GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering
Subject Code: 3162413
Semester – VI
Subject Name: Power Electronics Circuits - II

Type of course: Professional Core Course

Prerequisite: Circuit Theory, Basic Power Electronics Devices, Circuits and Applications, Power Electronics Circuits-1

Rationale: The Power Electronic converters are widely used in various domestic, commercial, and industrial applications where fixed/variable DC supply or fixed AC supply is required to be converted to AC at various frequencies and voltage. The course is aimed to provide construction, characteristics and operation of various converter circuits that provide such AC voltage.

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)	
3	1	2	5	70	30	30	20	150

Content:

Sr. No.	Content	Total Hrs	Weigh tage
1	AC-AC converters: • Introduction – Classification – Performance Parameters - Advantages • AC Voltage Regulators – Principle of On-Off (ICC) Control and Phase Control • Single Phase Controller with R and RL Load • Three Phase AC-AC Voltage Controller – Different Configurations • Cycloconverters: Single Phase and Three Phase • Static Switches	10	20%
2	DC-AC Converter Basics (Inverter): • Introduction – Principle of Operation – Classification • Square Wave & Quasi-Square Wave Inverter, Introduction to Series and Parallel Inverters • Dead Band & its Importance – Fourier Analysis and % THD • Performance Parameters – Applications • High and Low Side Switch Drivers for Inverter – Their Need and Importance	8	15%
3	Inverter Control Techniques: • Different Methods of Inverter Control: Internal and External • External Control Techniques: ◦ Input Side Control: Variation of DC by Uncontrolled Rectifier & Chopper	6	15%

	– Variation of DC by Controlled Rectifier ◦ Output Side Control: Varying Output AC Voltage by Using Transformer & AC Voltage Regulators • Internal Control Techniques: Voltage Mode & Current Mode • PWM Control of Inverters		
4	Single Phase Inverter: • Single Phase Half Bridge & Full Bridge Inverter on different loads • VSI – CSI – Sine Wave Inverter, PWM Inverters • Operation of Inverters with Different PWMs like SPWM, Bipolar and Unipolar – Stepped – Third Harmonic Injection – Trapezoidal - SHE	8	20%
5	Three Phase Inverters: • 120°, 150° and 180° Conduction Mode of Inverters - SPWM • SVPWM – Switching States – Space vectors – Dwell Time – Modulation Index – Over-modulation	6	20%
6	Introduction of Multilevel Inverters: • Basic Concept and Working Principle of Multilevel Inverter – Classification – Advantages & Disadvantages - Applications	4	10%

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
30	**35**	**20**	**10**	**5**	**---**

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

1. **Remembering:** Retrieving, recognizing, and recalling relevant knowledge from long-term memory.
2. **Understanding:** Constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining.
3. **Applying:** Carrying out or using a procedure for executing or implementing.
4. **Analyzing:** Breaking material into constituent parts, determining how the parts relate to one another and to an overall structure or purpose through differentiating, organizing, and attributing.
5. **Evaluating:** Making judgments based on criteria and standards through checking and critiquing.
6. **Creating:** Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing.

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: Converters, Applications and Design by Mohan, Undeland and Robbins, Wiley India
2. Power Electronics: Circuits, Devices and Applications, Third edition by M. H. Rashid, PHI.
3. High-Power Converters and AC Drives by Bin Wu, IEEE Press Wiley Interscience
4. Power Electronics by Barry Williams, CRC Press
5. Power Electronics: Essentials and Applications by L. Umanand, Wiley India.
6. Power Electronics by M. S. Jamil Asghar, PHI.
7. Power Electronics by Philips T. Krein, Oxford.
8. Power Electronics by Dr. P. S. Bhimbra, Khanna Publishers.
9. Power Electronics Handbook by M H Rashid, Academic Press
10. Power Electronics by P C Sen, TMH
11. Principles of Power Electronics by Kassakian, Schlecht & Verghese
12. The Essence of Power Electronics by Ross, Prentice Hall
13. The Power Electronics Handbook by T L Skvarenina, CRC Press
14. Power Electronics by M.D. Singh & K B Khanchandani, TMH
15. Power Electronic Circuits by Issa Batarseh, Wiley
16. Integrated Power Electronic Converters and Digital Control by Ali Emadi, CRC Press

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

Sr. No.	CO statement	Topics Mapped	Marks % weightage
CO-1	Illustrate the principle of operation of different power conversion circuits and their applications.	1, 2, 3, 4, 5, 6	20
CO-2	Compare performance of various power converter circuits with different control techniques and topologies.	1, 2, 3, 4, 5, 6	20
CO-3	Analyse power converter circuits and select suitable power electronic devices, control, and protection by considering the requirements of application.	1, 2, 3, 4, 5, 6	30
CO-4	Develop skills to design, test and troubleshoot power electronics converters and related circuits.	1, 2, 3, 4, 5, 6	30

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 AC-AC converters and study ICC & Phase Angle control technique.
- Study and design driving circuits for high and low side switches in inverters.
- Study and analyze half wave & full wave inverters in square wave and quasi-square wave operation, its THD analysis.
- Study different PWM techniques.

- To study different single phase and three phase Inverters.

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 and D. Total 10 experiments from Group A, B & C 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 (AC-AC Converters):

1. To study Integrated Cycle Control technique for AC-AC converter.
2. To study Phase Angle Control technique for AC-AC converter.
3. To study single phase and three phase Cycloconverters.
4. To study static switch for AC/IOT applications.

Group B (PWM Inverters):

5. To study and analyze square wave operation of inverter.
6. To study and analyze quasi-square wave operation of inverter.
7. To study and analyze Inverter operation with SPWM.
8. To study and analyze Inverter operation with Unipolar and Bipolar PWM.
9. To study SVPWM for inverters.

Group C (Three Phase Inverters):

10. To study the 180° conduction mode of Inverter.
11. To study the 150° conduction mode of Inverter.
12. To study the 180° conduction mode of Inverter.

Group D (Inverter Drivers):

13. To study half bridge driver circuit for inverter (Any available IC based driver circuit may be studied)
14. To study full bridge driver circuit for inverter (Any available IC based driver circuit may be studied)
15. To study half/full bridge inverter driver IC based circuit with inbuilt features like inbuilt isolation, dead-band, switch protection, etc. for various applications. (ICs like IRS2453, TLE7182, IR2112, HCPL316J, LM5045, MAX8751, IRS2890DS, LT1158, etc. or any other available IC may be selected for study)

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/