GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Bachelor of Engineering
Level: UG
Branch: Power Electronics
Subject Code: BE05024021
Subject Name: Power Electronics Circuits - I

w.e.f. Academic Year:	2024-25
Semester:	5
Categoryof theCourse:	Professional Core Course

Prerequisite:	Power Electronics Devices, Circuits and Applications
Rationale:	Power Electronics Circuits – I deals with the systematic processing and control of electrical energy using power electronic converters. With rapid growth in industrial automation, electric drives, renewable energy systems, electric vehicles, and switched-mode power supplies, AC–DC and DC–DC converters have become fundamental building blocks of modern electrical systems. Controlled rectifiers and choppers are extensively used in automated industries, variable-speed motor control, battery charging systems, and regulated power supplies. In daily life, almost all electronic appliances such as mobile chargers, LED lighting, computers, and household equipment depend on efficient DC power conversion. This course provides essential analytical knowledge of converter operation, control, and performance, forming a strong foundation for advanced studies in power electronics, electric drives, smart grids, and energy-efficient power systems.

Course Outcomes:

Sr.No.	CO statement	Marks% weightage
CO-1	Explain the operation of uncontrolled AC–DC converters with different loads.	10
CO-2	Analyze controlled AC–DC converters and their triggering techniques.	20
CO-3	Evaluate the performance of thyristorized choppers in multi-quadrant operation.	15
CO-4	Assess non–isolated DC–DC converters operating in CCM and DCM.	20
CO-5	Compare isolated and resonant DC–DC converters for efficiency and performance.	20
CO-6	Interpret the operation of resonant converters using ZVS and ZCS techniques.	15

TeachingandExaminationScheme:

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	15	90	3	70	30	20	30	50	200

**** Problem-Based Learning (PBL) aims to accommodate learning beyond the syllabus as per clause 9.4 of NBA manual.***

Where L = Lecture, T= Tutorial, P= Practical, TW/SL = Term-Work / Self-Learning, TH = Total Hours, ESE = EndSemester Examination, PA = Progressive Assessment.

Content:

Sr.No.	Content	Total Hrs
1	**AC-DC converters (Uncontrolled):** Principle of Operation – Classification – Applications Single Phase Uncontrolled Rectifier: Half Wave and Full wave – Analysis on Different Types of Load – Working along with Necessary Wave forms. Three Phase Uncontrolled Rectifier: Half Wave, Full wave - Analysis on Different Types of Load – Working along with Necessary Wave forms – Working Principle of Multi-pulse Rectifiers Effect of source and load inductance. Applications.	5
2	**AC-DC converters (Controlled):** Principle of phase-controlled converter operation; Operation of single-phase half-wave converter with R, RL and RLE load; Significance of freewheeling diode; Single-phase full-wave converter: Centre-tapped and Bridge Configuration; Operation and analysis with R,RL, RLE load; Semi-converter/Half-controlled converter: Asymmetric and Symmetric Configurations; Rectification and Inversion Mode operation. Three Phase Half Wave and Full Wave Controlled Rectifier with R & RL Load – Half Bridge and Full Controlled Bridge Rectifier with R & RL Load. Dual Converter- Principle and operation; 1-phase and 3-phase configurations. Effect of source and load inductance. Various Triggering Circuits for 1-phase&3-phase Controlled Rectifiers like Inverse Cosine Method, UJT Firing Scheme, Transistorized Firing, Using Logic Gates. Applications.	9
3	**Thyristorized Choppers:** Chopper – Principle of Operation – Control Strategies: TRC & CLC – Classification. Step Down and Step Up Choppers – First Quadrant (Type A) Chopper – Second Quadrant (Type B) Chopper – Two Quadrant (Type A or Type C) Chopper – Two Quadrant (Type B or Type D) Chopper – Four Quadrant (Type E) Chopper. Principle of Working, Operation, Analysis and Applications of Jones Chopper and Morgan Chopper. Principle of Operation and Modes of Multi-phase Choppers. Applications.	8
4	**DC-DC Converters:** Importance & Requirement of DC Power Supply- Linear and Switching Power Supply – Principle – Classification based on various criteria – Performance Parameters. Non-Isolated DC-DC Converters: Buck, Boost, Buck-Boost and Cuk Converters in CCM & DCM – Their Operation – Analysis on Different Loads and Control along with Necessary Waveforms. Working Principle and Waveforms of Luo, Sepic and Zeta Converter	8
5	**Isolated DC-DC Converters:** Requirement and Importance of Isolation in Power Electronics Circuit – Advantages. Circuit, Working along with Wave forms, Analysis and Efficiency of: Fly-back – Forward – Push Pull – Half Bridge – Full Bridge Converters. Applications.	8
6	**Resonant Converters:** Review of Resonance – Advantages – Principle of Operation of Resonant Converters – Classification Series and Parallel Resonant Converters ZVS and ZCS Resonant Converters – Types (L & M) – Working Principle – Wave forms – Analysis – Comparison	7
	TOTAL	**45**

SuggestedSpecificationtablewithMarks(Theory):(ForB.E.only)

Distribution ofTheoryMarks					
RLevel	ULevel	ALevel	NLevel	ELevel	CLevel
20	25	20	15	10	10

R: Remembrance; U: Understanding; A: Application, N: Analyzeand 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 the above table.

The syllabus of Power Electronics Circuits – I directly aligns with SDGs 7 and 9 by emphasising efficient energy conversion and industrial innovation, while indirectly supporting SDGs 8, 11, 12, and 13 through the development of sustainable, energy-efficient, and low-emission electrical systems.

SDG 7	Affordable & Clean Energy – direct alignment Topics like AC–DC rectifiers, DC–DC converters (Buck, Boost, Cuk), and isolated converters (Flyback, Full Bridge) enable efficient power conversion in renewable systems, battery charging, and regulated power supplies.
SDG 8	Decent Work and Economic Growth — Indirect Alignment Knowledge of **power electronic circuits (rectifiers, choppers, converters)** supports industries such as manufacturing, EVs, and energy systems, enhancing productivity and creating technical employment.
SDG 9	Industry, Innovation & Infrastructure -direct alignment Study of controlled rectifiers, thyristorized choppers, dual converters, and resonant converters supports industrial drives, high-power applications, and advanced electrical infrastructure.
SDG 11	Sustainable Cities & Communities -indirect alignment Applications of rectifiers, converters, and choppers in power supplies, EV subsystems, and urban electrical systems contribute to reliable and efficient energy use in cities.
SDG12	Responsible Consumption & Production -indirect alignment Concepts like efficiency analysis, converter performance parameters, and controlled switching techniques promote reduced energy wastage, better resource utilization, and longer equipment lifespan.
SDG 13	Climate Action -indirect alignment Efficient designs using resonant converters (ZVS/ZCS), high-frequency switching, and optimized DC–DC conversion reduce switching losses and improve energy efficiency, lowering overall carbon emissions.

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. L Umanand, Power Electronics, Essentials & Applications, Wiley India
4. B. K. Bose, *Power Electronics and Motor Drives: Advances and Trends*, Academic Press (an imprint of Elsevier), Waltham, MA.
5. P. S. Bhimra, *Power Electronics*, Khanna Publishers
6. Philips T. Krein,Power Electronics, Oxford.
7. R. W. Erickson and D. Maksimović,*Fundamentals of Power Electronics*, Springer
8. B. K. Bose,*Modern Power Electronics and AC Drives*, Pearson.
9. Abraham I. Pressman and Keith Billings, *Switching Power Supply Design*, McGraw-Hill
10. Fang Lin Luo & Hong Ye,*Advanced DC to DC Converters*, CRC Press
11. M. S. Jamil Asghar,*Power Electronics*, PHI.
12. Research Papers on IEEE/IET/Science Direct etc.

List of Experiments:

1. Study of single-phase half-wave uncontrolled rectifier with R and RL loads.
2. Study of single-phase full-wave uncontrolled rectifier with R and RL loads.
3. Performance analysis of three-phase uncontrolled bridge rectifier.
4. Single-phase half-wave-controlled rectifier with R and RL load.
5. Single-phase full-wave controlled bridge rectifier with RLE load and freewheeling diode.
6. Study of effect of firing angle on output voltage and power factors.
7. Experimental verification of dual converter operation (simulation-based if hardware is limited).
8. Study of step-down (Type-A) chopper using pulse control.
9. Study of step-up (Type-B) chopper and regenerative operation.
10. Analysis of two-quadrant (Type-C/Type-D) chopper characteristics.
11. Performance evaluation of four-quadrant (Type-E) chopper (simulation-based).
12. Study of Buck, Boost, and Buck-Boost converters (CCM operation).
13. Study of Ćuk / SEPIC / Zeta converter waveforms and voltage conversion ratio.
14. Simulation of flyback and forward converters (MATLAB/PSIM/PLECS).
15. Performance comparison of resonant vs PWM converters under soft-switching conditions.

Major Equipment:

1. Power Electronics Trainer Kits (Chopper trainer kits, DC–DC Converter, AC-DC Converter Trainer kits)
2. Isolated DC–DC Converter Trainer (Flyback / Forward / Push–Pull)
3. Digital Storage Oscilloscope (DSO) – with isolation probes
4. MATLAB/Simulink Software with Simscape Electrical Toolbox

List of Open-SourceSoftware:

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

List of learning websites:

1. MIT Open Course Ware (https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/)
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 (PBL):

Sr. No.	PBL Category	Name of the activity	No. of hours	Evaluation Criteria
1	Industry / Research Laboratory Visit	Industry/Research laboratory Visit (Power converters/electronics/drives company)	Visit = 5hrs, Report preparation = 5hrs Total = 10hrs	Based on the report submitted. Report should contain observations and calculations based on industry/ lab data.
2	Video Based Learning	Technical Video-based learning related to the subject (MOOC/NPTEL Video)	Duration of video = 5hrs Report preparation = 5hrs Total = 10hrs	Report /presentation based on the video learning outcomes.
		Self-learning online course	Minimum duration of the course should be 10 hours.	Examination-based assessment at the end of course. Based on the certificate produced.
		Annotated Video Explanation of Concept/Problem	10hrs (Preparation + Recording + Submission)	Based on the accuracy of explanation, clarity, and presentation style.
3	Assignment/ Technical Writing / Research Writing	Assignment writing. Numerical-based assignment is preferable.	5 assignments of 2hrs each. Total = 10hrs	Based on the assignment submitted.
		Blog or Technical Article Writing	10hrs (Research – 6hrs, Writing – 4hrs)	Based on originality, technical content, references cited, and clarity of communication.
4	Complex Problem-Solvingtargeting relevant SDGs. / Mini Project	Complex problem solving	Maximum 2 problem. Study of the problem and solution finding, Total = 15 hrs	Based on the depth of the solution submitted.
5	Research Paper Review / Analysis	Discussion on a research paper based on a relevant subject (SCOPUS Index/any reputed Journal)	5 research paper = 20 hrs	Summarize research paper and evaluation of critical parameters
6	Poster/ Chart/ Power point presentation	Poster/chart/power point preparation on technical topics	Duration = 6 hrs	Based on poster/chart preparation and presentation skills
7	MicroProject	Working/non-working model on technical topics	Working = 10hrsnon-working = 10hrs	Based on inter-department/external evaluation
8	Group Discussion / Quiz / Simulation	Group Discussion on emerging/trending technical topics based on the subject	Duration = 1 hrs each	Based on performance in group discussion, technical depth,knowledge etc.
		Online Technical	Multiple quizzes	Based on quiz scores and the

Sr. No.	PBL Category	Name of the activity	No. of hours	Evaluation Criteria
		Quizzes/Simulations	summing up to 10 hours	reflection report after each quiz.
9	Case Study Analysis / Seminar	Real-world case studies-based learning	Duration of data collection/study = 5hrs Report preparation = 5hrs Total = 10hrs	Based on in-depth study, technical depth, data collected, fact finding, etc.
10	Other	Patent Search and Innovation Gap Identification	10hrs (Search + Report)	Based on number of relevant patents analyzed and identification of innovation scope.

Note:
In alignment with Outcome-Based Education (OBE) and NBA accreditation requirements, the subject **Power Electronics Circuits - I** incorporates;

- Mini Project – 10 Marks
- Micro Project – 5 Marks

These activities are incorporated as integral Project-Based Learning (PBL) components. These activities are designed to foster experiential learning, encourage innovation, and strengthen problem-solving skills by engaging students in practical applications of power converter design, simulation, and analysis. The inclusion of PBL ensures that learners develop higher-order cognitive abilities mapped to Bloom's taxonomy, while simultaneously enhancing teamwork, communication, and research competencies essential for professional engineering practice.

1. The hours allocated to specific activities should be proportionate to the total no. of PBL hours and marks.
2. In alignment with Outcome-Based Education (OBE) and NBA accreditation requirements, the subject

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