified by the instructor

Open Ended Problems:

Major Equipments:

Power Electronic Converters, Oscilloscopes (preferably DSO), Current Probe, Circuit Simulation Tools like MATLAB, PSIM or open source software to simulate power electronic converter circuits, and other basic equipment like meters, loads, motors 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