



Introduction to Power Electronics R&D

Michael Starke, PhD / Jake Mueller, PhD

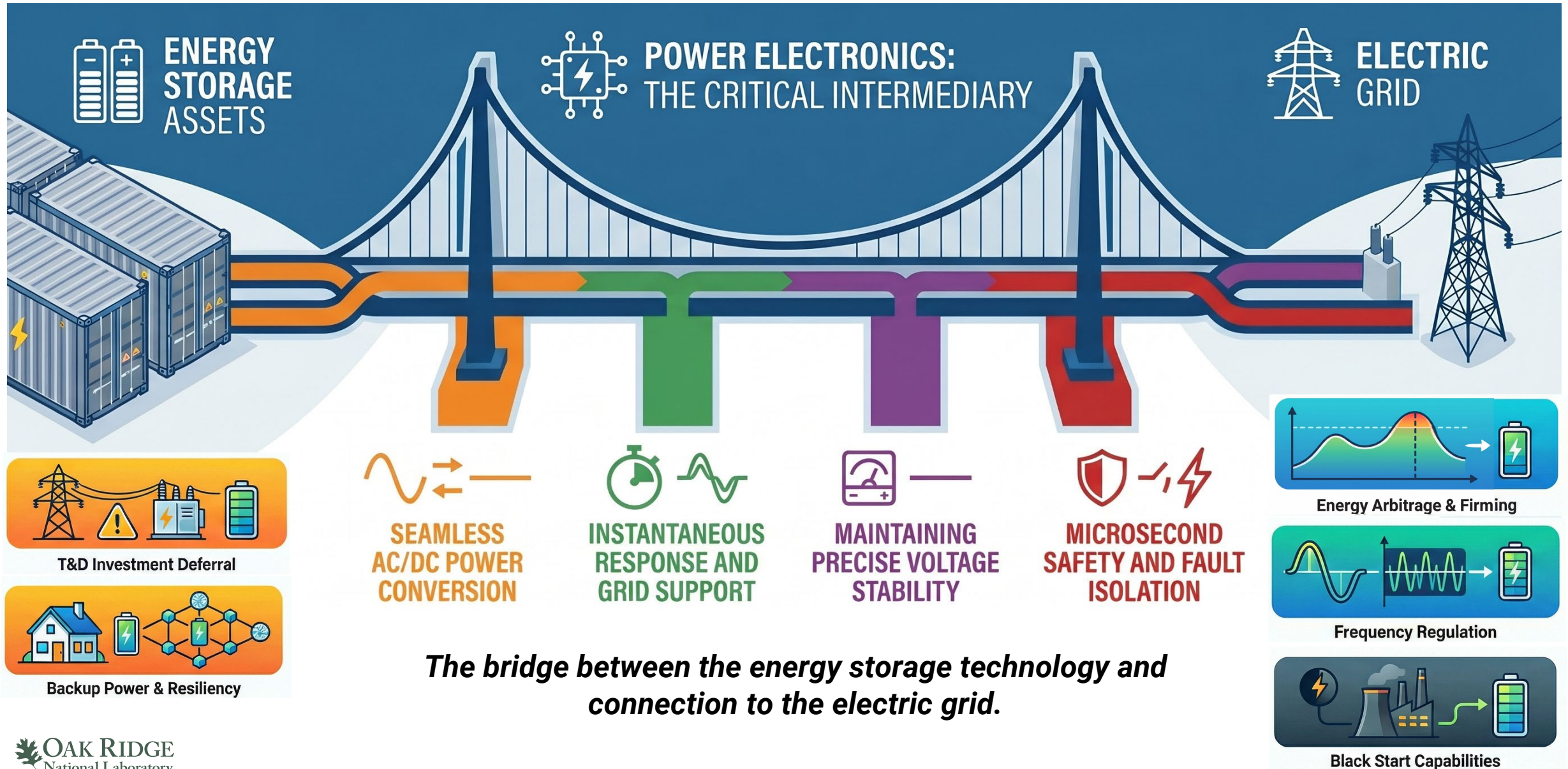
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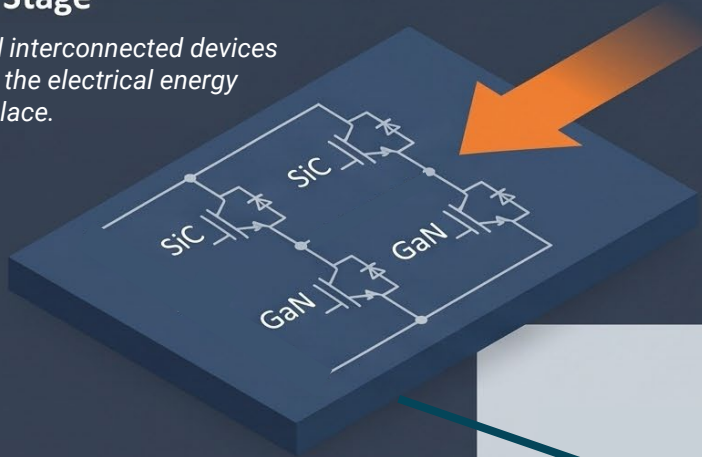
Importance of Power Electronics in Energy Storage Systems



Single Converter Power Electronic System Makeup

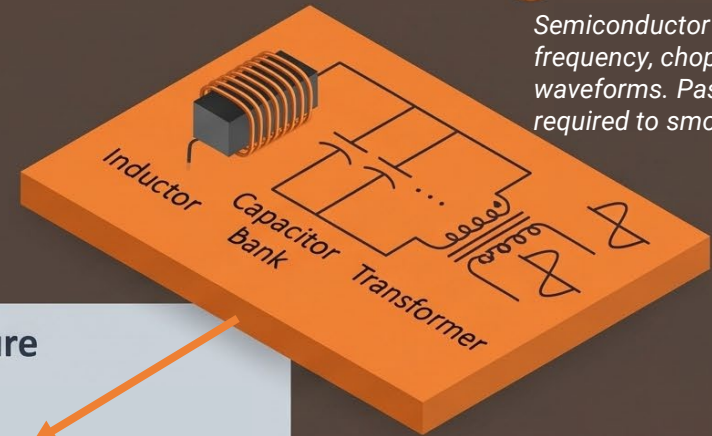
1 Power Stage

This is the physical interconnected devices or switches, where the electrical energy conversion takes place.

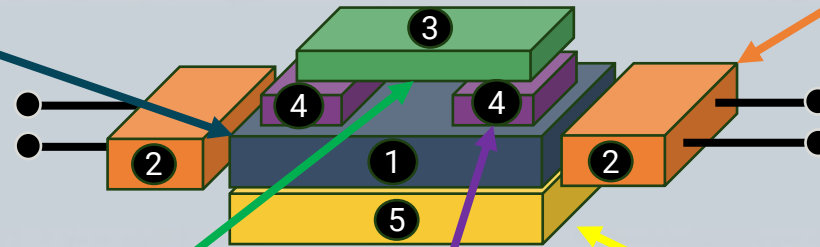


2 Passive Components

Semiconductor switches create high-frequency, chopped square waveforms. Passive components are required to smooth these waveforms.

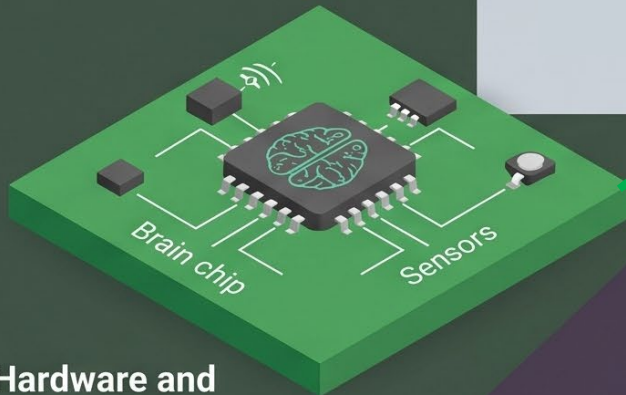


Integrated Converter Architecture



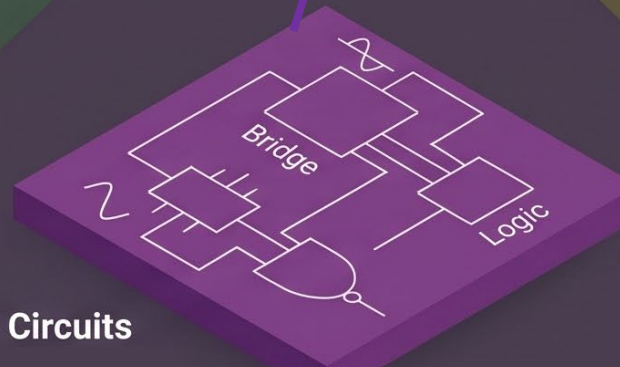
3 Control Hardware and Intelligence

This subsystem serves as the "brain" of the converter, constantly calculating how and when to pulse the semiconductor switches to achieve the desired output



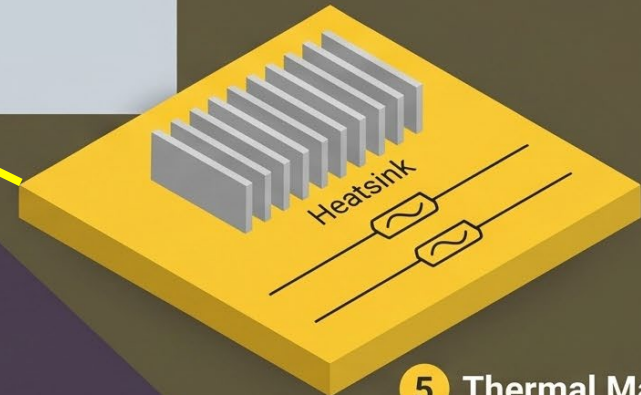
4 Gate Drive Circuits

The digital control brain typically outputs low-voltage, low-current signals (e.g., 3.3V or 5V). These signals are not capable of turning power-grade semiconductors on and off.

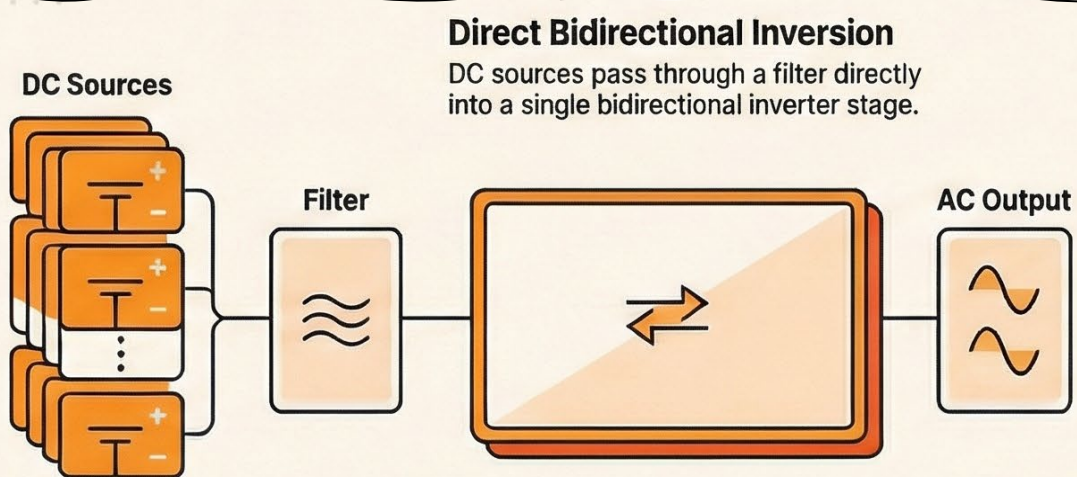


5 Thermal Management and Protection

A percentage of the power processed is lost as heat. Managing this heat is crucial to prevent failure.



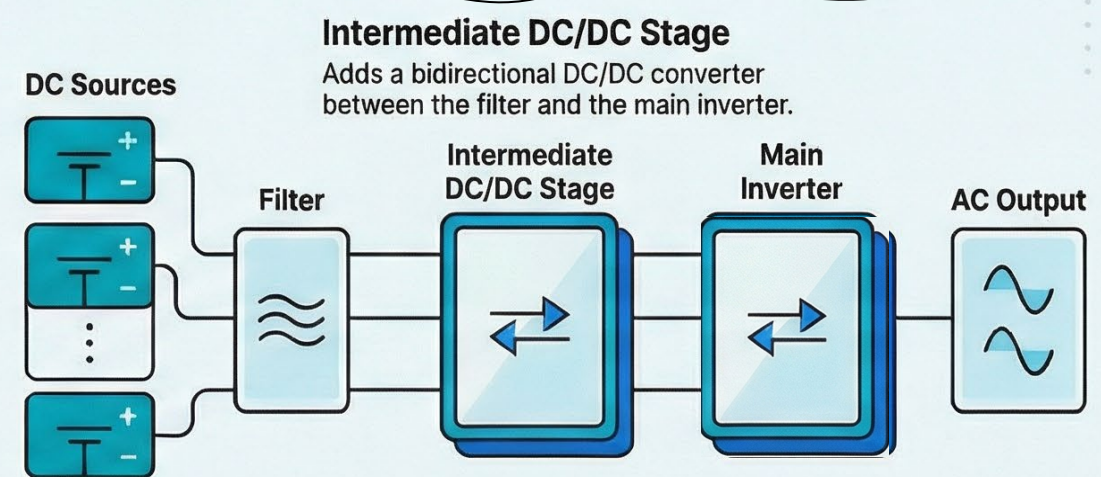
Power Electronic Topologies in Architecture



- Voltage Stacking Requirement**
High DC link voltages must be achieved by physically stacking multiple devices.
- Simpler Architecture**
Uses fewer components than the updated model, focusing on a streamlined power path.

Feature Comparison

- Stages: Single (DC to AC)
- Primary Challenge: High DC link voltage stacking
- Component Count: Lower

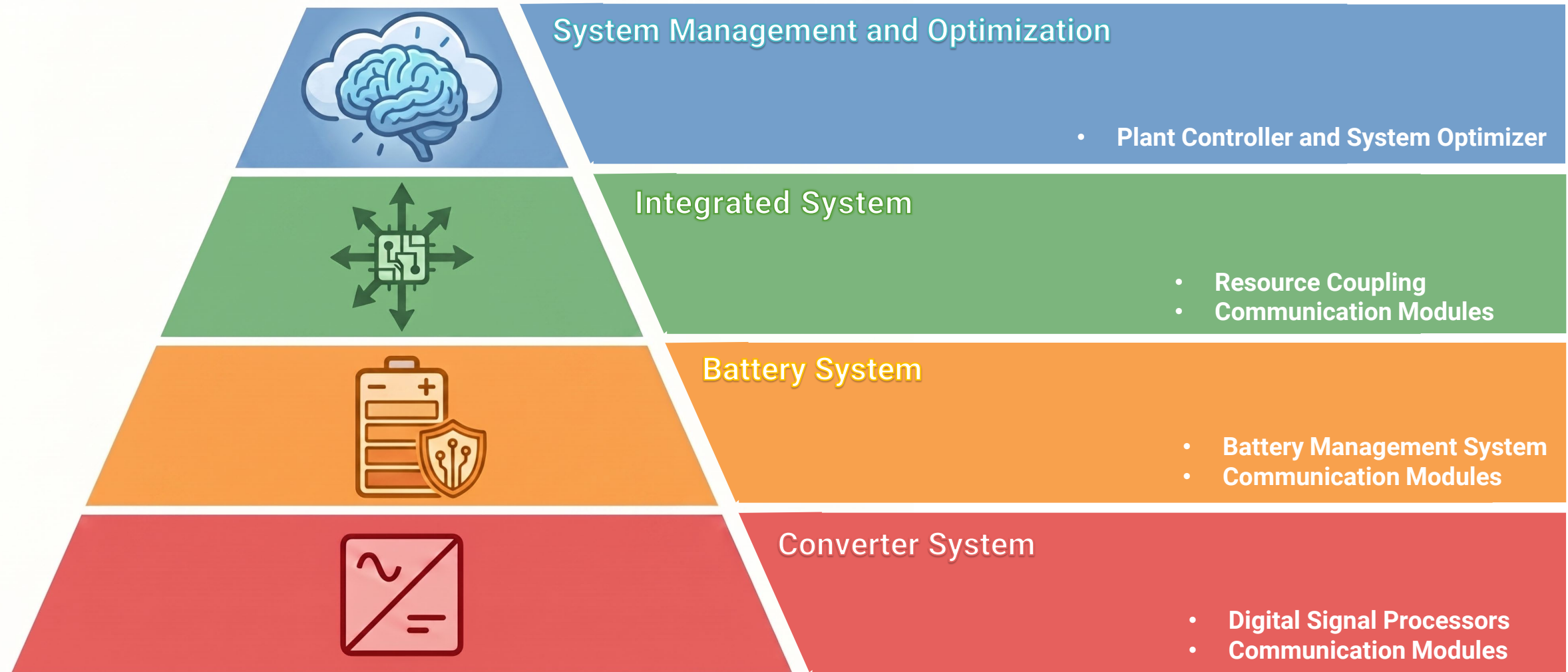


- Increased System Complexity**
Incorporating more devices results in a more intricate and complex system design.
- Enhanced Voltage Control**
Uses dedicated conversion stages to manage voltage instead of relying on device stacking.

Feature Comparison

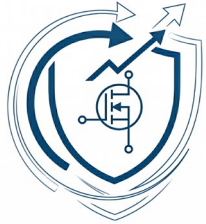
- Stages: Dual (DC/DC to DC/AC)
- Primary Challenge: High device count & complexity
- Component Count: Higher

Systems Architecture



R&D in Power Electronics

OBJECTIVES



Improving Reliability / Lifetime

Improve Mean Time Between Failures (MTBF) to 15–30 years



Lowering Cost / Increasing Value

Minimize the bill of materials, manufacturing complexity



Optimizing Space Utilization

Packing systems into smaller, lighter volumes



Maximizing Throughput/Minimize Loss

Higher power and more efficient designs/components



Integrated System Applications

Integrating power electronics to assets

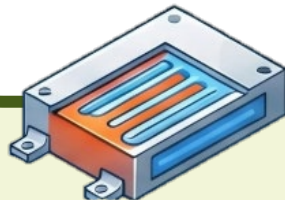
Advanced Semiconductor Materials & Devices

- Wide Bandgap Semiconductors
- New Materials for Devices
- High Voltage Systems



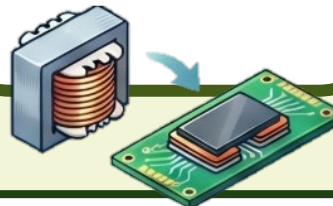
Packaging & Thermal Management

- Improved packaging to improve lifetime
- Increased thermal transfer to reduce aging



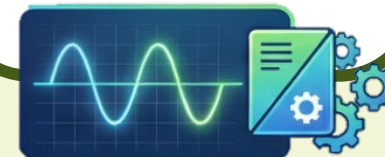
High-Frequency Magnetics & Passive Components

- Modular Designs
- Printed Circuit Board designs
- Planar & Integrated Magnetics



Artificial Intelligence for Power Electronics

- Design of components/systems
- Advanced dynamic control responses
- Diagnostics & Prognostics



Converter Topologies & Control Architectures

- New battery technologies
- New use cases and system needs
- Electrical system safety and integration



Esteemed Panel

Time	Lead	Title	Entity
10:25 AM	Renata Kimpura	Power Electronics for Flow Batteries	Oak Ridge National Laboratory
10:40 AM	Armando Montoya	Modular Energy Storage Platforms for Advanced Control, Diagnostics and Grid Integration	Sandia National Laboratories
10:55 AM	Jack Flicker	Immersion Cooling of Power Electronics	Sandia National Laboratories
11:10 AM	Jin Wang	Low-cost Magnetics-less Isolated Bidirectional GaN Power Converters for Grid-Ted Storage	Ohio State University
11:25 AM	Andrew Binder	Hafina Gate Dielectrics for Energy Conversion	Sandia National Laboratories