Power Devices & Circuits

(Code : 304194)

Semester VI – Electronics & Telecommunication Engineering

(Savitribai Phule Pune University)

Strictly as per the New Choice Based Credit System Syllabus (2019 Course)
Savitribai Phule Pune University w.e.f. academic year 2021-2022

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J. S. Katre

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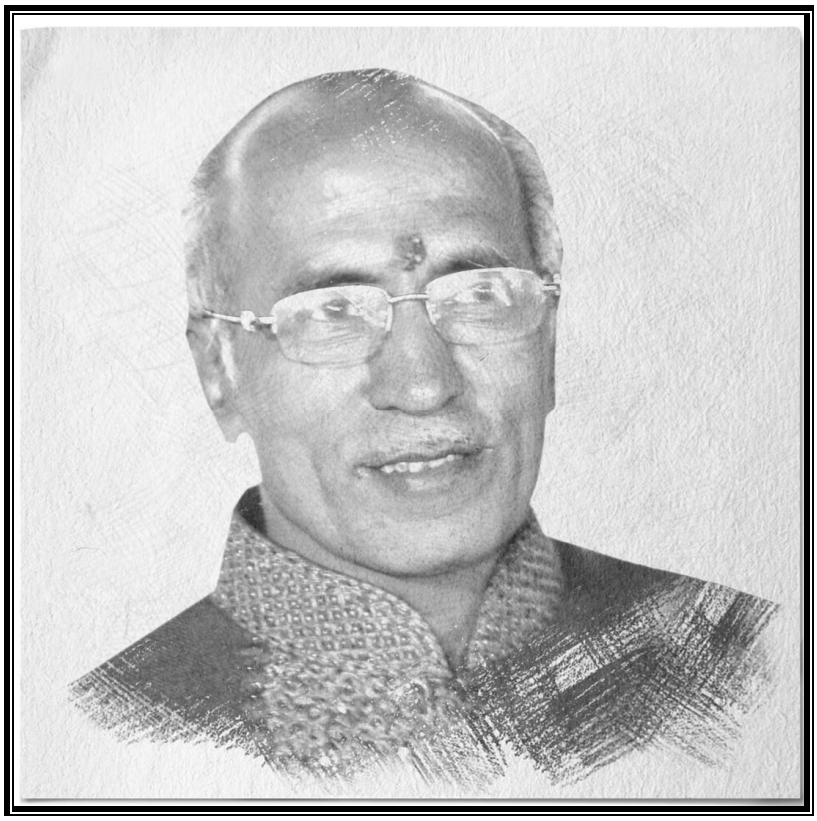
We dedicate this Publication soulfully and wholeheartedly,

in loving memory of our beloved founder director,

Late Shri. Pradeepji Lalchandji Lunawat,

who will always be an inspiration, a positive force and strong support behind us.



"My work is my prayer to God"

- Lt. Shri. Pradeepji L. Lunawat

Soulful Tribute and Gratitude for all Your Sacrifices, Hardwork and 40 years of Strong Vision…

(Book Code : PE146A)

Syllabus…

Power Devices & Circuits : Sem. VI, E & TC Engineering (SPPU)

Teaching Scheme	Credits	Examination Scheme
Theory : 03 Hrs/Week	**03**	**In-Sem (Theory) : 30 Marks**
		End-Sem (Theory) : 70 Marks

Prerequisite Courses, if any : --

1. Basic Electrical Engineering
2. Basic Electronics Engineering
3. Electronic Circuits
4. Electrical Circuits

Companion Course, if any : Power Devices & Circuits Lab

Course Objectives :

1. To introduce different power devices viz. SCR, GTO, MOSFET and IGBT with construction, characteristics, repetitive and non repetitive ratings and typical triggering / driver circuits.
2. To understand working, design and performance analysis and applications of various power converter circuits such as ac to dc converters, inverter and chopper.
3. To know various protection circuit requirements of power electronic devices.

Course Outcomes : On completion of the course, learner will be able

CO1 : To differentiate based on the characteristic parameters among SCR, GTO, MOSFET & IGBT and identify suitability of the power device for certain applications and understand the significance of device ratings.

CO2 : To design triggering / driver circuits for various power devices.

CO3 : To evaluate and analyze various performance parameters of the different converters and its topologies.

CO4 : To understand significance and design of various protections circuits for power devices.

CO5 : To evaluate the performance of uninterruptible power supplies, switch mode power supplies and battery.

CO6 : To understand case studies of power electronics in applications like electric vehicles, solar systems etc.

Course Contents

Unit I

Study of Power Devices :

Construction, VI characteristics (input, output and transfer if any), Switching characteristics of SCR, GTO, Power MOSFET and IGBT, Performance overview of Silicon, Silicon Carbide and GaN based MOSFET and IGBT, Various repetitive and Non-repetitive ratings of SCR, GTO, Power MOSFET and IGBT and their significance, Requirement of a typical triggering / driver (such as opto isolator) circuits for various power devices, Importance of series and Parallel operations of various power devices (No derivation and numerical). **(Refer Chapters 1 and 2)**

Mapping of Course Outcomes for Unit I :

CO1 : To differentiate based on the characteristic parameters among SCR, GTO, MOSFET & IGBT and identify suitability of the power device for certain applications and understand the significance of device ratings.

CO2 : To design triggering / driver circuits for various power devices.

Unit II

AC to DC Power Converters :

Concept of line and Forced commutation, Single phase Semi and Full converters using SCR for R and R-L loads and its performance analysis and Numerical, Effect of source inductance, Significance of power factor and Its improvement using PWM based techniques. Three phase full converters using SCR for R load and its performance analysis, Single phase PWM rectifier using IGBT, Three phase controlled rectifier using IGBT, Difference between SCR based conventional rectifiers and IGBT based rectifiers.

(Refer Chapters 3 and 4)

Mapping of Course Outcomes for Unit II :

CO3 : To evaluate and analyze various performance parameters of the different converters and its topologies.

Unit III

DC to AC Converters :

Single phase half and Full bridge square wave inverter for R and R-L load using MOSFET / IGBT and its performance analysis and numerical, Cross conduction in inverter, Need of voltage control and Strategies in inverters, Classifications of voltage control techniques, Control of voltage using various PWM techniques and their advantages, Concept and Need of harmonic elimination / reduction in inverters, Three phase voltage source inverter for balanced star R load with 120 and 180 degree mode of operation, Device utilization factor, Advanced converters like matrix inverter, Multi-level inverters and their topologies and its driver circuits (No derivation and numerical). **(Refer Chapters 5 and 6)**

Mapping of Course Outcomes for Unit III :

CO3 : To evaluate and analyze various performance parameters of the different converters and its topologies.

Unit IV

DC to DC Converters :

Classification of choppers, Step down chopper for R and RL load and its performance analysis, Step up chopper, Various control strategies for choppers, Types of choppers (isolated and non isolated) such as type A, B, C, D and E, switch mode power supply (SMPS) viz Buck, Boost and Buck-boost, Fly back, Half and Full bridge isolated and Non-isolated interleaved bidirectional topologies and Concept of integrated converter and Design of LM3524 based choppers, Concept of maximum power point tracking (MPPT).

(Refer Chapter 7)

Mapping of Course Outcomes for Unit IV :

CO3 : To evaluate and analyze various performance parameters of the different converters and its topologies.

Unit V

Power Devices Protection and Circuits :

Over voltage, Over current, di/dt and dv/dt protection circuits and Their design, Various cooling techniques and Heat sink design. Resonant converters such as Zero Current Switching (ZCS) and Zero Voltage Switching (ZVS). Electromagnetic interference such as radiated and Conducted EMI, Difference between EMI and EMC, EMI sources and Soft switching and Minimizing / Shielding techniques for EMI, Various EMI and EMC standards, Importance of isolation transformer. **(Refer Chapter 8 and 9)**

Mapping of Course Outcomes for Unit V :

CO4 : To understand significance and design of various protections circuits for power devices.

Unit VI

Power Electronics Applications :

AC voltage controller using IGBT and SCR, FAN regulator, Electronic ballast, LED lamp driver, DC motor drive for single phase separately excited dc motor, BLDC motor drive, Variable voltage and variable frequency three phase induction motor drive, ON-line and OFF-line UPS. Study of various selection criteria and Performance parameters of batteries in battery operated power systems, Battery charging models and modes for EVs, Architecture of EVs battery charger, PFC stage circuit topologies with details of Full-bridge boost rectifier and Full-bridge interleaved for EV battery charger, Case study of power electronics in electric vehicle and Photovoltaic solar system. **(Refer Chapters 10 and 11)**

Mapping of Course Outcomes for Unit VI :

CO5 : To evaluate the performance of uninterruptible power supplies, switch mode power supplies and battery.

CO6 : To understand case studies of power electronics in applications like electric vehicles, solar systems etc.

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Unit I

Chapter 1 : Thyristors **1-1 to 1-46**

Syllabus : Construction, VI characteristics (input, output and transfer if any), Switching characteristics of SCR, GTO, Various repetitive and non-repetitive ratings of rating of SCR, GTO and their significance, Requirement of typical triggering / driver (such as opto isolator) circuits for various power devices, Importance of series and parallel operation of various power devices.

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Unit I

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Unit II

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Unit II

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Unit III

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Syllabus : Single phase half and full bridge square wave inverter for R and R-L load using MOSFET / IGBT and its performance analysis and numerical, Cross conduction in inverter, Need of voltage control and Strategies in inverters, Classifications of voltage control techniques, Control of voltage using various PWM techniques and their advantages.

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UNIT IV

Chapter 7 : DC - DC Converters 7-1 to 7-56

Syllabus : Classification of choppers, Step down chopper for R and RL load and its performance analysis, Step up chopper, Various control strategies for choppers, Types of choppers (isolated and non isolated) such as type A, B, C, D and E, switch mode power supply (SMPS) viz Buck, Boost and Buck-boost, Fly back, Half and Full bridge isolated and Non-isolated interleaved bidirectional topologies and Concept of integrated converter and design of LM3524 based choppers, Concept of maximum power point tracking (MPPT).

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Unit V

Chapter 8 : Power Devices Protection & Circuits **8-1 to 8-26**

Syllabus : Over voltage, Over current, di/dt and dv/dt protection circuits and their design, Various cooling techniques and Heat sink design. Electromagnetic interference such as radiated and Conducted EMI, Difference between EMI and EMC, EMI sources and Soft switching and Minimizing / Shielding techniques for EMI, Various EMI and EMC standards, Importance of isolation transformer.

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Unit V

Chapter 9 : Resonant Converters **9-1 to 9-18**

Syllabus : Resonant converters such as Zero Current Switching (ZCS) and Zero Voltage Switching (ZVS).

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Unit VI

Chapter 10 : Power Electronics Applications **10-1 to 10-48**

Syllabus : AC voltage controller using IGBT and SCR, FAN regulator, Electronic ballast, LED lamp driver, DC motor drive for single phase separately excited dc motor, BLDC motor drive, Variable voltage and variable frequency three phase induction motor drive, ON-line and OFF-line UPS.

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Unit VI

Chapter 11 : Electric Vehicle Batteries 11-1 to 11-12

Syllabus : Study of various selection criteria and Performance parameters of batteries in battery operated power systems, Battery charging models and Modes for EVs, Architecture of EVs battery charger, PFC stage circuit topologies with details of Full-bridge boost rectifier and Full-bridge interleaved for EV battery charger, Case study of power electronics in electric vehicle and Photovoltaic solar system.

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