

GUJARAT TECHNOLOGICAL UNIVERSITY

Bachelor of Engineering

Subject Code: 3172413

Semester – VII

Subject Name: Advanced Power Electronics Devices and Interface Circuits

Type of course: Professional Core Course

Prerequisite: Analog & Digital Circuits, Basic Power Electronics Devices: Circuits and Applications, Power Electronics Circuits – I, Principles of Power Supply, Power Electronics Circuits – II.

Rationale: This subject focuses on the study of advanced materials used for power semiconductor devices and their applications. Additionally, the study of various integrated circuits (ICs) for interfacing in power electronics circuits, magnetic circuits, logic level circuits and use of various test and measurement instruments will enhance the knowledge of students.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks				Total Marks
L	T	P		Theory Marks		Practical Marks		
			ESE (E)	PA (M)	ESE (V)	PA (I)		
2	1	0	3	70	30	0	0	100

Content:

Sr. No.	Content	Total Hrs
1	Advanced Power Semiconductor Devices: <ul style="list-style-type: none">Review of power semiconductor devicesOverview and Concept of Wide Band Gap (WBG) Power Semiconductor Devices – Silicon Carbide (SiC) and Gallium Nitride (GaN) Devices – Driver RequirementsComparison of WBG (SiC, GaN) and Si devices – Their Merits and Demerits – Applications	4
2	Driver IC Study (Datasheet and Application Note) and Design: <ul style="list-style-type: none">Study and Design of Non-Isolated Driver Circuits based on Single Switch Unprotected Driver IC (e.g. UCC27531) – Half Bridge Driver IC (e.g. IR2110) – Half Bridge Driver IC with SC Protection (e.g. IR2114) – Single Switch Driver IC with SC Protection (e.g. MC33153) – Grounding Considerations for Driver CircuitsRequirement & Importance of Isolation – Design of Isolated Driver Circuits based on TRIAC Driver IC (e.g. MOC302x, MOC304x) – SCR Driver IC (e.g. MOC3002) – Single Switch Driver IC (e.g. TLP250) – Single Switch Driver IC (e.g. HCPL316J) with SC Protection – Relay driver-ULN 2803, DRV120 – Floating Ground Considerations for Isolated Driver Circuits	8
3	Measurement Systems & Interfacing with Digital Systems: <ul style="list-style-type: none">Galvanic Isolation – Interfacing of Signals Using Galvanic Isolation – Linear Opto-coupler (e.g. IL300), Isolation AmplifierMeasuring and Interfacing Analog Signals – ADC – Removing Common Mode Signals – Hall Effect Current Sensors, Current Transformer – DC Current Measurement (DC-Shunt, Allegro ACS7xx or other IC) – Voltage Measurement	8

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	(LEM LV 25-P, Using Discrete Components like Op-Amp, R, C, Isolator Circuits, etc.) – Principle of Frequency & Speed Measurement – F to V Converter (FVC Using LM331 or any other IC) <ul style="list-style-type: none"> Study and applications of Logic Analyzer, Oscilloscope, Power Scope, Differential Voltage Probe, Current Probe, Grounding Considerations for Power Circuits 	
4	High Frequency Magnetics Design: <ul style="list-style-type: none"> Types of Cores – Concept of Transformer Design – Transformer Design for Forward, Flyback, Bridge and Push-Pull Converters – Transformer Design for Driver Circuits Inductor Design for Power Converters 	6
5	Thermal Interface: <ul style="list-style-type: none"> Thermal Resistance & its Consideration – Heat Sink Calculations and Design. Cooling methods, Forced (Concept of Cooling Fan, Water and Oil for Cooling of Heat Sink) and Natural Cooling of Heat Sinks 	4

Suggested Specification table with Marks (Theory): (For BE only)

Distribution of Theory Marks					
R Level	U Level	A Level	N Level	E Level	C Level
10	20	20	15	15	20

Legends: R: Remembrance; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create and above Levels (Revised Bloom's Taxonomy)

- Remembering:** Retrieving, recognizing, and recalling relevant knowledge from long-term memory.
- Understanding:** Constructing meaning from oral, written, and graphic messages through interpreting, exemplifying, classifying, summarizing, inferring, comparing, and explaining.
- Applying:** Carrying out or using a procedure for executing or implementing.
- Analyzing:** Breaking material into constituent parts, determining how the parts relate to one another and to an overall structure or purpose through differentiating, organizing, and attributing.
- Evaluating:** Making judgments based on criteria and standards through checking and critiquing.
- Creating:** Putting elements together to form a coherent or functional whole; reorganizing elements into a new pattern or structure through generating, planning, or producing.

Reference Books/Material:

- Thermal Design by HoSung Lee, Wiley
- Power Electronics: Essentials & Applications by L. Umanand, Wiley
- Datasheets and Application Notes for various ICs as mentioned in the syllabus from Learning Websites as given below.
- IEEE, IEC, ECPE and other conference/journal papers.
- Design of Magnetic Components for Switched Mode Power Converters by L. Umanand and S. R. Bhat, New Age International
- Transformer and Inductor Design Handbook by Mcllyman
- Designing Magnetic Components for High Frequency DC-DC Converters by Mcllyman, Kg Magnetics Inc.
- Transformer and Inductor Design Handbook, 3ed by Mcllyman, Marcel Dekker, Inc.

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9. Power Electronics A First Course by Ned Mohan, Wiley

Additional Reference Books:

1. Operational Amplifiers: Applications and Design by Jerald G. Graeme & Gene E. Tobey, McGraw Hill.
2. Op-Amps Design: Application & Troubleshooting, 2ed by David L. Terrell, Butterworth Heinemann (Elsevier).
3. Power Electronics Design: A Practitioner's Guide by Keith H Sueker, Newnes (Elsevier).
4. Switchmode Power Supply Handbook, 3ed by Keith Billings & Taylor Morey.
5. Power Switching Converters, 2ed by Simon Ang and Alejandro Oliva, Yesdee.
6. The Art of Electronics by Paul Horowitz, Cambridge University Press.
7. Power Supply Cookbook by Marty Brown, Newnes.
8. The J & P Transformer Book, 12ed by Martin J. Heathcote, Newnes.
9. Power Electronics: Converters, Applications and Design by Mohan, Undeland and Robbins, Wiley India.
10. The Essence of Power Electronics by Ross, Prentice Hall
11. Practical Electronics for Inventors by Paul Scherz, McGraw Hill
12. Advanced DC to DC Converters by Fang Lin Luo & Hong Ye, CRC Press
13. The Power Electronics Handbook by T L Skvarenina, CRC Press

Course Outcomes:

At the end of the course, student should be able to:

Sr. No.	CO statement After studying this course, the student should be able to	Topics Mapped	Marks % weightage
CO-1	Discuss the necessity of advanced semiconducting materials for Power Electronics Devices.	1	20%
CO-2	Design and develop Analog/Digital interface with isolated/non isolated driver for Power Electronics Devices.	2, 3	30%
CO-3	Analyse the performance of measuring instruments and various measurement systems (Voltage, Current, Frequency, etc.) and be able to select and use proper ICs for various measuring applications, as required.	3	20%
CO-4	Design appropriate high frequency transformer and inductor and choose appropriate cooling method and heat sink for Power Electronics devices and converters.	4, 5	30%

Major Equipment:

Oscilloscope, Isolated Channel Power Scope, Power Converter Trainer Kits, Multi-meters, Variable Power Supply, Programmable Digital Power Supply, necessary components, etc.

List of Learning Websites:

- DC Shunt: <https://openenergymonitor.org/emon/buildingblocks/dc-shunt>
- <http://www.datasheetcatalog.com>
- <http://www.epe-association.org/epe/index.php>
- <http://www.ecpe.org/>
- www.electronicdesign.com

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- <http://nptel.iitm.ac.in/courses.php>
- <http://ocw.mit.edu>
- <http://www.ti.com>
- <http://www.st.com>
- <http://www.ni.com>
- <http://www.irf.com>
- <http://www.allaboutcircuits.com>
- <http://www.vishay.com>
- <http://www.lem.com>
- <http://www.motorola.com>
- <http://www.onsemi.com>
- <http://www.nxp.com>
- <http://www.toshiba.com>
- <http://www.linear.com>
- <http://www.infineon.com>
- <http://www.yokogawa.com>
- <https://www.agilent.com>
- <http://www.tek.com/>