GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Electrical Engineering
Subject Code: BE04009031
Subject Name: Power Electronics

w.e.f. Academic Year:	2025-26
Semester:	4
Category of the Course:	Professional Core Course

Prerequisite:	Basic knowledge of analog electronics, electric engineering
Rationale:	This course bridges the gap between basic electrical sciences and advanced applications. It builds upon prior knowledge of circuits, machines, and electronics while preparing students for modern industrial needs such as renewable energy, electric drives, and power conversion systems. The subject equips students with analytical, practical, and simulation skills, laying the foundation for advanced courses and emerging technologies like EVs and smart grids. Its inclusion ensures industry readiness, fosters innovation, and aligns learning with sustainable energy trends.

Course Outcomes:

Sr.No.	CO statements	Marks% weightage
CO-1	Describe the characteristics, switching behavior, and applications of power semiconductor devices including SCR, MOSFET, IGBT, TRIAC, and emerging wide-band gap devices.	20
CO-2	Analyze and design various converter topologies: AC–DC (controlled rectifiers), DC–DC (choppers), DC–AC (inverters), and AC–AC converters under different operating modes.	30
CO-3	Evaluate converter performance in terms of efficiency, harmonic distortion, and power factor using analytical and simulation-based approaches.	25
CO-4	Apply power electronics principles through laboratory experiments and simulations to solve engineering problems and validate converter behavior.	15
CO-5	Explore applications of power electronic converters in electric drives, renewable energy systems, electric vehicles, and power quality improvement.	10

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	SL	Total no of hours per semester		ESE (E)	PA / CA (M)	PA/ CA (I)	TW/ SL (I)	ESE (V)	
45	0	30	45	120	4	70	30	20	30	50	200

Content:

Sr.No.	Content	Total Hrs
1	**Power Semiconductor Devices:** Construction, characteristics and ratings of MOSFET, Insulated Gate Bipolar transistors (IGBTs), SCR, TRIACs, Unijunction transistor (UJT), Silicon carbide (SIC), Gallium nitride devices, Intelligent Modules,d snubber circuits, Firing circuit for thyristors; Gate drive circuits for MOSFET and IGBT	5
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, Time Ratio Control (TRC) and Current Limit Control (CLC) control strategies; multi-quadrant operation;forward and fly-back converters; EMI/EMC issues; zero-voltage switching (ZVS) and zero-current switching (ZCS) concepts.	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, Harmonics and its effects, Applications	10
5	**AC-AC Converters**:Single-phase and three-phase AC voltage regulators: 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	8
6	**Applications of Power Electronics Converters:**Electrical drives, high voltage DC Transmission, renewable energy-based systems – solar & wind, power quality improvement, electric vehicles, energy storage solutions	6
	TOTAL	45

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

Distribution ofTheory Marks					
RLevel	ULevel	ALevel	NLevel	ELevel	CLevel
20	**40**	**20**	**10**	**10**	**00**

R: Remembrance; U: Understanding;A:Application,N:AnalyzeandE:EvaluateC: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. Muhammad H. Rashid, Power Electronics: Circuits, Devices and Applications, Pearson Education, New Delhi
2. Ned Mohan, Tore M. Undeland and William P. Robbins, Power Electronics: Converters, Applications and Design, John Wiley & Sons, Inc., New York
3. B. Jayant Baliga, Power Semiconductor Devices, Thompson Course Technology, Singapore
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. Chetan Singh Solanki, Solar Photovoltaics: Fundamentals, Technologies and Applications, Prentice Hall, New Delhi
9. Joseph Vithayathil, Power Electronics, Principles and Applications, Indian Edition, McGraw-Hill
10. Research Papers on IEEE/IET/Science Direct etc

List of Experiments:

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

Major Equipment:

- SCR, MOSFET and IGBT device characteristics trainer board
- Single phase and three phase rectifiers
- Single phase and three phase inverters

- 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) / OpenModelica (https://openmodelica.org/) – For modeling and simulating power electronics circuits

List of learning website:

1. MIT OpenCourseWare (https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/) – Free courses on electrical machines and power electronics.
2. CircuitLab (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. Numericals based assignment is 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 problem. 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 paper = 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 technicaltopics 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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