GUJARAT TECHNOLOGICAL UNIVERSITY

POWER ELECTRONICS (24)
PRINCIPLES OF POWER ELECTRONICS
SUBJECT CODE: 2132404
B.E. 3rd Semester

Type of Course: Core Subject (Power Electronics).

Prerequisite: N.A.

Rationale: N.A.

Teaching and Examination Scheme:

Teaching Scheme			Credits	Examination Marks						Total Marks
L	T	P	C	Theory Marks			Practical Marks			
				ESE (E)	PA (M)		PA (V)		PA (I)	
					PA	ALA	ESE	OEP		
3	0	2	6	70	20	10	20	10	20	150

L- Lectures; T- Tutorial/Teacher Guided Student Activity; P- Practical; C- Credit; ESE End Semester Examination; PA- Progressive Assessment.

Content:

Sr. No.	Topics	Teaching Hrs.	Module Weightage
1.	**Power Electronics – An Introduction:** • Electrical Energy: Characteristics And Storage – Need For Energy Conversion and Power Processing • Power Electronics: Need and Role – History – Power Electronics System – Its Building Blocks and Components – Various Applications – Linear Electronics versus Power Electronics – Interdisciplinary Nature of Power Electronics Power Electronics Switch – Ideal and Practical Switch Characteristics – Losses in Practical Switch – Concept of Safe Operating Area (SOA) – Specifications – Semiconductor Materials Used – Classification and Comparison of Power Switches	4	15
2.	**Diodes:** • The Semiconductor Diode – VI Characteristics – Specifications & Ratings – Classification • Construction, Characteristics and Applications of Various Diodes like General Purpose Diode, Zener Diode, Tunnel Diode, Varactor Diode, LED, Photo Diode, Power Diode, Fast Recovery Diode, Schottky Diode, etc. Switching Characteristics of Diode – Series and Parallel Operation	6	15
3	**Transistors:** • BJT – Construction – Types: NPN & PNP – Principle – Working	6	15

	– Current Components in NPN & PNP Transistor – Drive Requirement – Transistor as an Amplifier – CB, CE and CC Configurations & Their Comparison – Current Gain – Input and Output Characteristics – Cut-Off, Active and Saturation Regions – Transistor as a Switch • Transistor Low Frequency Response – Small Signal Model – Two Port Devices and The Hybrid Model – Transistor h-Model – The h-Parameters DC and AC Load Line – Q-Point – Drive Requirement – Driving Circuits – Protection – Applications		
4	**Power BJT:** • Difference Between Signal and Power BJT – Construction: Vertical Power Transistor Structure – Physics of Operation – VI Characteristics – Switching Characteristics – Breakdown in Transistors (Primary and Secondary) Losses – SOA – Ratings – Specifications – Driving Circuits – Soft and Hard Switching of Transistor – Protection Circuits – Applications Like Power Darlington, Power Supplies, Power Switch, etc.	08	15
5	**Thyristors:** • Introduction – VI Characteristics – Construction – The Two Transistor Model – Turn ON Methods – Switching Characteristics – Gate Characteristics – SOA – Ratings – Protection – Series and Parallel Operation • Gate Drive Circuits • Types – Construction, Characteristics and Applications of Various Types of Thyristors Like SCR, DIAC, TRIAC, LASCR, RCT, MCT, SITH, GTO, PUT, UJT, IGCT, etc. Thyristor Commutation – Requirement of Commutation – Types: Class A, Class B, Class C, Class D, Class E & Class F	10	20
6	**FET & MOSFET:** • Field Effect Transistor – Principle – The Field Effect – Construction and Operation – VI Characteristics – Gate Control – Applications – Ratings – Specifications • MOSFET – Construction – Principle And Working – Ratings And Specifications • Power MOSFET – Construction – Difference – Equivalent Circuit – VI Characteristics – Physics of Operation – Gate Control – Field Effect – Switching Characteristics – Limitations – SOA – Ratings and Specifications – Protection – Applications – Paralleling Of MOSFETs • Gate Drive Circuits	08	20

Reference Books:

1. Power Electronics: Converters, Applications and Design by Mohan, Undeland and Robbins, Wiley India.
2. Power Electronics: Circuits, Devices and Applications, Third edition by M. H. Rashid, PHI
3. Power Electronics by Dr. P. S. Bhimbra, Khanna publishers
4. Power Electronics by M. S. Jamil Asghar, PHI
5. Principles of Electronics by V. K. Mehta, S. Chand
6. Integrated Electronics by Millman, Halkias & Parikh, McGraw Hill India
7. Power Electronics by Philips T. Krein, Oxford
8. Electronics Principles, Seventh Edition by Albert Malvino & David Bates, McGraw Hill India
9. Datasheets and application notes of various semiconductor manufacturers

Course Outcomes:

After learning the course the students should be able to:

1. Understand the difference between linear electronics and power electronics.
2. Understand the importance and requirement of power electronics in electrical engineering.
3. Understand different power electronics switches like diode, transistor, BJT, FET, MOSFET, SCR, etc. and differentiate between low power switches and high power switches.
4. Understand the characteristics of above stated switches, their applications and their gate drive circuits.

List of Practicals and Open Ended Problems:

Directions for Laboratory work:

- The list of experiments is given as a sample.
- Minimum 10 experiments should be carried out.
- At least one experiment should be selected from each group.
- Similar laboratory work fulfilling the objectives can also be considered.
- As far as possible printed manual should be preferred so that students can concentrate in laboratory experiments and related study.

Objectives: The laboratory work is aimed at putting the theory learnt in class in practice and to show the results are nearly matched with theory. In this context, following are the core objectives of this subject.

- ✓ Develop understanding of basic electronics devices
- ✓ Differentiate the linear and nonlinear region of operation of various semiconductor devices
- ✓ Making use of semiconductor device as switch (particularly power switch)
- ✓ Develop understanding of drive requirements of a semiconductor power switch

Group A (Diode and BJT):

1. To study ideal switch characteristics
2. To study and obtain characteristics of Diode and Power Diode
3. To study and obtain CE/CB/CC characteristics of BJT
4. To study and obtain switching characteristics of BJT
5. To study characteristics of Photodiode/LED/Zener diode

Group B (FET Devices):

6. To study and obtain characteristics FET/MOSFET
7. To study and obtain switching characteristics of FET/MOSFET
8. To study parallel operation of FET/MOSFETs

Group C (Thyristor Family):

9. To study and obtain characteristics of SCR
10. To study and obtain characteristics of TRIAC
11. To study Thyristor commutation techniques: Class A, B, C, D, E & F

Group D (Driving Circuits for Power Switches):

12. To study base drive circuits for power BJT
13. To study base drive circuits for power MOSFET
14. To study gate drive circuits for SCR and TRIAC

List of Open Source Software/learning website:

Open Source Software:

- TINA-TI for circuit simulation (http://www.ti.com/tool/tina-ti)
- OSCAD for CAD application (http://www.oscad.in/downloads)
- Fritzing for bread board/GP board wiring planning (http://fritzing.org/download)

Web-base tools for design:

- http://www.fairchildsemi.com/support/design-tools/power-supply-webdesigner/
- http://www.ti.com/lsds/ti/analog/webench/overview.page
- https://www.circuitlab.com/editor/

Open source for Math Tools:

- http://maxima.sourceforge.net/
- http://www.sagemath.org/
- http://www.scilab.org/
- http://www.gnu.org/software/octave/

Learning website:

- http://www.datasheetcatalog.com/
- http://nptel.iitm.ac.in/courses.php
- http://ocw.mit.edu/
- http://www.electrical-engineering-portal.com

Major Equipments:

- Oscilloscope, Power Scope, Differential Voltage Probe, Current Probe, Power Devices Trainer Kits, Multimeters, Variable Power Supply, etc.

Active learning Assignments (AL) : Preparation of power-point slides, which include videos, animations, pictures, graphics for better understanding theory and practical work – The faculty will allocate chapters/ part of chapters to groups of students so that the entire syllabus of Fluid Mechanics is covered. The power-point slides should be put up on the web-site of the college/Institute, along with the name of the group, the name of faculty, Department and College on the first slide. The best three works should be sent on achievements@gtu.edu.in