



GUJARAT TECHNOLOGICAL UNIVERSITY

Program Name: Engineering

Level: Diploma

Branch: Power Electronics

Course / Subject Code: DI03024041

Course / Subject Name: Elements of Power Electronics

w. e. f. Academic Year:	2024-25
Semester:	3 rd
Category of the Course:	PCC

Rationale:	Power electronics concerns with applications of electronic into situation that are rated at higher power level rather than small signal level power. Many semiconductor devices such as SCR, DIAC, TRIAC, MOSFET and power transistors are available for such higher power applications. These contents of the course will create a general understanding of these power electronic semiconductor devices. Further, the course is intended to generate the requisite skills required in the industry for selecting and maintaining of various power electronic devices and related circuits.
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Course Outcome:

After Completion of the Course, Student will able to:

No	Course Outcomes	RBT Level
01	Identify various power electronic switches.	R, U
02	Select Thyristor switches for various operations.	R, U, A
03	Select Transistor switches for various operations.	R, U, A
04	Design various triggering circuits for semiconductor switches.	R, U, A
05	Protect semiconductor switches by various protection circuits.	R, U, A

*Revised Bloom's Taxonomy (RBT)

Teaching and Examination Scheme:

Teaching Scheme (in Hours)			Total Credits L+T+ (PR/2)	Assessment Pattern and Marks				Total Marks
L	T	PR	C	Theory		Tutorial / Practical		
				ESE (E)	PA(M)	PA(I)	ESE (V)	
3	0	2	4	70	30	20	30	150



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Course Content:

Unit No.	Content	No. of Hours	% of Weightage
1.	<p><u>Fundamentals of Power semiconductor Devices</u></p> <p>1.1 Introduction to power electronics, History of Power Electronics Development.</p> <p>1.2 Applications of power electronics: Power electronics in Information technology, robotics and flexible production, role of power electronics in providing sustainable electric energy-Energy conversation, Electric-Motor Driven Systems, Lighting, Transportation, Renewable Energy and Utility Applications of Power Electronics</p> <p>1.3 Semiconductor devices: Diode, Thyristor family (DIAC, SCR, LASCR, ASCR, RCT, GTO, SITH, MCT, TRIAC, SCS, SUS, SBS), Transistor family (BJT, MOSFET, IGBT, SIT, PUT, UJT)-symbol, maximum ratings.</p> <p>1.4 Recent and potential advancements in power electronics devices.</p> <p>1.5 Power electronic converters: AC-DC, DC-DC, DC-AC, AC-AC converters with their applications.</p>	7	15%
2.	<p><u>Thyristor Family</u></p> <p>2.1 SCR: Construction, Principle of operation, characteristics (V-I, & gate), advantages, disadvantages applications.</p> <p>2.2 GTO: Structure, turn on and turn off process, I-V characteristics, advantages, disadvantages applications.</p> <p>2.3 DIAC: Schematic diagram, characteristics and applications.</p> <p>2.4 TRIAC: Structure, SCR Equivalent circuit, characteristics (V-I), mode of turn on process, advantages, disadvantages applications.</p> <p>2.5 MCT: features, Basic structure, characteristic, advantages-disadvantages. Advantages, disadvantages applications.</p> <p>2.6 Compare various Thyristors.</p>	11	25%



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3.	<p><u>Power Transistor Family</u></p> <p>3.1 Power BJT: function as a switch – cut off mode and saturation mode.</p> <p>3.2 Power MOSFET: Types (enhancement mode- P-channel, N-channel), basic structure, characteristics (I-V and transfer) as an ideal and real switch, advantages, disadvantages applications.</p> <p>3.3 IGBT: Basic structure, characteristics (I-V and transfer) as an ideal and real switch, advantages, disadvantages applications.</p> <p>3.4 Compare various transistors.</p>	9	20%
4.	<p><u>Control circuits for Power semiconductor devices.</u></p> <p>4.1 Pulse transformer connections for two SCRs</p> <p>4.2 Commonly used optoisolators; working, advantages and applications.</p> <p>4.3 UJT: structure, equivalent circuit, normal UJT biasing, applications.</p> <p>4.4 Turn on methods: Gate triggering: Resistive, RC, Pulse triggering using UJT (ramp triggering)</p> <p>4.5 Gate-drive circuit of a GTO for turn-on and turn-off using BJT.</p> <p>4.6 TRIAC gate circuit using DIAC.</p> <p>4.7 Triggering circuit for BJT/MOSFET/TRIAC using optoisolators (optocoupler). Triggering circuit for BJT/MOSFET/TRIAC using TCA 785 IC.</p>	11	25%
5.	<p><u>Power semiconductor switches protection and ratings.</u></p> <p>5.1 SCR Protection: Power circuit: di/dt, dv/dt, over current, over voltage, snubber circuit. Gate circuit: Gate circuit protection using Zener diode.</p> <p>5.2 MOSFET Protection: overvoltage, over current, Gate protection.</p> <p>5.3 Thyristor ratings: Voltage ratings: Peak working forward-blocking voltage (VDWM), Peak repetitive forward blocking voltage (VDRM), Peak working reverse voltage (VRWM), Peak repetitive reverse</p>	7	15%



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	voltage (VRRM), Voltage safety factor, finger voltage, on state voltage drop. Current ratings: Average On-State current, RMS On-State current, holding and latching current. 5.4 MOSFET ratings: Breakdown voltage, maximum on state voltage, Maximum Gate voltage, maximum continuous current, switching time and average power dissipation, on state resistance.		
	Total	45	100

Suggested Specification Table with Marks (Theory):

Distribution of Theory Marks (in %)					
R Level	U Level	A Level	N Level	E Level	C Level
20	60	20	--	--	--

Where R: Remember; U: Understanding; A: Application, N: Analyze and E: Evaluate C: Create (as per Revised Bloom's Taxonomy)

References/Suggested Learning Resources:

(a) Books:

S. No.	Title of Book	Author	Publication with place, year and ISBN
1	Power Electronics	Singh M. D.; Khanchandani K.B.	McGraw Hill,2020 ISBN: 978-0070583894
2	Power Electronics Semiconductor Switches	Ramshaw R.S.	Springer, 2010 ISBN 978-0412288708
3	Power electronics	Bimbhra P.S.	Khanna Publishers,2021 ISBN: 9788174092793
4	Power electronics	Muhammad Rashid	Pearson Education, 2017 ISBN: 978-8120345317
5	Power Electronics: Devices, Circuits and Industrial Applications	Moorthi. V.R.	Oxford University Press, ISBN: 978-0195670929

(b) Open-source software and website:

1. <https://www.vlab.co.in>
2. <https://nptel.ac.in>
3. <https://swayam.gov.in/>



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4. <https://shodhganga.inflibnet.ac.in/>

Suggested Course Practical List:

S. No.	Practical list
1.	Study maximum ratings of various power semiconductor switches.
2.	Design SCR testing kit
3.	Understand VI characteristics of SCR
4.	Understand VI characteristics of TRIAC
5.	Understand VI characteristics of GTO
6.	Understand VI characteristics of MCT
7.	Understand VI characteristics of MOSFET
8.	Understand VI characteristics of IGBT
9.	Test the performance of BJT as a switch.
10.	Design gate triggering circuits (R and RC) for SCR.
11.	Test the performance of ramp comparator triggering circuit using Uni-Junction Transistor (UJT).
12.	Test the performance of Gate-drive circuit by using BJT of a GTO to turn-on and turn-off.
13.	Evaluate the performance of single-phase AC voltage control circuit using TRIAC/DIAC combination. Record the waveforms of input supply voltage, output voltage, TRIAC voltage, DIAC voltage and capacitor voltage under different firing angles.
14.	Evaluate the performance of Triggering circuit for BJT/MOSFET/TRIAC using optoisolators (optocoupler).
15.	Evaluate the performance of a TCA-785 based triggering circuit used to trigger SCR/TRIAC/MOSFET.
16.	Test the performance of snubber circuit for dv/dt protection of an SCR.
17.	Test the performance of Gate triggering protection circuit by Zener diode of an SCR.
18.	Test the performance of overvoltage protection circuit for MOSFET.

List of Laboratory/Learning Resources Required:

S. No.	Equipment Name with Broad Specifications
1	SCR Characteristics Kit: Working voltage :(220-240) VAC, Anode Voltage :0-30VDC, Gate Voltage :0-30VDC, Output Voltage :0-30VDC, Output Current :1 Amps, 4. Digital Voltmeter DC 3½ Digit having Dual range of 20V/200V, Digital Current meter DC 3½ Digit having range of 0-1A



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S. No.	Equipment Name with Broad Specifications
2	TRIAC Characteristics Kit: Kit Working voltage: Anode Voltage :0-30VDC, Gate Voltage :0-30VDC, Output Voltage :0-30VDC, Output Current :1 Amps, VI characteristic of TRIAC Study Module, Patch cards, 6A power supply card, 3A Fuse.
3	Semiconductor and thyristor characteristics trainer: Power Supplies: DC Power Supply 5V/15V at 150mA Switch Selectable, DC Power Supply 15V/30V at 150mA Switch Selectable, Operated on Mains power 230V, 50Hz Analog Meters: Dual Range Voltmeter-5V/15V, Dual Range Voltmeter-25V/50V, Dual Range Ammeter 250uA/25mA, Dual Range Ammeter 5mA/50mA, Meter ranges are selectable with toggle switches. Components are mounted on the panels are: PN Junction Diode Germanium OA81, Zener Diode 6.2V, Led, Diac DB3, IGBT IRGBC20S, TRANSISTOR CL100, TRANSISTOR SK100, SCR TYN604, TRIAC BT136, UJT 2N2646, Voltage Control through Potentiometer.
4	SCR triggering circuit: On board AC source: 0 V - 18 V On board firing circuits: R Triggering Circuit RC Half Wave Triggering Circuit RC Full Wave Triggering Circuit Interconnections: 2 mm sockets Firing angle variation: Gradually variation using firing control Power Supply (Mains): 110V - 260V AC, 50/60Hz.
5	UJT triggering circuit: On board AC source: 18 V - 0 V - 18 V On board DC Supply: +5 V, +12 V On board triggering circuits: 555 IC triggering circuit UJT triggering circuit Interconnection: 2 mm socket SCR: SCRs TYN616, 600V/16 A
6	Power Electronics Lab: DC Power Supply : +5 V, -5 V 500 mA, +12V, -12 V 500 mA +15 V, 250 mA +35V, -35V, 250 mA AC Power Supply : 18V-0V-18V 0V-15V On board Firing Circuits Frequency range : 30Hz to 900Hz variable Amplitude : 12V PWM control of G1, G2, G3 and G4 Duty cycle control of "Gate" Signal is 0 to 100% SCR Assembly : 4 SCRs 2P4M, 400V/2A Power Devices : IGBT-G4BC20S, MOSFET, UJT, DIAC, TRIAC, PUT Pulse transformer on board
7	Single Phase Converter Firing Techniques using TCA 785: On board AC source: 0 V - 15 V, 18 V - 0 V - 18V On board firing circuits: TCA785 firing scheme Triangular comparator firing scheme Interconnections: 2mm sockets SCR assembly: 4 SCRs 2P4 M, 400V/2A Mains Supply: 230V, 50 Hz
8	Lamp Dimmer: DIAC TRIAC firing circuit, UJT firing circuit SCR & TRIAC: 1 SCRs TYN 616, 600V/16A and, TRIAC BT136, Load: Lamp 100W, Mains Supply (mains): 230V, 50 Hz



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Suggested Project List:

1. Make a gate/base driver circuit for thyristor/transistor
2. Prepare a report of maximum rating of semiconductor switches available in practice.

Suggested Activities for Students:

1. Interpret various ratings given in thyristor datasheets.
2. Interpret various ratings of different transistors from datasheets.
3. Make a chart of Classification of power semiconductor switches with their maximum ratings.
4. Undertake a market survey for thyristor switches.
5. Undertake a market survey for transistor switches.

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