GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Power Electronics Engineering
Subject Code: BE04024021
Subject Name: Power Electronic Devices, Circuits and Applications

w.e.f. Academic Year:	2024-25
Semester:	4
Category of the Course:	Professional Core Course

Prerequisite:	Basic knowledge of Electrical Engineering, Network Theory, Basic Electronics
Rationale:	Power Electronics is a cornerstone subject in electrical and electronics engineering, bridging the gap between theoretical circuit analysis and real-world energy conversion systems. The syllabus is designed to equip students with both foundational knowledge and applied skills across a spectrum of modern technologies.

Course Outcomes:

Sr. No.	CO statements	Marks% weightage
CO-1	Describe the characteristics, ratings, and switching behavior of various power semiconductor devices	20%
CO-2	Compare different converter topologies.	30%
CO-3	Assess the performance of different converter topologies	30%
CO-4	Apply power electronics concepts through practical experiments and simulations to solve real-life engineering problems.	20%

Teaching and Examination Scheme:

Teaching / Learning Scheme (in Hours per semester)					Total Credits	Assessment Pattern and Marks					Total Marks
						Theory		Tutorial / Practical			
L	T	P	PBL*	Total no of hours per semester		ESE (E)	PA / CA (M)	PA/ CA (I)	PBL (I)	ESE (V)	
45	0	30	45	120	4	70	30	20	30	50	200

Course Content:

Sr. No.	Content	Total Hrs
1	**Power Semiconductor Devices:** Introduction, Types of Power devices, Construction, characteristics and ratings of Power devices like Diodes, BJT, SCR, TRIAC, MOSFET, IGBT etc., Comparison of these devices, Construction and characteristics of DIAC, UJT, PUT etc., SiC (Silicon Carbide), GaN (Gallium Nitride) devices, Basics of Intelligent Modules, Snubber circuits,	**10**

Sr. No.	Content	Total Hrs
	Firing circuit for thyristors; Gate drive circuits for SCR, TRIAC, MOSFET and IGBT, Power Electronic converter types AC-DC, DC-DC, DC-AC, AC-AC	
2	**AC-DC Controlled Converters:** Single phase half and fully controlled converters: Performance analysis with R and RL load under continuous and discontinuous conduction modes, harmonics, input power factor; Concepts of PWM and phase-angle control; Effect of source impedance; Three-phase half and fully controlled converter: Performance analysis, harmonics, input power factor; Dual converters	8
3	**DC-DC Converters:** Buck, Boost and Buck-Boost DC-DC converters, design equations, forward and fly-back converters; Control strategies like TRC (Time Ratio Control) and CLC (Current Limit Control); multi-quadrant operation; EMI / EMC issues; Concept of soft switching techniques - ZVS (zero-voltage switching) and ZCS (zero-current switching)	8
4	**DC-AC Converters:** Inverter types, Single phase and three phase voltage source inverters (120° and 180° mode): analysis under R and RL loads, harmonic analysis; PWM control techniques: Square-wave, sinusoidal, modified sinusoidal and space-vector, selective harmonic elimination; Output voltage and frequency control, Harmonic spectrum and its effects, Applications	8
5	**AC-AC Converters**: AC voltage regulators (Single-phase and three-phase); Circuit configurations, performance analysis, harmonic analysis; Cyclo-converters; Matrix converters, principle of on-off control, basic principle of operation – single-phase to single-phase, multi-phase cycloconverters	5
6	**Power Electronics Applications:** Switching Power Supplies, Chargers, Electrical drives, high voltage DC Transmission, renewable energy - based systems like solar & wind, power quality improvement, electric vehicles, energy storage solutions, Elevators etc.	6
	TOTAL	**45**

Suggested Specification table with Marks (Theory): (For B.E. only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
0	**20**	**20**	**30**	**30**	**00**

R: Remembrance; U: Understanding; A: Application, N: Analyze; 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. B. Jayant Baliga, Power Semiconductor Devices, Thompson Course Technology, Singapore
2. Muhammad H. Rashid, Power Electronics: Circuits, Devices and Applications, Pearson Education, New Delhi
3. Ned Mohan, Tore M. Undeland and William P. Robbins, Power Electronics: Converters, Applications and Design, John Wiley & Sons, Inc., New York
4. L Umanand, Power Electronics, Essentials & Applications, Wiley India
5. M. S. Jamil Asghar, Power Electronics, Prentice-Hall of India Pvt. Ltd., New Delhi
6. P. S. Bhimbra, Power Electronics, Khanna Publishers, New Delhi
7. M. D. Singh and K. B. Khanchandani, Power Electronics, Tata McGraw-Hill Publishing Company Ltd., New Delhi
8. Joseph Vithayathil, Power Electronics, Principles and Applications, Indian Edition, McGraw-Hill
9. Research Papers on IEEE/ IET/ Science Direct etc.

Sample List of Experiments:

1. Static and dynamic characteristics of SCR, MOSFET and IGBT
2. Demonstrate single phase SCR full-controlled bridge converter with different loads
3. Modeling and simulation of DC-DC Buck/ Boost/ Buck-Boost converter.
4. Modeling and simulation of Forward / Flyback converter.
5. Performance of 1-phase bridge inverter with R and R-L load
6. Study of the three-phase voltage source inverter in 180 and 120-degree mode of conduction
7. Simulation of SVPWM and to study its effectiveness over SPWM.
8. Perform single phase semi-controller rectifier with R and RL load application
9. Design and simulate single phase ac-ac converter with R load
10. Develop the simulation of single-phase dual converter.

Major Equipment:

- SCR, TRIAC, MOSFET, IGBT device characteristics trainer board / kits.
- Trainer kit for Single phase and three phase-controlled rectifiers
- Trainer kit for Single phase and three phase inverters
- Trainer kit for Buck, Boost and Buck-boost Converter
- Control circuit for inverter

- Various controllers for designing the control circuit
- Various Sensors for close loop operation

List of Open-Source Software

1. Scilab (https://www.scilab.org/) – An open-source alternative to MATLAB
2. PSIM (Free Version) / Open Modelica (https://openmodelica.org/) – For modeling and simulating power electronics circuits

List of learning websites:

1. MIT Open Course Ware (https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/) – Free courses on electrical machines and power electronics.
2. Circuit Lab (Free with limited access) (https://www.circuitlab.com/) – Web-based circuit simulator
3. Virtual Labs by IITs (Government of India Initiative) (https://vlab.co.in/) – Simulations and experiments related to Power electronics.
4. Reputed Research Journal Website

- **List of suggested activities for Problem Based Learning:**

Sr. No.	Name of the activity	No. of hours	Evaluation Criteria
1	Industry/Research laboratory visit	Visit = 5h, Report preparation = 5h Total = 10h	Based on report submitted. Report should contain observations and calculations based on industry/ lab data.
2	Technical Video based learning related to the subject	Duration of video = 5h Report preparation = 5h Total = 10h	Report /presentation based on the video learning outcomes.
3	Assignment writing. Numerical based assignments are preferable.	5 assignments of 2h each. Total = 10h	Based on the assignment submitted.
4	Self-learning on-line course	Minimum duration of the course should be 10h.	Examination based assessment at the end of course. Based on the certificate produced.
5	Complex problem solving	Maximum 2 problems. Study of the problem and solution finding, Total = 10h	Based on the depth of the solution submitted.

6	Discussion on research paper based on relevant subject	5 research papers = 20 h	Summarize research paper and evaluation critical parameters
7	Poster/chart/power point preparation on technical topics	Duration = 6 h	Based on poster/chart preparation and presentation skills
8	Working/non-working model on technical topics	Working = 12 h non-working = 8 h	Based on inter department/external evaluation
9	Group Discussion on emerging/trending technical topics based on subject	Duration = 1 h each	Based on performance in group discussion, technical depth, knowledge etc.
10	Real world case studies-based learning	Duration of data collection/study = 5h Report preparation = 5h Total = 10h	Based on in-depth study, technical depth, data collected, fact finding, etc.
11	Blog or Technical Article Writing	10h (Research – 6h, Writing – 4h)	Based on originality, technical content, references cited, and clarity of communication.
12	Annotated Video Explanation of Concept/Problem	10h (Preparation + Recording + Submission)	Based on accuracy of explanation, clarity, and presentation style.
13	Online Technical Quizzes/Simulations	Multiple quizzes summing up to 10h	Based on quiz scores and reflection report after each quiz.
14	Patent Search and Innovation Gap Identification	10h (Search + Report)	Based on number of relevant patents analyzed and identification of innovation scope.

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