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Introduction

Data centers have evolved into the most essential infrastructure for modern industry, serving as the foundational platform that allows artificial intelligence, cloud services, and the global internet to thrive. At their core, these facilities consist of high-density server clusters supported by a complex infrastructure of power electronics. Supporting devices such as solid-state transformers, rack-level power distribution units, and Battery Energy Storage Systems (BESS) are critical to maintaining the stringent uptime requirements these servers demand.

Of these supporting devices, the BESS has become an indispensable tool for managing the massive fluctuating power demand characteristics of AI workloads. BESS is utilized in conjunction with the grid to manage, optimize, and store energy, providing a stabilized energy reservoir for data center operation. A BESS is a utility-scale energy storage system designed to operate for extended periods, supporting system protection and managing transient energy fluctuations from the grid. Ultimately, a BESS ensures a consistent, optimized, and reliable energy supply.

What is a BESS

BESS is an external management system utilized to store power for use during critical stages and to maximize energy efficiency. BESS stores energy from the power grid or renewable energy sources and provides energy to the applicable load while also handling circuit protection, power conversion, energy monitoring, and energy storage. A BESS makes sure the load is not exposed to too much or too little power, keeping it optimized and efficient. Within the BESS, several key systems are utilized, including a BMS (Battery Management System) and an EMS (Energy Management System).

The EMS is utilized to properly measure and track incoming energy from the grid and outgoing energy to the system. The EMS makes high-level algorithmic decisions for the BESS, such as charging, discharging, and other macro-level energy decisions. The BMS is utilized to protect, manage, and optimize battery cells. The BMS and EMS systems work together with power conversion systems to properly manage and optimize energy usage.

A BESS is used commonly in conjunction with renewable energy to store excess capacity to provide efficient power utilization and reduce operational expenditures. To optimize energy management, a BESS is used for grid support, which is what keeps the energy from the grid stable and reliable. To properly support the grid, the BESS provides peak shaving, frequency regulation, and other ancillary services. Peak shaving reduces energy drawn from the grid during peak hours. A BESS is charged during lower energy demand times and then utilized during peak times to provide energy independence and lower energy costs. Frequency regulation stabilizes the frequency of incoming power, with the BESS providing fast response times and precise control to keep grid connections in sync.

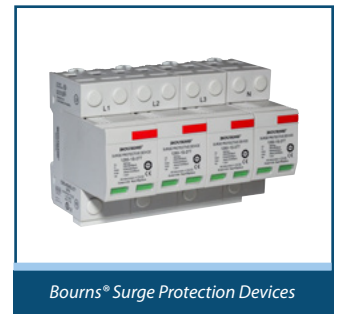
Excess energy is stored within battery cells within the BESS, which is managed by the BMS. The energy from the battery cells is then converted to AC power and fed back into the system to ensure optimal energy levels. Many different battery chemistries can be utilized within BESS, with the most common being lithium-ion due to its energy density, high performance, and robust nature.

Input Protection

Circuit protection is crucial for safeguarding the entire BESS system from voltage transients. Power protection within a BESS is usually located at the primary input before the EMS. Common forms of circuit protection within a BESS include high-speed fuses, surge protective devices, and circuit breakers. These components prevent overcurrent and overvoltage events from damaging sensitive power electronics. By implementing robust input protection, the BESS ensures that electrical faults are isolated quickly, preventing downtime and protecting the long-term health of the battery cells. Bourns, a leading components manufacturer, offers many reliable and efficient forms of input protection for BESS applications, such as the Bourns® POWrFuse™ High-Power Fuses, which can withstand high temperatures and are rated for high power, making them ideal for high-power industrial applications such as data centers. Bourns also offers surge protection devices (SPDs) that offer robust protection against transient electrical surges.



Bourns® POWrFuse™
High-Power Fuses



Bourns® Surge Protection Devices

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Battery Management System (BMS)

The battery management system serves as the internal manager and protector of the battery stack. Within an AI data center, where power density is exceptionally high, the BMS is responsible for ensuring that thousands of individual lithium-ion cells operate in precise coordination. Its primary function is to monitor the voltage, current, and temperature of individual cells to prevent degradation or dangerous conditions like thermal runaway. Because these battery racks often operate at very high bus voltages, the BMS must maintain strict electrical isolation between the high-power battery cells and the sensitive control logic.

For the BMS to operate with high precision and safety, many critical components are required. Some crucial components required for BMS operation include signal transformers and current sense resistors. Bourns offers many high-quality components that enable a BMS to function with high reliability and performance. For instance, Bourns® BMS Signal Transformers are utilized to provide high-voltage isolation for stable data transmission between cell controllers.

To handle the vital task of current measurement, Bourns offers high-accuracy current sense resistors and shunts, which allow the BMS to track energy flow with minimal thermal dissipation and power loss. Furthermore, for circuit protection at the board level, Bourns® TBU® High-Speed Protectors act as extremely fast-acting electronic fuses that shield sensing lines from transient surges.



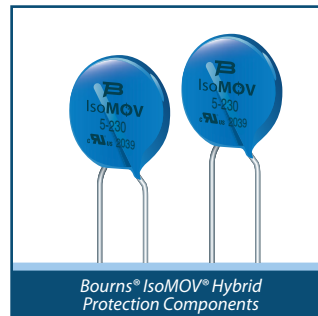
Bourns® TBU® High-Speed Protectors

Energy Management System (EMS)

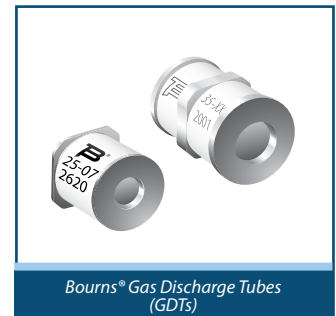
While the BMS focuses on the health of individual cells, the energy management system acts as the central controller that interacts with the data center load and the utility grid. The EMS tracks the total incoming energy from the grid and outgoing energy to the servers, making the strategic decisions of when to charge or discharge. In the context of AI, the EMS is essential for buffering the grid against the sudden power spikes caused by massive computations. It translates the needs of the data center into actionable commands for the battery system, ensuring that energy usage is both cost-effective and reliable.

The reliability of the EMS depends heavily on clean signals and protection from external electrical threats, areas where Bourns components are frequently utilized. Since the EMS is often exposed to the grid, Bourns® Gas Discharge Tubes (GDT) and IsoMOV® Hybrid Protectors are used to clamp high-voltage spikes from lightning or grid switching before they can reach the control circuitry.

To ensure the EMS can communicate clearly in the electrically noisy environment of a data center, Bourns® Common-Mode Chokes are employed to filter out electromagnetic interference on data lines. Additionally, Bourns provides a wide range of power inductors and DC-DC transformers that the EMS uses to create its own stable, internal power supply, ensuring the control system of the BESS remains operational even during fluctuating grid conditions.



Bourns® IsoMOV® Hybrid Protection Components



Bourns® Gas Discharge Tubes (GDTs)



Bourns® Common-Mode Chokes and Power Inductors



Bourns® Transformers

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Power Conversion Systems

The Power Conversion System (PCS) is the critical hardware that facilitates the actual movement of energy into and out of storage. While the batteries hold the energy in the form of DC power, the utility grid and the data center cooling and server infrastructure operate on AC. The PCS acts as the bidirectional bridge between these two worlds. When the BESS is charging, the PCS converts AC from the grid into DC for the batteries; when the data center requires power, the PCS reverses this process, converting the stored DC back into AC to feed into the data center.

The efficiency of this conversion is paramount for AI data centers because even a small percentage of energy loss during conversion results in massive amounts of waste heat and higher utility bills. Modern PCS units utilize high-frequency switching and advanced components to maximize this efficiency. Within these high-power environments, Bourns components play a vital role in managing the extreme electrical stresses that occur during the conversion process.

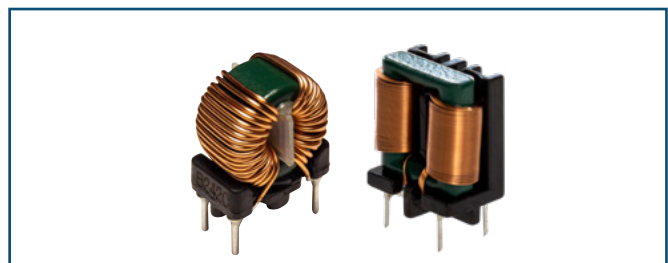
Bourns offers high-quality GDTs to protect against high-voltage transients and surges. Bourns® Insulated Gate Bipolar Transistors (IGBTs) deliver robust performance with very low switching loss. Bourns also offers custom magnetic solutions and high-current power inductors to optimize the filtering and regulation stages of the conversion process.



Bourns® Gas Discharge Tubes (GDTs)



Insulated Gate Bipolar Transistors (IGBTs)



Bourns® Custom Magnetic Solutions

Conclusion

The integration of battery energy storage systems represents a fundamental shift in how AI-driven data centers manage the intersection of high-performance computing and energy sustainability. By bridging the gap between volatile grid conditions and the constant, high-density power requirements of modern server clusters, BESS technology ensures that the digital economy remains resilient. The success of these systems relies on the seamless coordination of energy management, battery safety, and highly efficient power conversion.

As power demands continue to scale, the reliability of the underlying components becomes the deciding factor in system longevity. Through advanced circuit protection, high-precision sensing, and robust magnetic components, Bourns provides the essential building blocks that allow these systems to operate with maximum uptime and minimal loss. Ultimately, the adoption of sophisticated BESS solutions not only lowers operational costs through strategies like peak shaving but also provides the stability required for the next generation of artificial intelligence to thrive.