Government of Karnataka
DEPARTMENT OF TECHNICAL EDUCATION

Program	**Electronics and Communication Engineering**	**Semester**	**IV**
Course Name	**Power Electronics**	**Type of Course**	Integrated
Course Code	**25EC41I**	**Contact Hours**	8 Hours/week 104 Hours/semester
Teaching Scheme	L: T:P: 4:0:4	**Credits**	6
CIE Marks	**50**	**SEE Marks**	**50 (Theory)**

1. Rationale:

The Power Electronics course is designed to provide students with a deep understanding of the principles and applications of power electronic systems. This knowledge is critical in modern engineering, where efficient power management and conversion are essential for various industries, including renewable energy, transportation, and industrial automation.

This course equips students with the theoretical knowledge and practical skills necessary to excel in the field of power electronics. By understanding the components, design principles, control techniques, and applications of power electronic systems, students will be prepared to innovate and develop efficient solutions for energy conversion and management. This comprehensive approach ensures that graduates are ready to meet the challenges of modern engineering and contribute to advancements in technology and sustainability.

2. Course Outcomes: At the end of the course, the student will be able to

CO-01	Explain the principles and applications of power semiconductor devices.
CO-02	Illustrate the SCR operation with protection methods.
CO-03	Construct or simulate the single-phase controlled rectifiers and chopper circuits and test or troubleshoot for the required output.
CO-04	Construct or simulate the inverter, SMPS and cycloconverter circuits and test or troubleshoot for the required output.
CO-05	Infer the emerging trends in power electronics.

3. Course Content:

WEEK	CO	PO	Theory	Practice
1	**1**	**1**	1. Overview of Power Electronics: Scope, importance and applications. video demonstration on application of power electronics in industrial Automation. 2. Basics of power semiconductor devices with examples: Power Diodes, Power Transistors - symbol,	1a. Interpret the datasheets of Power diode and Power MOSFET. 1b. Interpret the datasheets of SCR and IGBT.

			function, characteristic and application. Compare ordinary diodes and power diodes. Compare ordinary transistors and power transistors. 3. Thyristors: SCR & TRIAC - symbol, function, application. 4. DIAC & GTO - symbol, function, application.	2. Identify all the power semiconductor devices and list them with symbols.
2	**1**	**1,2**	Power MOSFET: 1.Power MOSFET - symbol, applications. 2. N channel enhancement power MOSFET - working, characteristics. 3. Summary of advantages of N channel enhancement power MOSFET over all other types of MOSFET. 4. Compare power BJT and power MOSFET.	1. Conduct / simulate an experiment to obtain VI characteristics of any power MOSFET. Compare the results with its datasheet. 2. Video demonstration on working of N channel MOSFET.
3	**1**	**1,2 ,3**	Power IGBT: 1. IGBT - symbol, list of various terminologies, importance. 2. Explain the best features of power BJT and power MOSFET used in power IGBT. 3. Advantages and disadvantages of power IGBT. 4. Discuss and list the Real time applications of power IGBT.	1.Conduct / simulate an experiment to obtain VI characteristics of any IGBT. 2. Video demonstration on applications of IGBT.

4	**2**	**1,2,3**	1. Silicon Controlled Rectifier (SCR) - VI characteristics, latching current, holding current and breakdown voltage of SCR. 2. Turn ON methods of SCR - Explanation for each method. 3. SCR Triggering circuits: R-triggering, RC-triggering (only Full wave). 4. SCR Protection circuits - Over voltage, over current, di/dt & dv/dt (Snubber circuit) and Gate protection.	1. Conduct an experiment to obtain forward VI characteristics of SCR and determine the holding and latching currents. Compare the results with its datasheet. 2a. Construct R-triggering circuits and verify the working. 2b. Discuss and construct a pulse triggering circuit using UJT relaxation oscillator and verify the working.
5	**2**	**1,2,3,4**	1. Commutation of SCRs: Definition, Need and conditions for commutation, types -Natural or Line & Forced. 2. Natural or Line commutation methods - Circuit, waveform & working. Forced commutation methods - Classification. 3. Explanation of Class A and Class B - Circuit, waveform & working. 4. GTO - VI characteristics and working principle.	1. Conduct the experiment to turn ON and OFF an LED bulb using a single channel 5V/12V Solid State Relay module. Performance comparison with Electromagnetic relay. 2. Conduct the experiment to verify the light dimmer circuit using DIAC and TRIAC.
6	**3**	**1,2,3,4**	1. AC-to-DC Converters: Introduction to phase-controlled rectifiers or converters. Single-phase half-wave controlled rectifiers with R load - Circuit diagram, waveform & working. 2. Single phase converters: Single-phase full-wave mid-point controlled rectifiers with R load - Circuit diagram, waveform & working. 3. Single-phase fully-controlled bridge converters with R load - Circuit Diagram, waveform and explanation. Illustration of Single-phase semi converters.	1. Conduct an experiment to study the performance of single-phase half-wave controlled rectifiers with resistive load. 2. Conduct an experiment to study the performance of single-phase full-wave controlled rectifiers with resistive load.

			4. Concept of freewheeling diode. Comparison between half controlled and full controlled rectifiers.	
7	**3**	**1,2,3,4**	1. DC-to-DC Converters: Introduction to choppers - definition, principle of operation, Concept of Step-down and Step-up choppers. 2. Classification of choppers: Class A choppers - Circuit diagram, quadrant diagram and working. 3. Class B choppers - Circuit diagram, quadrant diagram and working. 4. Class E choppers - Circuit diagram, quadrant diagram and working, Applications of choppers.	1. Conduct / simulate an experiment to study the working of a step-up chopper. 2. Conduct / simulate an experiment to study the working of a step-down chopper.
8	**4**	**1,2,3,4**	1. DC-to-AC Converters: Introduction to inverters - working principle. 2. Inverters - classification, applications. 3. Half-bridge inverters- Circuit diagram, waveform and explanation. 4. Full-bridge inverters - Circuit diagram, waveform and explanation.	1. Construct / simulate the half-bridge inverters. 2. Conduct the experiment to study the working of an inverter using Arduino and MOSFET/ IGBT.
9	**4**	**1,2,3,4**	1. Series inverters - Circuit diagram and working. 2. Voltage control in inverters - Need and Listing of different methods. 3. Introduction to PWM techniques: Single-pulse PWM - definition and waveform. 4. Multiple-pulse PWM - definition and waveform.	1. Construct / simulate an experiment to study the Series inverter circuit. 2. Construct an experiment to study the generation of PWM signals using kit / simulation.
10	**4**	**1,2,3,4**	1. AC to AC converters: Introduction to cycloconverter. Classification - Step down and Step up cycloconverter.	1. Conduct the experiment to study the Single-phase cycloconverter operation with resistive load.

			2. Principle of operation of single phase cycloconverters - Circuit diagram, operation and waveforms. 3. Bridge type cycloconverter. Applications of cycloconverter. 4. Difference between cycloconverters, choppers, rectifiers and inverters.	2. Build a 12V Battery charger circuit using SCR with all protective components. https://www.academia.edu/9138297/Battery_Charger_Circuit_Using_SCR
11	**4**	**1,2,3,4**	1. Applications of Thyristors: Light dimmer circuit using DIAC and TRIAC. 2. Burglar alarm using SCR - Circuit diagram and explanation. 3. Photo-electric control of SCR - Circuit diagram and explanation. 4. Switched-Mode Power Supply (SMPS) - Block diagram and working. List the safety devices used in SMPS.	1. Build a FAN speed regulator using DIAC & TRIAC. 2. Build / simulate a simple 5V/12V 1 Amp SMPS circuit. https://www.electronicsforu.com/electronics-projects/simple-12v-smps
12	**4**	**1,2,3,4,7**	1. Metal Oxide Varistors (MOV) - working principle, characteristics & specifications. 2. Application of Gas Discharge Tubes (GDTs) in Power Circuits - working principle, features & specifications. 3. Video demo on working of AC/DC motors. Electronic control of AC/DC motors: Need for electronic control of motors. 4. Armature voltage control of DC shunt motor.	1. Collect and analyse the datasheets of all the safety components/ devices used in power applications. (MOV, GTD etc.) 2. Conduct the experiment to control the direction of rotation of a DC motor using any H-Bridge Motor Driver Module.
13	**5**	**1,2,3,4,7**	1. Emerging Trends in Power Electronics: Introduction to wide bandgap semiconductors: Silicon Carbide (SiC) Devices and Gallium Nitride (GaN) Devices - energy band diagram, construction diagram-explanation.	1. Industrial visit to any SMPS/ Power supply development/ Inverter manufacturing industry and submit a report.

			2. Renewable energy applications: Solar inverters, wind energy converters. 3. Application of power electronics in electric vehicles (EV) and smart grids. 4. Future trends: Wireless power transfer and power electronics in automation - brief introduction.	2.Industrial visit to any power station and submit a report.

Note:

1. In practice sessions all video demonstrations should be followed by MCQ/Quiz/ Subjective questions and evaluation has to be documented.

2. Online course completion certification to be done on relevant topics on Swayam/NPTEL/Infosys Springboard platforms or any other platform.

3. Problem statements to be collected from the relevant industries, resolve and submit it to the course coordinator.

4. References:

- POWER ELECTRONICS HANDBOOK by MUHAMMAD H. RASHID.
- "GaN and SiC Power Devices: From Fundamentals to Applied Design and Market Analysis" by Maurizio Di Paolo Emilio (2024).
- Power Electronics (Second Edition) by M D Singh, K B Khanchandani, McGrawHill (2015) publishers .
- Power Electronics by P.S. Bimbhra 2022 Jan edition.
- Principles of Power Electronics by John G. Kassakian, David J. Perreault, George C. Verghese, Martin F. Schlecht 2023 edition.
- Power Electronics by Soumitra Kumar Mandal Mc GrawHill publishers.
- https://www.youtube.com/watch?v=XKc1LyCmosM&list=PL_mruqjnuVd9_mwhgK3nAy-cHyslXCnRk&index=4
- https://www.youtube.com/watch?v=i_WxKve1eqw&list=PL_mruqjnuVd9_mwhgK3nAy-cHyslXCnRk&index=5
- https://www.youtube.com/watch?v=HI4Z6imxUIM

5. CIE Assessment Methodologies

Sl. No	**CIE Assessment**	**Test Week**	**Duration (minutes)**	**Max marks**	
1.	CIE-1 Theory Test	4	90	50	
2.	CIE-2 Practice Test	7	180	50	Average of all CIE=50 Marks
3	CIE-3 Theory Test	10	90	50	

4.	CIE-4 Practice Test	13	180	50	
5	CIE-5 Portfolio evaluation of all the activities through Rubrics	1-13		50	
				Total	**50 Marks**

Note: -
Portfolio evaluation includes average of (a) and (b).

(a) Any one of the Suggested activity model with report and presentation evaluated for 50 marks.

(b) Each laboratory exercise will be evaluated for a total of 50 marks. The evaluation will include the following components:

1. Written description of the experiment in the observation book.
2. Conducting the experiment and the associated learning outcomes.
3. The results obtained from the experiment.
4. Corrections and evaluations of the experiment completed in the previous class, documented in the record book.

6. SEE - Theory Assessment Methodologies

Sl. No	SEE – Theory Assessment	Duration	Exam Paper Max marks	Exam Paper Max Marks scale down to (Conversion)	Min marks to pass
1.	Semester End Examination-Theory	3 Hours	100	50	20

7. CIE Theory Test model question paper

Program	**Electronics and Communication Engineering**			**Semester -IV**	
Course Name	Power Electronics			**Test**	**I/II I**
Course Code	**25EC41I**	Duration	**90 min**	**Marks**	**50**
Name of the Course Coordinator:					
Note: Answer any one full question from each section. Each full question carries equal marks.					

Q.No	Questions	Cognitive Level	Course Outcome	Marks
	Section - 1			
1	a) Describe the working principle of an IGBT.	L2	1	10
	b) Compare ordinary diodes and power diodes.	L2	1	5
	c) Illustrate the working of protection circuits in SCR application.	L3	2	10

2	a) Describe the working principle of a power MOSFET. b) Compare ordinary transistors and power transistors. c) Construct R-triggering circuit for SCR and explain with waveform.	L2 L2 L3	1 1 2	10 5 10
	Section - 2			
3	a) Illustrate the latching current, holding current and breakdown voltage of SCR. b) Explain the turn ON methods of SCR. c) Compare the functions of SCR and ordinary DIODE.	L2 L2 L3	2 2 2	10 10
4	a) Construct and explain a pulse triggering circuit using UJT relaxation oscillator. b) Explain the construction and VI characteristics of GTO. c) Discuss the need for commutation SCRs.	L2 L2 L3	2 2 2	5 10 10 5

Note for the Course coordinator:
1. Each question may have one, two or three subdivisions. Optional questions in each section carry the same weightage of marks, cognitive level and course outcomes.
2. All questions must be framed under Understand (L2) & Apply (L3) cognitive level using Revised Bloom's Taxonomy.

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

8. CIE Practice Test model question paper

Program	**Electronics and Communication Engineering**			**Semester**	**IV**
Course Name	Power Electronics			**Test**	**II/IV**
Course Code	**25EC41I**	**Duration**	**180 min**	**Marks**	**50**
Name of the Course Coordinator:					
Questions				**CO**	**Marks**
Write-up for two experiments and conduction of any one experiment.					**50**
Scheme of assessment **a) Writing the Circuit diagram, tabular column, calculations etc..for two experiments.** **b) Rig up the circuit (Any one)** **c) Conduction** **d) Result** **e) viva-voce**					**10** **10** **15** **05** **10**
Total Marks					**50**

Signature of the Course Coordinator **Signature of the HOD** **Signature of the IQAC Chairman**

9. Suggestive Activities for Tutorials:

The List is an example and not inclusive of all possible activities of the course. Students and Faculty are encouraged to choose activities that are relevant to the topic.

Note: Activity can be undertaken by either an individual or a team comprising up to 5 students.

Sl. No.	Suggestive Activities
01	Build a FAN speed regulator using DIAC & TRIAC on general purpose PCB and submit a detailed analysis report.
02	Build a 5V/12V 1A SMPS on general purpose PCB and submit a detailed analysis report.
03	Build a 12V Battery charger circuit using SCR with all protective components on general purpose PCB and submit a detailed analysis report.
04	Build a simple BLDC motor controller circuit Using IRFZ44N MOSFET. https://www.youtube.com/watch?v=LU_6lCu8uTs
05	Build an Inverter circuit using IRFZ44N MOSFET & CD4047. https://www.youtube.com/watch?v=ux6xuhfdSyw
06	Build any one real time application of SCR/TRIAC.

10. Rubrics for Assessment of Activity (Qualitative Assessment)

Sl. No.	Dimension	Beginner	Intermediate	Good	Advanced	Expert	Students Score
		10	20	30	40	50	
1		Descriptor	Descriptor	Descriptor	Descriptor	Descriptor	40
2		Descriptor	Descriptor	Descriptor	Descriptor	Descriptor	30
3		Descriptor	Descriptor	Descriptor	Descriptor	Descriptor	50
4		Descriptor	Descriptor	Descriptor	Descriptor	Descriptor	20
	Average Marks=(40+30+50+20)/4=35						**35**

Note: Dimension and Descriptor shall be defined by the respective course coordinator as per the activities

11. Equipment/software list with Specification for a batch of 30 students

Sl.No.	Particulars	Specification	Quantity
01	Computers	Intel Core i5 11th gen/8GB RAM/1 TB HDD/256GB SSD/ Graphics 2 GB	30
02	POWERSIM simulation software		
03	Dual trace oscilloscope	20-30MHz	30
04	Function generator		30
05	SCR, TRIAC, DIAC, IGBT, GTO		30 each
06	Universal Motor (AC/DC)	FHP/230V	30

07	DC Motor, H-Bridge		30 each
08	Solid State Relays	5V/12V	30
09	Pedestal Fan	230VAC 50Hz	1
10	Protection devices (MOV, GTD etc.)		30each
11	Rechargeable Battery	Sealed Lead Acid Battery 12V, 1.3 Ah or 7Ah	10
12	Arduino development boards	Arduino UNO	10
13	Transformers	6-0-6, 12-0-12/1A	20
14	Decade Resistance Box (DRB), Potentiometers		20