

Power Electronics Laboratory

The Power Electronics Lab is a state-of-the-art facility that provides hands-on experience with key devices, circuits, and systems essential for the conversion and control of electrical power. As a core component of modern technology, power electronics plays a pivotal role in optimizing energy efficiency, particularly in electric vehicles (EVs) and renewable energy systems. This lab is designed to equip students, engineers, and industry professionals with the practical skills and theoretical understanding necessary to drive innovation in the rapidly evolving field of electric mobility.

With a focus on the integration of power semiconductor devices and advanced control strategies, the lab enables participants to explore crucial concepts such as Pulse Width Modulation (PWM), DC-DC converters, and inverter systems. These technologies are fundamental for enhancing the performance, efficiency, and reliability of EV propulsion and charging systems. By engaging with real-world applications and cutting-edge tools, participants will gain the knowledge required to design and optimize sustainable, zero-emission mobility solutions.

Key Areas of Focus

1. DC Converter Analysis Setup

The DC-DC Converter Analysis Setup is a comprehensive tool designed for performance analysis and hands-on learning of a range of DC-DC converter topologies, such as buck, boost, buck/boost, isolated forward, isolated flyback, and interleaved boost converters. These converters are essential for controlling and converting power between the EV battery, motor, and charging systems.

Key features of the setup include:

- **Adjustable Components:** The setup includes variable resistors, inductors, and capacitors that allow users to modify circuit configurations and test different scenarios.
- **Customizable Configurations:** The power circuit boards are flexible, enabling users to create and test various converter topologies, offering a deep understanding of each type's performance characteristics.
- **Digital Signal Processor (DSP) Control:** The system is integrated with a Digital Signal Processor (DSP) for precise Pulse Width Modulation (PWM) control, ensuring accurate and efficient power conversion.
- **In-Depth Performance Analysis:** Students will study the behavior of converters under different load conditions, optimizing for efficiency, response time, and thermal management.

Through this setup, participants will develop a strong understanding of how power converters manage energy in electric propulsion systems, battery charging systems, and other key applications in electric vehicles and renewable energy systems.



2. Three-Phase DC-AC Inverter Setup

The Three-Phase DC-AC Inverter Setup offers a practical platform to explore the operation of three-phase inverters, a critical technology in EV propulsion systems and industrial power conversion applications. Three-phase inverters are key for converting DC power from the battery into AC power, which drives the electric motor.

Key features of the setup include:

- **Digital Signal Processor (DSP) Control for PWM:** The system utilizes a Digital Signal Processor (DSP) to implement Pulse Width Modulation (PWM), enabling precise control over the inverter's output.
- **Comprehensive Load Testing:** The setup includes a rheostat load, variable inductor load, and variac to test the inverter under a range of real-world conditions, simulating various operational scenarios.
- **Harmonic Analysis & Waveform Capture:** The analyzer supports harmonic analysis, waveform capture, and regenerative power testing, making it ideal for assessing the performance of modern EV motor systems. This helps engineers understand the efficiency of power conversion and identify areas for optimization.
- **Regenerative Power Testing:** The ability to test regenerative power scenarios ensures that users can explore how energy recovery systems work in an EV, an essential feature for enhancing battery life and driving range.

By engaging with this setup, participants will gain valuable insights into the operation of inverter-based powertrains, learn how to optimize motor and inverter performance, and develop skills that are directly applicable to electric vehicle and sustainable energy technologies.



3.Power Analyzer

The Power Analyzer is an essential tool in the Power Electronics Lab, used to measure and analyze key electrical parameters in electric vehicle (EV) systems. This device provides accurate, real-time data, helping engineers and students test and improve the efficiency, performance, and reliability of EV components, such as motors, inverters, and batteries.



Power Measurements:

- **Active Power (Real Power):** Measures the actual power used by the vehicle's motor and other systems.
- **Reactive Power:** Analyzes power needed for the motor's magnetic fields.
- **Apparent Power:** Total power, including both active and reactive power.

Voltage and Current Monitoring:

- Tracks the voltage and current in key parts of the system like the motor, battery, and inverter.

Power Quality Analysis:

- Measures Total Harmonic Distortion (THD) to ensure clean power and improve motor performance.
- Captures waveforms to identify any electrical issues.

Torque and Speed Measurements:

- Measures the torque (rotational force) and speed of the motor to assess its performance.

Efficiency Analysis:

- Assesses how efficiently energy is being converted and used in the EV system, including the effectiveness of regenerative braking.

The Power Electronics Lab is designed to provide both theoretical and practical knowledge in several crucial areas of electric mobility and renewable energy systems:

- **Power Conversion Efficiency:** Learn how to optimize the efficiency of power converters in EV applications, ensuring maximum energy utilization and minimizing losses.
- **Control Techniques for Power Electronics:** Gain expertise in advanced control strategies such as PWM to manage the power flow in EV systems, battery charging circuits, and renewable energy integration.
- **Power Management in Electric Vehicles:** Understand how DC-DC converters, AC-DC inverters, and other power electronics devices work together to control power flow and enhance vehicle performance, battery life, and energy efficiency.
- **Real-World Application of Power Electronics:** Develop hands-on skills that are directly transferable to careers in the EV industry, renewable energy, and smart grid technologies.
- **Troubleshooting and Optimization:** Learn how to identify and troubleshoot issues in power conversion systems, optimizing performance for both reliability and efficiency in real-world applications.

The Power Electronics Lab provides a unique, hands-on learning experience that is vital for anyone pursuing a career in the electric vehicle industry, renewable energy, or advanced power electronics. Key advantages include:

- **Comprehensive Hands-On Learning:** Gain practical experience with real-world power electronics setups, including DC-DC converters and AC-DC inverters, crucial for electric vehicle propulsion and charging systems.
- **Advanced Control and Analysis Tools:** Utilize DSP controllers, PWM techniques, and power analyzers to deepen your understanding of power conversion and management in electric mobility systems.
- **Collaborative Environment:** Work alongside peers, researchers, and industry professionals to solve complex power electronics challenges, fostering innovation and advancing the field of electric transportation.
- **Industry-Relevant Training:** The lab provides industry-grade equipment and training that prepares participants to meet the demands of the rapidly growing electric vehicle and renewable energy sectors.

By leveraging state-of-the-art equipment and providing in-depth theoretical and practical learning opportunities, the Power Electronics Lab is instrumental in shaping the next generation of engineers and researchers dedicated to the development of sustainable, zero-emission mobility solutions.