



Power Electronics Track Program Goal

Comprehensive Understanding & Circuit Design

Agnes

Core Curriculum Overview

Fundamentals of Power Electronics

Power Semiconductor Devices

These devices are the cornerstone of power electronics, enabling precise control and efficient conversion of electrical energy. The curriculum covers key types like Diodes, Thyristors, MOSFETs, and IGBTs.



High-Speed Switching

Efficiency

Controllability

AC-DC Converters (Rectifiers)

Focuses on converting AC to DC, a fundamental operation. Covers various rectifier topologies, essential for DC power supplies, battery charging, and grid interfacing.

Rectification

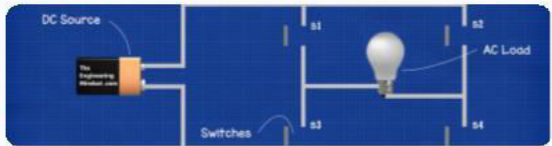
Power Supply

Grid Interface

Advanced Converter Topologies & Control

DC-DC & DC-AC Converters

Study of circuits that modify DC voltage levels (Buck, Boost) and convert DC to AC (Inverters), critical for portable electronics, EVs, and renewable energy systems.



PWM Techniques & Control

Covers Pulse Width Modulation (PWM), a cornerstone control method for managing output voltage, frequency, and harmonics using techniques like SPWM and Space Vector Modulation.

Modulation

Harmonic Reduction

Precision Control

Real-World Applications & Practical Experience

Motor Drives

Applying converters in Variable Frequency

Renewable Energy

Integrating solar and wind energy into the

Mini Project

A hands-on project to design and simulate a

Phase 1: Foundational & Core Concepts (Online)

Month 1: Foundational Theory & Devices

Introduction to the core principles of power electronics, definitions, and the role of semiconductor devices, laying the groundwork for power conversion.

Building Core Knowledge

This phase is dedicated to the controllable conversion and processing of electrical energy. We ensure a robust understanding of fundamental concepts before tackling advanced applications.

Semiconductor Devices: Delve into the characteristics of diodes, thyristors, MOSFETs, and IGBTs—the building blocks for controlling electrical flow and enabling efficient energy conversion.

Converter Circuits & Control: Explore various converter topologies and master Pulse Width Modulation (PWM) for regulating output, frequency, and minimizing

Month 2: Converter Topologies & Control

Deep dive into various power converter types (AC-DC, DC-DC, DC-AC) and the essential PWM control techniques for precise energy management.

Hands-on Simulation

Integrate theory with practical experience using industry-standard tools. Simulation is crucial for designing, analyzing, and validating circuits without physical prototyping.



Month 1: Devices & Rectifiers



Power Semiconductor Devices: The Building Blocks

These devices are the core components for the controllable conversion and processing of electrical energy, acting as high-speed switches.

Diodes: Simplest devices used for uncontrolled rectification, allowing one-way current flow.

Thyristors (SCRs): A 1956 breakthrough enabling phase-controlled conversion, foundational to classical power electronics.

MOSFETs & IGBTs: Advanced devices with superior switching. MOSFETs excel in high-frequency, while IGBTs are for high-power applications.



Switching Devices

Energy Control

High Power

High Frequency



AC-DC Converters: Transforming Power

Also known as rectifiers, these circuits convert alternating current (AC) to direct current (DC), a fundamental operation in power electronics.

Uncontrolled Rectifiers: Use diodes for simple, fixed DC output voltage based on the AC input.

Controlled Rectifiers: Employ thyristors (SCRs) to vary the DC output voltage by adjusting the device's firing angle.

Key Applications: Rectifiers are indispensable for DC power supplies, battery chargers, electrochemical processes, and large-scale High Voltage Direct Current (HVDC) power transmission systems.

Rectification

Voltage Conversion

Power Supplies

HVDC

Month 2: Converters & PWM Techniques

DC-DC Converters: Mastering Voltage Transformation

Core Function: Efficiently convert a DC voltage from one level to another, crucial for adapting power sources to device requirements.

Buck (Step-Down): Reduces input DC voltage for devices like microprocessors.

Boost (Step-Up): Increases input DC voltage for EVs and renewable energy systems.

Buck-Boost: Provides a variable output voltage, ideal for fluctuating input sources.

Efficiency: Utilizes rapid switching of semiconductors to store and release energy, often achieving over 90% power conversion efficiency.



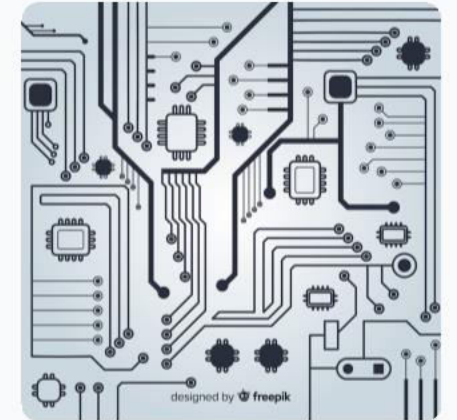
DC-AC Inverters: Generating Alternating Current

Core Function: Convert DC from sources like batteries or solar panels into AC for use with standard loads or the utility grid.

Single-Phase: Produces a single AC waveform for residential loads.

Multi-level: Synthesizes a near-sinusoidal waveform from multiple DC levels, reducing distortion for high-power applications.

Applications: Crucial for renewable energy grid integration (solar/wind), uninterruptible power supplies (UPS), and AC motor drives.



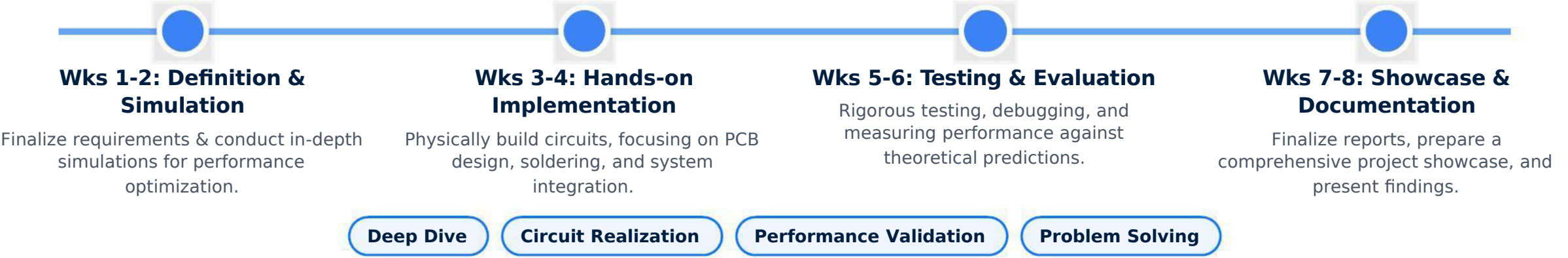
AC Generation

Grid Integration

Harmonic Reduction

Phase 2: Industry Immersion & Integrated Project (Offline)

Month 3: Capstone Mini Project



Offline Immersion & Team Collaboration

This phase marks the transition to a fully immersive offline experience, granting direct access to state-of-the-art power electronics laboratories and expert mentorship.

The Capstone Mini Project is a collaborative effort, mirroring real-world engineering environments and



Applying Theory to Real-World Design

The project is a direct application of all theoretical knowledge, challenging students to design and build a functional system that addresses a real-world need.

This phase emphasizes the complete engineering design cycle—from requirements to component selection, testing, and troubleshooting.



Capstone Mini Project: Design & Control



1. Project Kick-off: Buck Converter or Inverter Design

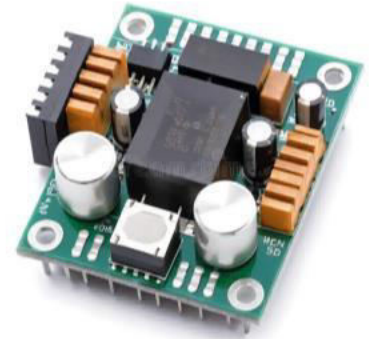
Initial Scope: Students select a core converter (Buck or Inverter) to define operational parameters like voltage, power, and efficiency.

Theoretical Foundations: Review relevant circuit topologies and principles from prior learning to establish a solid design base.

Design Selection

Requirements Definition

Topology Review



2. Detailed Component Selection & Simulation Setup



Component Sizing: Meticulous selection of power devices (MOSFETs, IGBTs), passive components, and gate drivers based on ratings and thermal characteristics.

Simulation Environment: The circuit is modeled in industry-standard software like MATLAB/Simulink or LTSpice to verify design functionality and predict performance.

Component Sizing

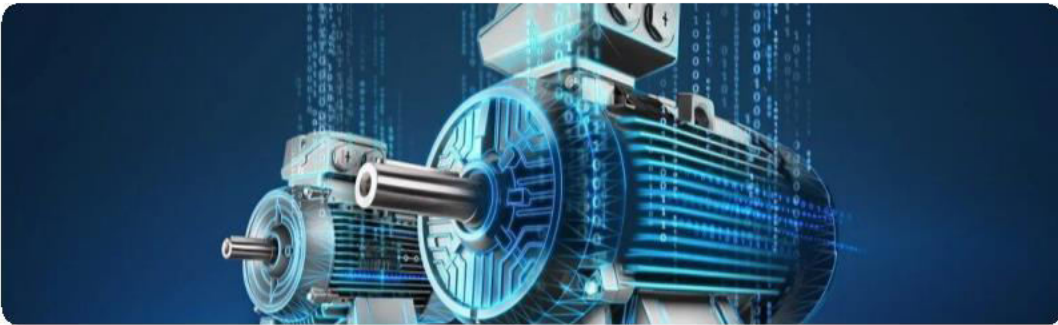
Circuit Modeling

Virtual Testing

Real-World Applications



Motor Drives: Enhanced Control & Efficiency



Power electronic converters are extensively utilized in **motor drives**, revolutionizing industrial and commercial motor control. **Variable Frequency Drives (VFDs)** precisely control AC motors by adjusting their supply frequency and voltage, leading to significant **energy savings** and enhanced performance in pumps, fans, and manufacturing machinery. **DC motor drives**, often employing **DC choppers**, allow for controlled variation of DC voltage. This enables precise speed and torque control for various industrial processes, improving overall system efficiency and responsiveness.

VFDs

DC Choppers

Energy Efficiency

Precise Control



Renewable Energy: Seamless Integration



Power electronics is fundamental to the efficient integration of **renewable energy sources** into the power grid or independent systems. **Solar Photovoltaic (PV) inverters** convert DC power from solar panels into grid-compatible AC, while **wind turbine converters** manage the variable output of wind generators. These converters ensure **efficient power conversion**, grid synchronization, and energy storage management, underpinning the transition to sustainable energy solutions and fuel cell power conversion.

Solar PV

Wind Integration

Grid Synchronization

Sustainable Energy

Project Showcase & Career Pathways

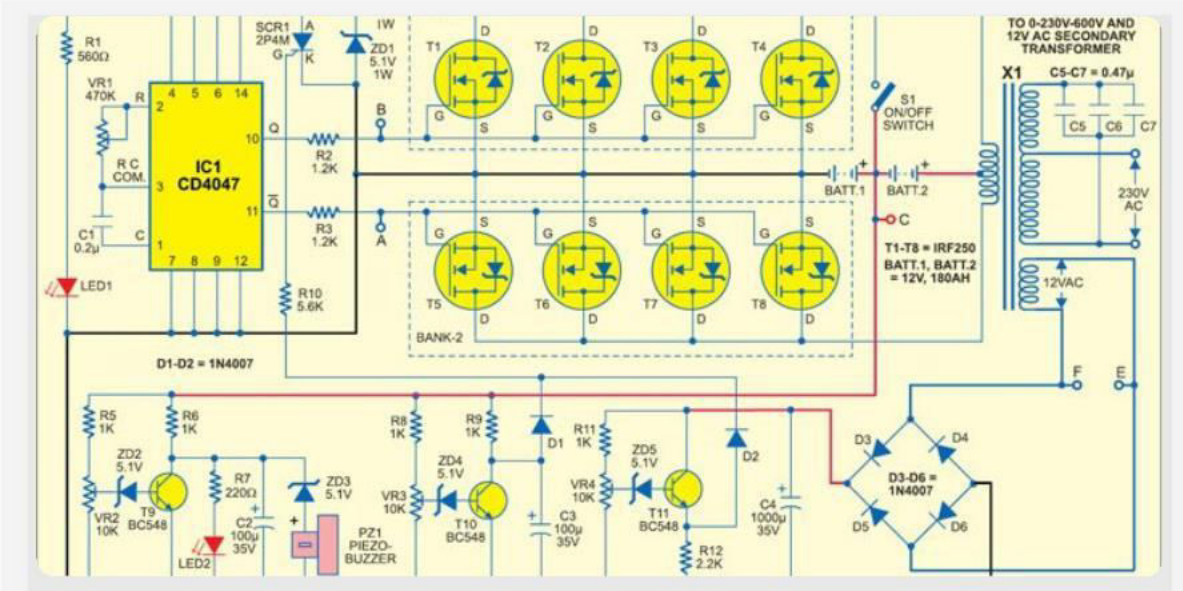


Final Project Presentation & Documentation: Showcasing Your Expertise

The Capstone Mini Project serves as the ultimate demonstration of your acquired power electronics knowledge and practical skills. This phase involves transforming your design and implementation into a compelling presentation and comprehensive documentation, showcasing your ability to tackle complex engineering challenges.

Key Components:

- **Professional Presentation:** Articulate your project's objectives, design methodology, simulation results, and performance analysis. Emphasize your problem-solving approach and the project's real-world relevance.
- **Comprehensive Documentation:** Develop a detailed technical report with schematics, component rationale, calculations, and results. This forms a vital part of your technical portfolio.



Thank You



Thank You for Your Time

For further inquiries, please contact:

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