GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3172418
Semester – VII
Subject Name: Advanced Power Converters

Type of course: Professional Elective Course V

Prerequisite: Basic Power Electronics Devices, Power Electronics Circuits-1, Power Electronics Circuits-2

Rationale: The course is aimed to provide exposure of advanced power electronics converter topologies which are used in industrial application, understand their operation, advantages, drawbacks, applications, etc.

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 Hours
1	Multilevel Inverters: • Introduction – Concept – Principle of Operation – Classification – Advantages & Disadvantages – Applications • Diode Clamped MLI: Three-Level Inverter – Converter Configuration – Switching State – Commutation – Causes of Neutral-Point Voltage Deviation – Effect of Motoring and Regenerative Operation – Feedback Control of Neutral-Point Voltage – Five-Level Diode-Clamped Inverters • Cascaded H-Bridge MLI: Bipolar and Unipolar Pulse-Width Modulation – CHB Inverter with Equal and Unequal DC Voltage – Carrier Based PWM Schemes: Phase-Shifted and Level-Shifted Multicarrier Modulation – Comparison – Staircase Modulation • Flying Capacitor MLI: Inverter Configuration – Modulation Schemes – Capacitor Voltage Unbalance • Review of PWM techniques, SVPWM – Switching States – Space Vectors – Dwell Time Calculation – Modulation Index – Over-modulation – Switching Sequence – Even-Order Harmonic Elimination	12
2	Resonant Converters:	8

	• Introduction – Classification – Resonant Switch: ZC and ZV • Concept of Soft Switching – Quasi Resonant Converters – Comparison between ZVS and ZCS • ZVS in High-Frequency Applications • Load Resonant Converters – Series Resonant Converters – Parallel Resonant Converters – Series-Parallel Resonant Converters • Basic Control Circuits for Resonant Converters – Snubbers • Soft Switching DC-AC Power Inverters	
3	Multi-pulse Converters: • Multi-Pulse Diode Rectifiers – Six Pulse Diode Rectifiers – Series Type and Separate Type Multi-Pulse Diode Rectifiers. • Multi-pulse SCR Rectifiers – Six Pulse SCR Rectifier – Twelve Pulse SCR Rectifier – Introduction to 18 and 24 Pulse SCR Rectifiers. • Phase Shifting Transformers – Introduction –Transformer connections-Y/Z Phase Shifting Transformers – Δ/Z Transformers – Harmonic Current Cancellation.	9
4	Switched Capacitor DC-DC Converters: • Step Down Converter – Step Up Converter – Voltage Polarity Inverting Converter – N-Stage Step Up Converter – N-Stage Step Down Converter, • Bi-Directional Power F1ow SCC – Switched Capacitor Luo Converter – Losses on Switched Capacitor Power Converter.	8
5	Cycloconverters and Matrix Converter: • Single Phase-Single Phase Cycloconverter – Three Phase Cycloconverter – Cycloconverter Control Scheme - Forced-Commutated Cycloconverter (FCC) - Applications of Cycloconverters – Concept of AC Choppers • Matrix Converter – Introduction – Operation and Control Methods of the Matrix Converter: Venturini Method and SVM Method –Comparison of the Two Methods – Commutation and Protection Issues in a Matrix Converter – Applications of Matrix Converters	8

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
20	**35**	**25**	**10**	**10**	**--**

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

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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 Electronics Handbook by M H Rashid, Academic Press
2. High-Power Converters and AC Drives by Bin Wu, IEEE Press Wiley Interscience
3. Power-Switching Converters, Second Edition by Simon Ang and Alejandro Oliva, Taylor & Francis

Course Outcomes:
At the end of the course, student should be able to:

Sr. No.	CO statement After studying this course, the student should be able to	Topics Mapped	Marks % weightage
CO-1	Discuss the principle and operation of various advanced power converters.	1, 2, 3, 4, 5	35%
CO-2	Compare and illustrate the performance of advanced power converters.	1, 2, 3, 4, 5	30%
CO-3	Select a suitable advanced power converter for a given application.	1, 2, 3, 4, 5	20%
CO-4	Develop skills to identify, test and troubleshoot advanced power converters.	1, 2, 3, 4, 5	15%

Objectives: The laboratory work is aimed at putting the theory learnt in class in practice and to show that the results are matched with theory closely. In this context, following are the core objectives for laboratory work of this subject.

- Study various Multilevel Inverters and their control.
- Study the operation of resonant converters and soft switching circuits.
- Study switched capacitor-based DC-DC converters.
- Study different multi pulse rectifiers and phase shifting transformers.
- To study cycloconverters and MATRIX converters.

Directions for Laboratory work:

- ✓ The list of experiments is given as a sample.
- ✓ Minimum 10 experiments should be carried out.
- ✓ At least one experiment should be selected from each group.
- ✓ Similar laboratory work fulfilling the objectives can also be considered.
- ✓ Each experiment may be simulated before verifying practically.
- ✓ As far as possible, **printed manual should be preferred** so that students can concentrate in laboratory experiments and related study. The sample list of experiments is given below.

Suggested List of Experiments and Design Based (DP)/Open Ended Problems:

There are four experiment groups: A, B, C, D and E. Total 10 experiments from Group A, B, C, D and E should be carried out (At least one-two experiments from each group). Over and above 10 performance experiments, self-study work may be given to students. This includes study of datasheets, protection &

driver circuits for power semiconductor switches, practical applications of different power electronics converters, etc.

Group A (Multilevel Inverters Converters):

1. To study and simulate the diode clamped multi-level inverter.
2. To study and simulate Cascaded H-Bridge multi-level inverter.
3. To study working principle of flying capacitor multi-level inverter.

Group B (Resonant Converters):

4. To study various pulse width modulation technique used for power converters.
5. To study concept of ZVS and ZCS used in power electronics.
6. To study operation of series and parallel load resonant converter.

Group C (Multi pulse Converters):

7. To study working principle and the performance of diode multi-pulse rectifier.
8. To study working principle and the performance of SCR multi-pulse rectifier.
9. To study working principle of Y/Z Phase Shifting Transformers and Δ/Z Transformers
10. Simulation of 6 pulse, 12 pulse, 24 pulse multi-pulse converters

Group D (Switched Capacitor DC-DC Converters):

11. To study step up DC-DC power converter based on switched capacitor topology.
12. To study step down DC-DC power converter based on switched capacitor topology.

Group E (Cyclo-Converters and MATRIX Converters):

13. To study and simulate single phase cyclo-converter.
14. To study working principle of matrix converter.

Major Equipment:

Oscilloscope, Isolated Channel Power Scope, Power Converter Trainer Kits, Multi-meters, Variable Power Supply, Programmable Digital Power Supply etc.

List of Open-Source Software/learning website:

- **Learning website:**

  - http://nptel.iitm.ac.in/courses.php
  - http://ocw.mit.edu/
  - https://swayam.gov.in/
  - https://nptel.ac.in/courses/108/105/108105066/
  - https://nptel.ac.in/courses/108/102/108102145/
  - https://nptel.ac.in/courses/108/101/108101126/
  - https://nptel.ac.in/courses/108/107/108107128/
  - https://www.elprocus.com/what-is-an-inverter-types-circuit-diagram-applications/