ETPE3008 INDUSTRIAL POWER ELECTRONICS (3-0-0)

Course Learning Objectives: This course will enable students to:

- Understand the characteristics and operation of power semiconductor devices.
- Analyze single-phase and three-phase rectifiers and their performance.
- Explain DC–DC converters, inverter topologies, and PWM techniques.
- Understand AC–AC converters and their industrial applications.
- Apply power electronics principles in industrial drives with proper protection and reliability.

Module I (6 Hours)

Power Semiconductor Devices and Uncontrolled Rectifiers:
Introduction to high-voltage engineering and insulation systems in power electronic converters; characteristics, working, and applications of power diodes, power transistors, MOSFETs, and IGBTs; uncontrolled single-phase rectifiers – half-wave, full-wave, and bridge types; three-phase Half-wave and bridge rectifiers; performance parameters and waveform analysis for R and RL loads. Thyristors – static and dynamic I–V characteristics, triggering and turn-on methods, gate characteristics, two-transistor model, ratings, and protection. Design of snubber circuits, series and Parallel operation of thyristors, and commutation techniques – natural and forced commutation.

Module II (6 Hours)

Phase Controlled Rectifiers:
Principle of phase control; single-phase controlled rectifiers – half-wave, full-wave, bridge, semi-converter, and full converter operation under continuous and discontinuous conduction modes.
Analysis for R, RL, and RLE loads with and without free-wheeling diodes.
Three-phase controlled rectifiers – half-wave, full-wave, and bridge configurations; semi-converter and full converter operation; performance parameters, waveform analysis, and dual converter operation. Effect of source impedance on converter performance and voltage regulation.

Module III (6 Hours)

DC–DC Converters (Choppers):
Principle of step-down and step-up operation; control strategies and duty cycle generation.
Topologies of DC–DC converters – Buck, Boost, and Buck–Boost converters; performance parameters and waveform analysis. Types of chopper circuits – first-quadrant, second-quadrant, two-quadrant, and four-quadrant choppers. Thyristor-based chopper circuits – control characteristics and industrial applications.

Module IV (6 Hours)

DC to AC Converters:
Principle of inverter operation; single-phase and three-phase voltage source inverters (VSI) – 180° and 120° conduction modes; output voltage and harmonic analysis; introduction to current source inverters (CSI). Voltage control of single-phase inverters – single-pulse and sinusoidal pulse width modulation (PWM). Voltage control of three-phase inverters using sinusoidal PWM.
Industrial applications of inverters – uninterruptible power supplies (UPS), variable frequency drives (VFDs), and renewable power systems.

Module V (6 Hours)

AC to AC converters and Drives:
AC voltage controllers – principle of phase control and integral cycle control; single-phase full-wave controllers with R and RL loads; performance parameters and waveform analysis.
Cycloconverters – single-phase cycloconverters, operation, performance characteristics, and waveform analysis. Applications of power electronics in industrial systems – DC and AC drives, induction heating, welding, illumination,

and process control. Protection and reliability considerations in industrial converter systems – overcurrent, overvoltage, and EMI/EMC protection.

Course Outcomes (CO): On completion of this course, students are able to:

CO1. Explain the construction, working, and characteristics of power semiconductor devices and their role in industrial converter systems.
CO2. Analyze the performance and operation of uncontrolled and controlled rectifiers for single-phase and three-phase industrial applications.
CO3. Design and evaluate DC–DC converters (buck, boost, and buck–boost) and their control strategies for regulated industrial power supplies.
CO4. Examine the operation and control of inverters and PWM techniques for industrial power control and drive applications.
CO5. Apply power electronic converters such as AC voltage controllers and cycloconverters in industrial systems including drives, heating, and illumination applications.

Text Book(s):

1. M. H. Rashid, Power Electronics: Circuits, Devices and Applications, Pearson Education, 5th Edition, 2023.
2. P. S. Bimbhra, Power Electronics, Khanna Publishers, 2019.

Reference Book(s):

1. Ned Mohan, T. M. Undeland, and W. P. Robbins, Power Electronics: Converters, Applications and Design, Wiley, 4th Edition, 2022.
2. B. W. Williams, Power Electronics: Devices, Drivers, Applications and Passive Components, McGraw Hill, 2020.
3. Bimal K. Bose, Modern Power Electronics and AC Drives, Pearson, 2021.