



Government of Karnataka
DEPARTMENT OF COLLEGIATE AND TECHNICAL EDUCATION

Programme	Electrical and Electronics Engineering	Semester	IV
Course Code	20EE42P	Type of Course	Programme Core
Course Name	Power Electronics	Contact Hours	8 hours/week 104 hours/semester
Teaching Scheme	L:T:P :: 3:1:4	Credits	6
CIE Marks	60	SEE Marks	40

1. Rationale:

Power electronics is the application of solid-state electronics to the control and conversion of electric power. Power semiconductor devices are used to construct converters and inverters in the various applications such as power supplies, Electric drives, Flexible AC Transmission systems and Distribution systems, EV's, Energy storage devices. An Electrical Technician shall apply the knowledge of Power electronics to control and convert Electrical Power for an application.

2. Course Outcomes/Skill Sets: On successful completion of the course, the students will be able to

CO-01	Identify the power electronic devices using relevant datasheets and demonstrate its suitability to produce specified electrical and thermal characteristics.
CO-02	Build a power electronic circuit for a given application, demonstrate its working either in real or simulated environment.
CO-03	Test a given power electronic circuit, identify the problem and troubleshoot to obtain the desired result/output.

3. Course Content

Week	CO	PO*	Lecture (Knowledge Criteria)	Tutorial (Activity Criteria)	Practice (Performance Criteria)
			3 hours/week		4 hours/week (2 hours/batch twice in a week)
1	1,2	1,4	1. Concept of power electronics, Draw the layer structure of the power diode and explain it. V –I characteristics of power diode.	Refer Table 1	1a. Study and interpret the datasheet of given power diode and BJT. 1b. Test the given Diode and BJT for its working condition. 1c. Simulate VI characteristics of power diode.
			2. Types of power diodes and their applications		2. Simulate output characteristics of Power BJT
			3. Types of Power transistors, BJT output characteristics, BJT as a switch.		
2	1,2	1,4	1. Operation of N-channel enhancement power MOSFET, and its transfer characteristic curve, Application of MOSFET.	Refer Table 1	1a. Study and interpret the datasheet of power MOSFET and IGBT 1b. Identify various Power MOSFET by its number and test by using a multimeter 1c. Identify IGBTs by their numbers and test by using a multimeter.
			2. Structure of IGBT and its characteristics		

			3. Application of IGBT, Compare MOSFET, BJT and IGBT		2a. Simulate the transfer characteristics of power MOSFET and IGBT. 2b. Rig up the circuit of power MOSFET as a switch
3	1,2	1,4	1. Layer diagram of SCR and Concept of two transistor analogy of SCR.	Refer Table 1	1. Test the given SCR for its working condition.
			2. Static V-I characteristic curve of SCR, Enumerate Reverse blocking, Forward blocking, forward conduction mode.		2. Simulate VI characteristics of SCR, GTO and LASCR.
			3. GTO, principle of operation and list its application, layer structure of LASCR and explain its operation.		
4	1,2	1,4	1. Layer structure, operation and characteristics of TRIAC	Refer Table 1	1a. Test the given TRIAC and DIAC for its working condition. 1b. Simulate VI characteristics of TRIAC and DIAC.
			2. 4-Modes of turn on of TRIAC and state the preferred mode of turn-on.		2. Build and test a TRIAC- fan motor speed control circuit.
			3. Operation of DIAC and its V-I characteristic, curve, application of DIAC.		
5	1,2	3,4	1. SCR Control Circuits: Methods of turn on of SCR	Refer Table 1	1. Build R firing circuit and determine the maximum firing angle.
			2. General layout of firing circuit.		2. Build R – C firing circuit and determine the maximum firing angle.
			3. R firing circuit and R-C firing circuit with waveforms.		
6	1,2	3,4	1. Construction, operation and characteristics of UJT	Refer Table 1	1. Build and test UJT Relaxation oscillator.
			2. Synchronized UJT pulse trigger circuit with waveform.		2. Build and Test time delay relay using SCR and UJT.
			3. Digital firing scheme with waveforms.		
7	1,2	3,4	1. Commutation, line commutation, forced commutation and methods of forced commutation, Load commutation and complementary commutation.	Refer Table 1	1. Simulate Line commutation and forced commutation circuits and observe waveforms.
			2. Voltage and current ratings of SCR and Reliability of SCR, MTBF.		2. Construct a snubber circuit for protecting SCR use freewheeling diode to reduce back emf.
			3. How SCR can be protected against overvoltage and over current, di/dt & dv/dt. Different types of mounting of SCR.		
8	1,2	4	1. CONVERTERS: types of power electronic converters: Single -quadrant semi-converter, two- quadrant full- converter and dual converter.	Refer Table 1	1. Build single-phase full controlled bridge converter for resistive load. Trace the waveforms across SCR and load.
			2. Single-phase full converter RLE type with continuous load current		2. Simulate single-phase Dual

			3.single-phase dual converter and principle of operation.		converter and observe waveforms.
9	1,2	4	1. Gating pulse requirement of three-phase full converters.	Refer Table 1	1.Test three-phase bridge rectifier module (36MT160)
			2.Three-phase bridge converter and 180 conduction mode with waveforms.		2. Simulate three-phase Bridge converter and observe waveforms.
10	1,2	4	1. DC Chopper- Step-down and Step-up chopper and its operation.	Refer Table 1	1.Simulate/Build step-down chopper and observe waveforms.
			2. Different chopper configurations- (A, B, C, D and E).		
			3. Inverter- Types of inverters (VSI and CSI).		2. Simulate / Build step-up chopper and observe waveforms.
11	1,2	4	1. Half bridge and full-bridge inverter and its operation.	Refer Table 1	1.Simulate Full-bridge Inverter and observe waveforms.
			2. Cycloconverter- Draw the circuit of mid- point Step-down cyclo-converter and its operation with waveforms.		2.Build and test a inverter. Ref.7(18)
			3. Cycloconverter- Draw the circuit of a mid- point step-up cycloconverter and its operation with waveforms.		
12	2,3	2,4	DC-DC converters: 1. Working principle of Buck converter (regulator).	Refer Table 1	1a. Build & test IC based - DC –DC converter for different voltages. Ref.7(8)
			2. Working principle of Boost converter (regulator). Ref.7(9,10,11,12)		1b. Test the monolithic synchronous buck regulator (MP2305).
			3.Working principle of Buck-boost and flyback converter. Ref.7(14,15,16,17)		2.Test and Troubleshoot regulators. Ref.7(13)
13	2,3	2,3,4	1. SMPS and its operation and application.	Refer Table 1	1a. Identify various input and output sockets/ connectors of the given SMPS. 1b. Identify major sections/ ICs/components of SMPS. 1c. Troubleshoot given SMPS. Ref.7(19,20)
			2. UPS, Battery size and required voltage for UPS		
			3a. Draw the block diagram of offline online UPS and its operation. 3b. List basic troubleshooting steps for UPS. Ref.7(21,23)		2a. Identify front panel control & indicators of UPS. 2b. Connect battery & load to UPS & test on battery mode. 2c. Open top cover of UPS & identify isolator transformer & UPS transformer & additional circuit other than inverter.

					2d. Identify various circuit boards in UPS and monitor voltages at various test points. 2e. Test UPS under fault condition & rectify fault. Ref: 7(22,24)
Total in hours			39	13	52

***PO= Program Outcome as listed and defined in year 1 curriculum and CO-PO mapping with strength (Low/Medium/High) has to be mapped by the course coordinator. (Above only suggestive).**

Table 1: Suggestive Activities for Tutorials: (The List is only shared as 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 and on the availability of such resources at their institution).

Sl No	week	Activity
1	1	Study a datasheet of power diode 6A01-6A0, select a diode which has peak repetitive voltage (VRRM) of 1000V, RMS Voltage of 700V, Average rectified current of 6 Amp, can withstand temperature of 150 degrees Celsius. Demonstrate in the class importance of the Datasheet in selecting a diode for given electrical and thermal characteristics. Demonstrate method of mounting of a given power diode or its alternative.
2	2	Study Data sheet of given IGBT (FGA15N120 IGBT) 1. Explain Pin description of IGBT 2. List Explain the features of given IGBT 3. List alternatives for given IGBT 4. List applications of IGBT 5. Rig up a circuit to turn on/ off IGBT 6. Explain switching characteristics of given IGBT
3	3	Study Data sheet of given SCR (TN3050H-12WY) 1. Explain features of given SCR 2. Explain Pin description of given SCR 3. Analyse electrical characteristics of SCR, check suitability of SCR for a given specification.
4	4	Study Data sheet of given TRIAC (BTA16-600CW3G) 1. Explain features of given TRIAC 2. Explain Pin description of given TRIAC 3. Analyse electrical characteristics of TRIAC, check suitability of TRIAC for a given specifications.
5	5	Design an R-triggering circuit for a half wave-controlled rectifier circuit for 24 V ac supply. The SCR to be used has the following data. Igmin = 0.1 mA, Igmax = 12 mA, Vgmin = 0.6V, Vgmax = 1.5 V
6	6	Design a UJT relaxation oscillator using UJT2646 for triggering an SCR. The UJT has the following parameters $\eta = 0.63$, $V_{BB} = 20$ V, $V_P = 13.2$ V, $I_P = 50$ μ A $V_V = 2$ V, $I_V = 6$ mA, $R_{BB} = 7$ k Ω , leakage current = 2.5 mA Also find the minimum and maximum time period of oscillation.
7	7	Design snubber circuit to protect given SCR against dv/dt used in single-phase converter circuits. Input line to line voltage has peak value of 425 volts and source inductance is 0.2 H

8	8	1.Explain advantages and disadvantages of power electronic converters. 2. Study Industrial rectifiers 1) List Types of Industrial rectifiers and their applications 2) Typical specifications of commercially available rectifiers 3) Cooling methods employed in rectifiers.
9	9	Study given Standard Rectifier Module (VUO190-16N07) 1. List the features of given Rectifier module 2. List applications of given Rectifier module 3. Explain the different ratings of the Rectifier module. 4. Check its suitability for a given specification Study Industrial rectifiers 1) List Types of Industrial rectifiers and their applications 2) Typical specifications of commercially available rectifiers 3) Cooling methods employed in rectifiers
10	10	Study the Intelligent Power Module (STK551U3A2A-E) 1. Explain features of Intelligent power module 2. List applications of Intelligent power module 3. Explain rating of given IPM
11	11	Study research report “DC-DC Converter Topologies for Electric Vehicles, Plug-in Hybrid Electric Vehicles and Fast Charging Stations: State of the Art and Future Trends” 1. Explain Block diagram of an electric vehicle powertrain. 2. Compare batteries, supercapacitors and fuel cells. 3. Explain Categories of DC-DC Converter for EVs’ Powertrain 4. Parameter comparison of Si with respect to Wide Bandgap Semiconductors (SiC and GaN.) 5. Explain Why WBGs (SiC and GaN.) are preferred in EVs
12	12	Study the latest technological changes in this course and present the impact of these changes on industry.
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4. CIE and SEE Assessment Methodologies

Sl. No	Assessment	Test Week	Duration In minutes	Max marks	Conversion
1.	CIE-1 Written Test	5	80	30	Average of three tests 30
2.	CIE-2 Written Test	9	80	30	
3	CIE-3 Written Test	13	80	30	
4.	CIE-4 Skill Test-Practice	6	180	100	Average of two skill test reduced to 20
5	CIE-5 Skill Test-Practice	12	180	100	
6	CIE-6 Portfolio continuous evaluation of Tutorial sessions through Rubrics	1-13		10	10
Total CIE Marks					60
Semester End Examination (Practice)			180	100	40
Total Marks					100

5. Format for CIE written Test

Course Name	Power Electronics	Test	I/II/III	Sem	III/IV
Course Code	20EE42P	Duration	80 Min	Marks	30
Note: Answer any one full question from each section. Each full question carries 10 marks.					
Section	Assessment Questions	Cognitive Levels	Course Outcome	Marks	
I	1				
	2				
II	3				
	4				
III	5				
	6				
Note for the Course coordinator: 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.					

6. Rubrics for Assessment of Activity (Qualitative Assessment)

Sl. No.	Dimension	Beginner	Intermediate	Good	Advanced	Expert	Students Score
		2	4	6	8	10	
1		Descriptor	Descriptor	Descriptor	Descriptor	Descriptor	8
2		Descriptor	Descriptor	Descriptor	Descriptor	Descriptor	6
3		Descriptor	Descriptor	Descriptor	Descriptor	Descriptor	2
4		Descriptor	Descriptor	Descriptor	Descriptor	Descriptor	2
Average Marks= (8+6+2+2)/4=4.5							5

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

7. Reference:

Sl. No	Description
1	Power Electronics by Dr P S Bimbhra , Khanna Publishers, New Delhi
2	Industrial Electronics and Control Biswanath Paul PHI Publication Edition-II
3	Thyristorised power controllers GK Dubey
4	Power and industrial Electronics by Harish C Rai
5	Power electronics by Mohan Undeland & Robbins, Wiley Publications
6	Modern Power Electronics by P.C.Sen
7	Power Electronics – RaghunathRao
8	https://components101.com/ics/ncp3064-dc-dc-converter-ic
9	https://www.youtube.com/watch?v=4IQBN6Oy8Lg
10	https://www.youtube.com/watch?v=Rf29oUGpwI
11	https://www.youtube.com/watch?v=vmNpsofY4-U
12	https://www.youtube.com/watch?v=yD7fMylYgXw
13	https://www.youtube.com/watch?v=-3tBw6WSZVM
14	https://www.youtube.com/watch?v=zNfbbPobtus
15	https://www.youtube.com/watch?v=ZiD_X-uo_TQ
16	https://www.youtube.com/watch?v=9--jaxiXhE
17	https://www.youtube.com/watch?v=Fk-B6O06GB8https

18	https://www.youtube.com/watch?v=6CsTIPjFZ48 www.youtube.com/watch?v=I8c5DLJgS3o
19	https://www.youtube.com/watch?v=PPLjXkca7eo
20	https://www.powersupplyrepairguide.com/previewssmpsebook.pdf
21	https://www.youtube.com/watch?v=C1BYo88HSU0
22	https://www.youtube.com/watch?v=3oq18dZmb3Q
23	https://www.apc.com/lr/en/faqs/FA279110/
24	https://www.youtube.com/watch?v=lkriUIUdfIM https://www.youtube.com/watch?v=JHgKBDQCyQ
25	https://inst.eecs.berkeley.edu/~ee100/su07/handouts/EE100-MultiSim-Tutorial.pdf
26	http://eceweb1.rutgers.edu/~psannuti/ece223/Manual-for-multisim.pdf
27	https://www.multisim.com/help/getting-started/

8.1 CIE-4&5 Skill Test Scheme of Evaluation

SL. No.	Particulars/Dimension	CO	Marks
1	Portfolio evaluation of Practice Sessions		10
2	Identify and explain the Data Sheets for the given power Electronic Devices	1	10
3	Demonstrate the working condition of power electronics devices (power Diode, power transistors).	2	10
4	Identify the problem in a given circuit and demonstrate the troubleshooting method used to rectify that problem.	3	20
5	Building and Demonstration of the working Circuit including i. Drawing of the Circuit diagram using the right symbols 05 ii. Build the circuit as per the circuit diagram 10 iii. Demonstrate the working of the circuit. 20 iv. Document the necessary readings of the expected circuit outcomes. 05	2	40
6	Viva-voce		10
Total Marks			100

8.2 SEE Scheme of Evaluation

SL. No.	Particulars/Dimension	CO	Marks
1	Portfolio evaluation of Practice Sessions		10
2	Building and Demonstration of the working Circuit including i. Drawing of the Circuit diagram using the right symbols 10 ii. Identify and explain the Data Sheets for the given power Electronic Devices. 10 iii. Demonstrate the working condition of power electronics devices. 10 iv. Build the circuit as per the circuit diagram 15 v. Demonstrate the working of the circuit. 20 iv. Document the necessary readings of the expected circuit outcomes. 05	2	70
3	Viva-voce		20
Total Marks			100

9. Equipment/software list with Specification for a batch of 20 students

Sl. No.	Particulars	Specification	Quantity
1	DC Regulated power supply	(0-300V, 2A)	5
2	DC Regulated Dual power supply	(0-30V, 2A)	5
3	Cathode Ray Oscilloscope	Dual trace, 25 MHz.	5
4	Digital Multimeter	31 / 2" 1-ph	5

5	1-ph Induction Motor	220v,1ph,	1
6	Battery	6 V/12 V 60 AH	2
7	SMPS		5
8	UPS 2kVA	2 kVA	1
Software			
1	GNU-Octave/MatLab/P-spice/Multisim		20 License