Department of Electrical Engineering

Delhi Technological University
Shahbad Daulatpur, Main Bawana Road
Delhi-110042, India

M.Tech. (Power Electronics and Systems)

COURSE OUTCOMES (COs)

After completing this course students should be able to:

Sl. No.	Course	Course Code	Course Outcomes
1	**Modelling of Electrical Systems**	**PES501.1**	(i) To be able to develop and analyze mathematical models of electrical systems, students will gain proficiency in representing and simulating power generation, transmission, and distribution networks using advanced techniques.
		PES501.2	(ii) To be able to use industry-standard simulation software, they will perform detailed analyses and optimizations for improved system performance.
		PES501.3	(iii) To be able to design and validate models for modern electrical systems, students will ensure accuracy through experimental validation and real-world data comparisons.
		PES501.4	(iv) To be able to apply modeling techniques to solve complex engineering problems, they will identify, formulate, and address challenges in stability, control, and optimization of electrical systems.
2	**Power Electronics Converters**	**PES503.1**	(i) To be able to design and analyze AC-DC converters, students will master single-phase and three-phase rectifiers, including semi and fully controlled converters, with a focus on power factor improvement and the impact of source inductance.
		PES503.2	(ii) To be able to implement and control DC to AC inverters, they will learn principles of operation, performance parameters, and voltage control methods for single and three-phase inverters, including SPWM and space vector modulation.
		PES503.3	(iii) To be able to utilize AC to AC converters, students will explore voltage controllers, thyristor-based compensators, and cycloconverters for phase control and reactive power management.
		PES503.4	(iv) To be able to analyze DC-DC converters, they will study step-up, step-down, and advanced chopper circuits, including PWM techniques and multi-level inverters.
3	**Switch Mode Power Converters**	**PES5405.1**	(i) To be able to classify and understand power supplies, students will learn the types and characteristics of voltage regulators and the topologies of PWM DC-DC converters, with a focus on electromagnetic compatibility.
		PES5405.2	(ii) To be able to design and analyze non-isolated DC-DC converters, they will study various converter topologies, including Buck, Boost, and Buck-Boost in CCM and DCM, as well as Cuk and Sepic converters, with practical applications.

		PES5405.3	(iii) To be able to design and analyze isolated power supplies, students will explore Flyback and Forward converters, bidirectional converters, and advanced configurations like active clamping and two-switch converters.
		PES5405.4	(iv) To be able to model and control PWM converters, they will delve into small-signal modeling, average modeling in CCM and DCM, and the design of feedback controllers for impedance calculations.
4	**Renewable Energy Systems**	**PES5405.1**	(i)To be able to assess and compare different energy systems and resources, students will understand current energy requirements, environmental implications of conventional energy, and advantages and disadvantages of renewable sources like solar, wind, hydro, biomass, geothermal, and ocean energy.
		PES5405.2	(ii) To be able to design and optimize solar energy systems, they will learn about solar radiation measurement, thermal collectors, photovoltaic cell basics, array design, and power control for both off-grid and grid-connected systems.
		PES5405.3	(iii) To be able to analyze and implement wind energy systems, students will study wind turbine classifications, wind regime analysis, aerodynamics, energy estimation, and wind energy conversion system components.
		PES5405.4	(iv) To be able to develop and manage biomass, ocean, and hydro energy systems, they will explore biomass production and conversion, ocean thermal and wave energy principles, and the components and operational aspects of small and large hydropower plants, including site selection and system advantages.
5	**Advanced Power Semiconductor Devices and Magnetics**	**PES502.1**	(i)To be able to analyze and design power diode circuits, students will understand the basic structure, I-V characteristics, switching behavior, breakdown voltages, and snubber design for power diodes and Schottky diodes.
		PES502.2	(ii) To be able to evaluate and implement thyristor-based systems, they will master the characteristics and limitations of thyristors, triacs, and gate turn-off thyristors (GTOs), including gate drive requirements and snubber design.
		PES502.3	(iii)To be able to design and optimize circuits using power BJTs, MOSFETs, and IGBTs, students will learn about their structures, switching characteristics, transient analyses, and protection mechanisms.
		PES502.4	(iv) To be able to incorporate thermal design and magnetic components, they will study heat transfer methods, heat sink selection, magnetic material properties, inductor design, and related standards.
6	**Controller Design for Power Electronic Converter**	**PES504.1**	(i) To be able to understand the architecture and small-signal modeling of DC-DC converters, students will learn AC equivalent circuit modeling, perturbation, linearization techniques, and state-space averaging methods.
		PES504.2	(ii)To be able to develop and analyze converter transfer functions, they will master circuit averaging, average circuit modeling, and the development of canonical circuit models, including modeling of pulse width modulators.

		PES504.3	(iii)To be able to design compensators for voltage and current controllers in both non-isolated and isolated DC-DC converters, students will study stability analysis and PID control methods, considering converter types such as Buck, Boost, Buck-Boost, Cuk, Sepic, Flyback, Forward, and Full Bridge.
		PES504.4	(iv)To be able to implement advanced control techniques, students will explore non-linear control methods like adaptive control, tracking control, and sliding mode control for non-isolated converters.
7	**Grid Connected Power Converter and Systems**	**PES5408.1**	(i)To be able to understand and implement grid-connected converters, students will explore various inverter structures derived from H-bridge topology, ensuring grid integration of renewable energy sources like wind turbines and photovoltaic systems.
		PES5408.2	(ii)To be able to meet grid connectivity requirements and ensure synchronization, they will study international regulations, standards, and techniques for islanding detection and grid synchronization.
		PES5408.3	(iii)To be able to design and control grid converters effectively, students will learn power configurations, topologies, and control methods for active power, frequency, and reactive power regulation.
		PES5408.4	(iv) To be able to manage grid faults, they will study control strategies for unbalanced grid voltage conditions, ensuring grid stability and reliability.
8	**Energy Storage System**	**PES5308.1**	(i) To be able to comprehend battery technologies, students will explore energy storage parameters, constructional features, charge-discharge cycles, and applications of lead-acid, nickel-cadmium, zinc manganese dioxide, zinc-air, nickel hydride, and lithium batteries, considering aspects of performance measurement, storage density, energy density, and safety.
		PES5308.2	(ii) To be able to understand ultracapacitors and supercapacitors, they will study their types, components, advantages, and applications in various sectors, comparing them with battery systems in terms of energy density, power density, price, and market dynamics.
		PES5308.3	(iii) To be able to analyze fuel cell technologies, students will learn about their types, efficiencies, power outputs, advantages, and disadvantages, focusing on hydrogen oxygen cells, hydrocarbon cells, alkaline fuel cells, and phosphoric fuel cells.
		PES5308.4	(iv) To be able to evaluate other energy storage methods, including pumped hydroelectric storage, compressed air energy storage, and flywheels, students will explore their capabilities, applications, design strategies, and advancements in superconducting magnetic energy storage systems.
9	**Pulse Width Modulation for Power Converters**	**PES5312.1**	(i) To be able to comprehend the principles of power electronic converters, including basic topologies, switch constraints, bidirectional functionality, and output voltage control.
		PES5312.2	(ii) To understand various modulation techniques for single-phase and three-phase inverters, such as PWM, sine-triangle modulation, and space vector modulation, and their applications in controlling voltage sources efficiently.

		PES5312.3	(iii) To analyze and evaluate various modulation schemes for single- phase and three-phase inverters, including PWM, sine-triangle modulation, and direct modulation, and to compare their performance based on duty cycle variation and frequency ratios.
		PES5312.4	(iv) To comprehend advanced modulation strategies such as space vector modulation, overmodulation, and zero space vector placement, and their impact on harmonic losses and efficiency.
10	**Standards for Microgrid Application and Control**	**PES5202.1**	(i)To be able to comprehend the overview of smart grids and related organizations worldwide, students will explore the influence of renewable energy generation on smart grids and significant standards for power grid communication and energy management systems.
		PES5202.2	(ii) To be able to understand the standards for electric storage, distributed energy sources, and e-mobility, students will study communication requirements, protocols, and IP standards for microgrids, ensuring network interoperability and cybersecurity for the future of smart grids.
		PES5202.3	(iii) To be able to analyze fuel cell technologies, students will learn about their types, efficiencies, power outputs, advantages, and disadvantages, focusing on hydrogen oxygen cells, hydrocarbon cells, alkaline fuel cells, and phosphoric fuel cells.
		PES5202.4	(iv) To be able to evaluate other energy storage methods, including pumped hydroelectric storage, compressed air energy storage, and flywheels, students will explore their capabilities, applications, design strategies, and advancements in superconducting magnetic energy storage systems.
11	**Energy Management System**	**PES5204.1**	(i) To be able to understand intermittencies in renewable energy systems, microgrid fundamentals, and electric vehicle requirements, students will explore energy systems technologies and integration of energy storage systems in microgrids.
		PES5204.2	(ii) To be able to model energy storage systems, students will learn about battery, fuel cell, ultracapacitor, and flywheel models, including parameter identification and transient matching.
		PES5204.3	(iii) To be able to estimate battery state of charge (SoC), state of energy (SoE), and state of health (SoH) using experimental, model-based, and joint estimation methods.
		PES5204.4	(iv) To be able to implement battery balancing techniques and battery management systems in electric vehicles, students will study passive and active balancing methods and typical structures of battery management systems.
12	**Electric Vehicles and E-Mobility**	**PES5210.1**	(i)To be able to comprehend the evolution and socio-ecological impact of electric vehicles (EVs) compared to fuel-driven vehicles, students will explore EV components and basic architectures.
		PES5210.2	(ii)To be able to analyze vehicle dynamics, students will study forces affecting vehicle movement and formulate dynamic equations, considering torque-speed and power-speed characteristics, and perform performance analysis including acceleration, braking, power, energy, and braking distance calculations.
		PES5210.3	(iii) To be able to select motor drives and HEV architectures, students will learn about regenerative braking fundamentals and control strategies for

			maximum energy recovery.
		PES5210.4	(iv) To be able to design power electronics converters and storage systems for EV applications, students will explore non-isolated and isolated converters and various charging standards and architectures including onboard, off-board, and wireless power transfer.
13	**Smart Grid and Distribution Automation**	**PES6401.1**	(i) To be able to understand the structure and fundamental challenges of electrical power systems, students will delve into classical and instantaneous power theories, distributed generation, and energy storage benefits, including grid damping and fully integrated power systems.
		PES6401.2	(ii)To be able to analyze distributed energy resources, they will explore variable and adjustable speed generation systems, wind energy conversion, photovoltaics, and fuel cells, focusing on grid integration dynamics and small-scale hydroelectric power generation.
		PES6401.3	(iii) To be able to address protection issues for microgrids, students will study islanding scenarios, parallel operation requirements, transformer protection, and voltage/frequency protection mechanisms, ensuring grid stability and reliability.
		PES6401.4	(iv) To be able to design power electronic interfaces, students will learn about power converter controls, PWM rectifiers, multi-level converters, and VSC systems, considering integration concerns and control strategies in islanded mode.
14	**Non Linear Control of Power Electronic Converters**	**PES6403.1**	(i) To be able to analyze nonlinear systems effectively, students will use perturbation theory, phase plane trajectories, describing functions, and Lyapunov & Pupov's methods.
		PES6403.2	(ii)To be able to design nonlinear control systems, they will explore tracking, deadbeat, passivity-based control, feedback linearization, and input-output linearization, addressing MIMO system design issues.
		PES6403.3	(iii)To be able to model power electronic converters, students will employ state space averaging and conduct small signal analysis.
		PES6403.4	(iv)To be able to implement nonlinear control for power converters, students will utilize adaptive, adaline, and tracking control techniques.
15	**Energy Efficiency, Auditing and Loss Reduction**	**PES6405.1**	(i) To be able to comprehend the principles of electrical systems and electric motors including electricity billing, load management, and maximum demand control.
		PES6405.2	(ii) To understand power factor improvement, capacitor selection, and performance assessment.
		PES6405.3	(iii) To analyze losses in induction motors, motor efficiency, and factors influencing motor performance.
		PES6405.4	(iv) To evaluate energy-saving opportunities through efficient motor usage, rewinding techniques, and replacement strategies.
16	**Thermal Design for Heat Sinks, Thermo-electrics and EMI/EMC**	**PES6407.1**	(i) To be able to grasp the fundamental concepts of thermodynamics, including energy, heat, work, and the laws governing heat engines, refrigerators, and heat pumps.
		PES6407.2	(ii) To understand the theory of heat transfer encompassing conduction, convection, and radiation.

		PES6407.3	(iii) To analyze heat sink designs, including longitudinal fin profiles, fin effectiveness, efficiency, and optimization techniques for various cooling methods.
		PES6407.4	(iv) To comprehend thermoelectric principles, figure of merit, generator and cooler designs, and applications in heat sink design and heat exchange.
17	**MAJOR PROJECT -I**	**PES651.1**	Literature review: To be able to review past research and find out research gaps
		PES651.2	To carry out independent research
		PES651.3	To write an independent technical report on a research work carried out