DISCIPLINE SPECIFIC CORE COURSE –20: Power Electronics

CREDIT DISTRIBUTION, ELIGIBILITY AND PRE-REQUISITES OF THE COURSE

Course title & Code	Credits	Credit distribution of the course			Eligibility criteria	Pre-requisite of the course (if any)
		Lecture	Tutorial	Practical/ Practice		
Power Electronics	**4**	**3**	**-**	**1**	**Class XII passed with Physics + Mathematics/Applied Mathematics + Chemistry OR Physics + Mathematics/Applied Mathematics + Computer Science/Informatics Practices**	**-**

Learning Objectives

The Learning Objectives of this course are as follows:
This course introduces the student to the fundamental understanding of power control in domestic and industrial applications through semiconductor devices. It also familiarise students with role and advantage of power semiconductor devices in automating the control of heavy machinery or power control circuits. This course forms the basis for bridging the knowledge of circuits, devices, embedded systems, machines and controls systems together, useful for the present era of e-control in every domain.

Learning outcomes

The Learning Outcomes of this course are as follows:

- To get familiarise with and to understand the salient features and applicability of various types semiconductor devices through comparative study for power control
- To understand the construction, working and control of thyristors for power applications
- To learn various methods of conversion between DC and AC power

- To learn concepts involved in efficient electronic power control in DC and AC applications
- To practically apply the learning, for power control in real-life domestic applications

SYLLABUS OF ELDSC-20 **Total Hours- Theory: 45 Hours, Practicals: 30 Hours**

UNIT – I (12 Hours)

Power Semiconductor Devices:

Definition and Applications of Power Electronics, Need and History of Power Semiconductor Devices, Introduction of various Power Semiconductor Devices (Power diodes, different types of Transistors and Thyristors), Vertical structure, Enhancement of voltage blocking and current carrying capability.

Power Transistors: Comparative study (structural, operational, functional, specifications) of Power BJT, Power MOSFET and IGBT as power switch: Vertical structure, Enhancement of voltage and current rating, IV characteristics, Safe Operating Area, switching characteristics/performance, equivalent structure

Second breakdown, saturation and quasi-saturation state in BJT, inversion in IGBT, Latch-up in IGBT

Thyristors: Comparative Study of SCR, DIAC, TRIAC and GTO as power switch: Structure, IV characteristics, utility

Comparative of specifications of Power BJT, Power MOSFET, IGBT, SCR and GTO

UNIT – II (10 Hours)

Semiconductor Controlled Rectifier (SCR):

Dynamic Turn-on and Turn-off characteristics, Turn-on methods, Gate triggering circuits (R, RC and UJT triggering), Gate characteristics, Forced Commutation circuits, Voltage commutation, Current commutation, Load commutation, Two Transistor model, Internal regeneration, Factors affecting the characteristics/ratings of SCR, Protection of SCR, gate protection, di/dt and dv/dt protection using snubber circuit, series and parallel combination of SCRs

UNIT – III (13 Hours)

DC Power Control:

Single phase AC-DC converters: Phase-controlled rectifiers, half wave controlled rectifier with resistive and inductive load, full wave controlled rectifier using centre-tapped transformer and bridge configuration for resistive and inductive load, use of free-wheeling diode

DC-DC converters: Basic chopper circuit and classification, control strategies, step-up/down chopper (using both SCR and MOSFET), Class A-E choppers, Jones Chopper (load sensitive voltage commutation), Morgan's chopper

Applications of Phase-controlled rectifiers and choppers like DC motor speed control (in both directions), Light intensity of LED array, Variable DC power supply

UNIT – IV (11 Hours)

AC-AC converters: variable-voltage single phase AC power control, SCR and DIAC triggered TRIAC for half wave, full wave AC power control with inductive & non-inductive loads variable-frequency AC-AC Converters, introduction to single phase cycloconverters with resistive and inductive loads

DC-AC converters: Classification of inverters, Improved series inverter, limitations of series inverter, Parallel inverter with reactive feedback, single phase bridge inverter, introduction to McMurray Inverter, voltage control using PWM

Thyristor based control of domestic appliances like fan/others and Speed control of induction motors (block diagrams only)
Idea of Applicable IS/IEC Standards for Invertors and UPS.

Practical component (if any) – Power Electronics Lab
(Hardware and Software Simulation using Multisim/MATLAB/Other Electronics Simulation Software)

Learning outcomes

The Learning Outcomes of this course are as follows:

- Functioning and control of different types of transistors and thyristors
- Working of DC Power control circuits
- Working of AC Power control circuits
- To design and develop a small power control system

LIST OF PRACTICALS (Total Practical Hours- 30 Hours)

1. Study of IV characteristics of SCR/TRIAC, MOSFET/IGBT (Familiarity with use of commercially available Data-Sheet)
2. SCR based phase controlled rectifier with (a) R and RC triggering (b) R and RL loads (c) with and without free-wheeling diode
3. SCR/MOSFET based chopper (DC-DC converter)
4. AC-AC voltage controller using SCR/TRIAC (a) R and RC triggering (b) R and RL loads (c) with and without free-wheeling diode
5. Study of series, parallel and bridge inverter
6. Study of single phase cycloconverter
7. Micro-projects based on power electronics (at least one)
    a. DC motor control using SCR/IGBT based rectifier (AC-DC converter)
    b. Battery eliminator with 0-12V, 1A rating

c. AC motor (Fan) speed control using DIAC triggered TRIAC
d. AC voltage controller using TRIAC with UJT triggering
e. SCR based temperature controller using thermistor
f. Light intensity controller in an LED array
g. Any other similar circuit

Note: Students shall sincerely work towards completing all the above listed practicals for this course. In any circumstance, the completed number of practicals shall not be less than five and one micro-project.

Essential/recommended readings

1. Power Electronics, P.C. Sen, TMH
2. Power Electronics Circuits, Devices and Applications, M.H. Rashid, Pearson Education
3. Power Electronics, P.S. Bimbhra, Khanna Publishers
4. Power Electronics, M.D. Singh & K.B. Khanchandani, TMH

Suggestive readings

1. Power Electronics: Devices, Circuits and Industrial Applications, V.R. Moorthi, Oxford University Press
2. Power Electronics, K. Hari Babu, Scitech Publishing
3. An Introduction to Thyristors and their applications, M. Ramamoorty, Palgrave Macmillan/East West Press

Note: Examination scheme and mode shall be as prescribed by the Examination Branch, University of Delhi, from time to time.