ABB POWER PROTECTION OF AI DATA CENTERS

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EXECUTIVE SUMMARY

As artificial intelligence (AI) workloads continue to scale in complexity and intensity, data centers face unprecedented demands on their power infrastructure. Traditional UPS (Uninterruptible Power Supply) systems, designed and optimized for steady-state loads, are now challenged by AI compute cycles' dynamic, high-variability nature. These include rapid transitions between idle and peak loads and frequent overload events.

This whitepaper delves into ABB's unique approach to tackling these challenges with its LV (Low Voltage) and MV (Medium Voltage) UPS systems. These systems, specifically engineered and tested for AI readiness, stand out with their advanced features. Drawing on real-world case studies, lab simulations, and component-level analysis, we showcase how ABB's MegaFlex and HiPerGuard UPS families enable next-generation AI data centers to operate reliably, efficiently, and sustainably.

1. INTRODUCTION: WHAT IT MEANS TO BE “AI READY”

The term “AI-ready” is rapidly becoming a benchmark in data center design, but what does it entail from a power infrastructure perspective?

AI workloads, particularly those involving large-scale model training and inference (e.g., LLMs, computer vision, generative AI), exhibit non-linear, bursty power consumption patterns. These include:

- Dynamic load cycles: Rapid shifts from low to high power demand within milliseconds.
- Overload peaks: Short-duration spikes that exceed 100% of UPS-rated capacity.
- High variability: Load profiles differ significantly based on chip architecture, software stack, and redundancy configurations.

These characteristics place significant stress on the UPS and upstream systems, such as grids and generators, which may not be designed to handle such volatility.

ABB’s response to this challenge is a new generation of UPS systems — LV and MV — that are AI-aware by design. Through advanced control logic, real-time load simulation, and rigorous compliance with IEC 62040-3 Class 1 standards, ABB is redefining what it means to deliver resilient, scalable, and future-proof power for AI data centers.

2. UNDERSTANDING AI LOAD PROFILES

AI workloads are fundamentally different from traditional IT loads. Their power consumption is higher and more volatile, driven by the nature of AI compute cycles. To design a truly AI-ready power infrastructure, it is essential to understand the two key components of AI load behavior: dynamic load cycles and overload peeks.

01

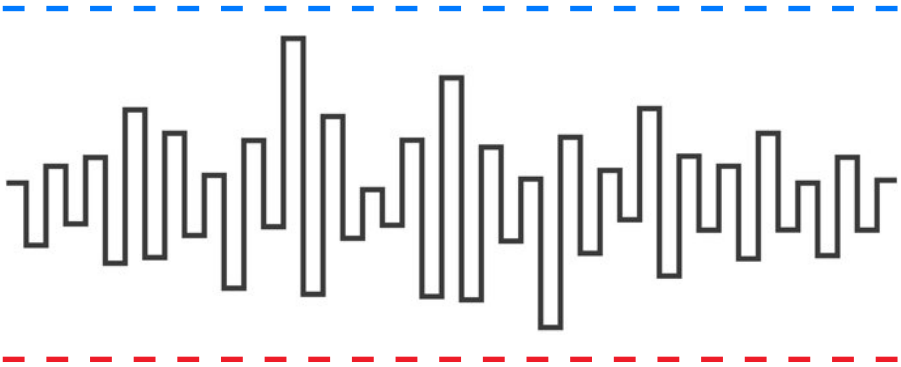
Dynamic Load Cycles

AI systems, especially those based on GPU (Graphical Processing Units) or custom accelerators, operate in repetitive cycles of high and low computational intensity:

- **Idle/Low Load:** During data preprocessing, memory access, or waiting for I/O, power demand may drop to 40% or less of UPS capacity.
- **High-Intensity Load:** Demand can spike up to 90% or more of UPS capacity during model training or inference, often within milliseconds.

These rapid transitions between low and high load states occur every few seconds, creating a dynamic waveform that challenges the UPS's ability to maintain voltage stability and efficiency.

Figure 1
Characteristic of dynamic load cycles



02

Overload Peaks

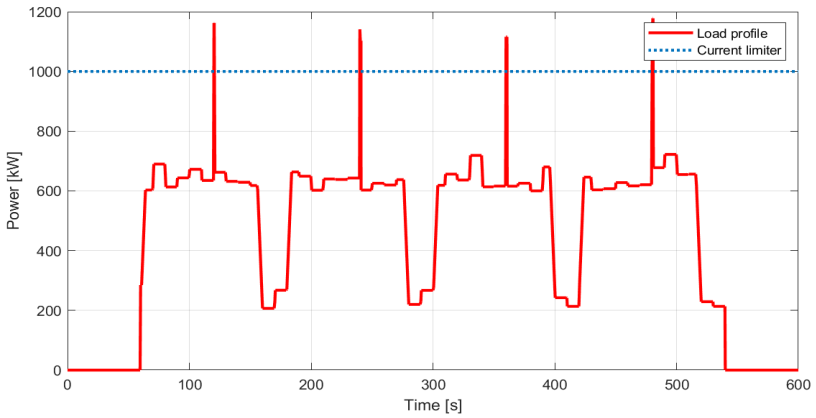
In addition to dynamic cycles, AI workloads can generate short-duration overload peaks that exceed 100% of the UPS's rated capacity.

These peaks:

- are often tied to parallel processing bursts or redundancy architectures.
- can last for milliseconds but occur repeatedly.
- stress the UPS's inverter, rectifier, and DC link components.

UPS systems must absorb these peaks without compromising performance or triggering bypass modes — a requirement beyond standard load handling.

Figure 2
Overload peeks characteristic



03

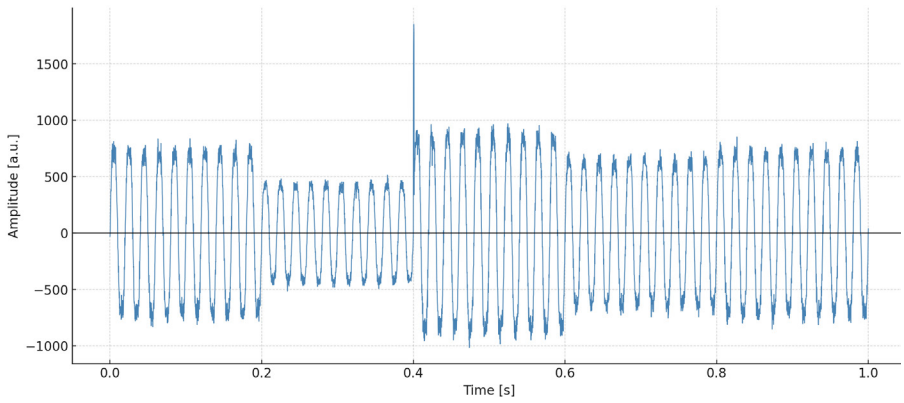
Combined Load Profile: Real-World Complexity

In practice, AI data centers exhibit a hybrid load profile combining dynamic cycles and overload peaks. For example:

- A server cluster running a large language model may oscillate between 50% and 90% load every few seconds.
- Simultaneously, it may generate 120% load spikes during distributed training synchronization.

ABB's testing with real customer profiles — including those based on latest generations of GPUs — confirms that UPS systems must be validated under these combined conditions to be considered AI-ready.

Figure 3
Actual combined dynamic cycles and overload peeks



04

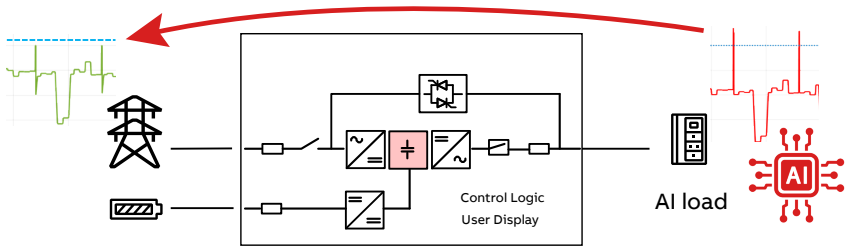
Upstream Impact: From Chip to Grid

AI load behavior doesn't just affect the UPS — it also reflects upstream to the grid or generator:

- Dynamic fluctuations can cause voltage and frequency instability.
- Overload peaks may exceed generator response capabilities.
- Load mix (AI vs. non-AI) and UPS redundancy architecture influence the severity of these effects.

ABB's UPS systems, such as the MegaFlex DPA and HiPerGuard, are designed to smooth out these reflections, protecting upstream infrastructure. However, the question remains: "Is the grid or generator ready to handle AI loads — even if the UPS is?"

Figure 4
AI load impact to the grid



3. REAL-WORLD TESTING AND VALIDATION

ABB has conducted extensive field testing and lab simulations using real AI load profiles to ensure that UPS systems are truly AI-ready. These tests, which validate compliance with international standards and long-term reliability under the stress of dynamic and peak loads, underscore ABB's commitment to delivering a reliable product.

01

Field Case Study: ABB MegaFlex UL in a Data Center

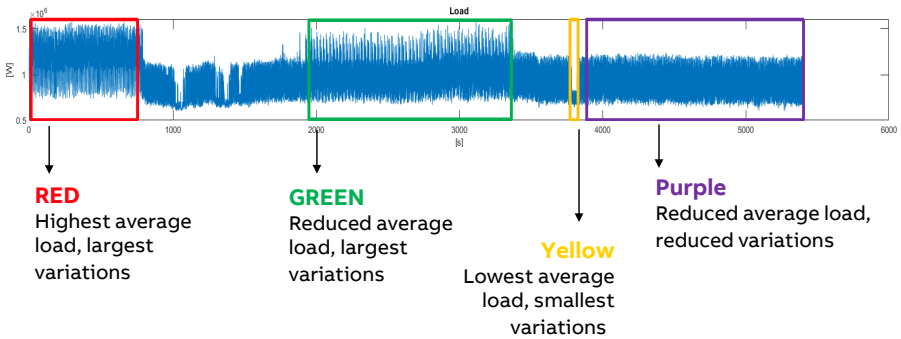
In October 2024, ABB deployed a 1.5 MW MegaFlex UL UPS system at a data center running state-of-the-art AI servers. The system was monitored for one week in March 2025, capturing real-time load behavior and UPS performance. This real-world case study demonstrates the practicality and effectiveness of ABB's UPS systems in handling the intensity and variability of modern AI workloads.

Key Findings:

- The UPS sustained dynamic AI load cycles and overload peaks without deviation from its technical specifications.
- The battery system required no energy contribution, even during peak events.
- The system maintained IEC 62040-3 Class 1 voltage performance, confirming its AI readiness.

This real-world validation demonstrates that ABB's UPS architecture can handle the intensity and variability of modern AI workloads without compromising uptime or efficiency

Figure 5
Field testing of the load profile



02

Component-Level Durability Analysis

ABB's R&D and IEC compliance teams collaborated with component suppliers to assess the long-term impact of AI load profiles on UPS hardware.

Results:

- No reduction in component lifetime was observed for AI load profiles that did not exceed 100% UPS capacity.
- Key components remained within safe thermal and electrical limits even under repetitive dynamic cycles.

This analysis confirms that ABB's UPS systems are compliant and durable under AI-specific stress conditions.

03

Customized Load Simulation: ABB Switzerland R&D Laboratory

ABB developed a custom AI load simulator to replicate more extreme AI scenarios at its Quartino R&D Lab in Switzerland. This facility can simulate up to 4 MW of AI load, including:

- Dynamic cycles with rapid transitions.
- Overload peaks up to 130% of UPS capacity.
- Real customer profiles digitized and applied to test benches.

Test Results:

- ABB's MegaFlex DPA UPS family sustained all test cases without battery support.
- Output voltage remained stable, and load was fully transferred to the grid.
- Even under 120% overload for 15 ms, the system maintained compliance with IEC standards.

This capability allows ABB to validate AI readiness on a customer basis, ensuring tailored performance for diverse AI deployments.

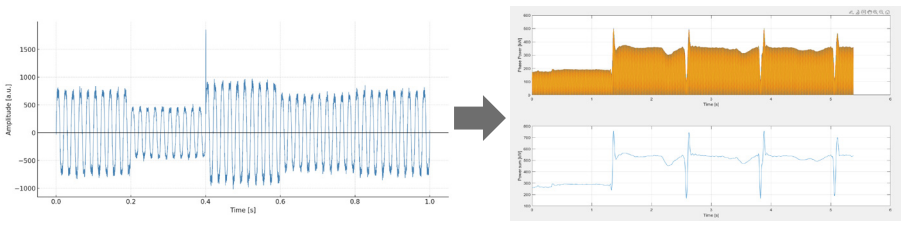


Figure 6
Acquisition and digitalization process of the load profile

4. UPS SYSTEM PERFORMANCE AND COMPONENT DURABILITY

As AI workloads push the boundaries of power infrastructure, UPS systems must meet performance standards and maintain long-term reliability under stress. ABB's approach combines rigorous testing, component-level analysis, and system-level optimization to ensure its UPS solutions are AI-capable and durable.

01

Performance Under Overload Conditions

ABB's MegaFlex DPA and UL UPS systems have been tested with AI load profiles featuring overload peaks up to 130% of rated capacity. These tests revealed:

- Stable output voltage even during rapid load transitions.
- No reliance on battery systems for short-duration overloads (e.g., 15 ms spikes).
- Full compliance with IEC 62040-3 Class 1 voltage performance standards.

This means the UPS can absorb and manage AI load spikes without triggering bypass or compromising power quality — a critical requirement for uninterrupted AI operations.

02

Component Stress and Lifetime Analysis

AI workloads introduce frequent and sharp load variations, which can stress key UPS components such as:

- DC link capacitors.
- IGBTs in inverters and rectifiers.

ABB's R&D team, in collaboration with component suppliers, conducted lifetime impact assessments under real AI load conditions.

The findings:

- No component lifespan reduction was observed for load profiles that did not exceed 100% capacity.
- Even under repetitive dynamic cycles, thermal and electrical stress remained within safe operating limits.

This confirms that ABB's UPS systems are functionally AI-ready and built to last under AI-specific stress profiles.

03

AI Load Mode Optimization

To further enhance performance, ABB is developing an AI Load Mode — a firmware-level optimization that:

- minimizes grid contribution during overload events.
- leverages the DC link to absorb short spikes.
- dampens upstream reflections, reducing stress on generators and grid interfaces.

Initial test results show that this mode can significantly reduce the impact of 120% overload peaks on the grid, without affecting output voltage or requiring battery support. This makes it ideal for generator-backed or grid-sensitive environments.

5. MEDIUM VOLTAGE UPS FOR LARGE-SCALE AI DEPLOYMENTS

As AI data centers scale into the gigawatt range, traditional low-voltage power architectures face efficiency, footprint, and scalability limitations. To meet the demands of hyperscale AI workloads, ABB has developed the HiPerGuard Medium Voltage (MV) UPS — a high-efficiency, high-capacity solution designed for the next generation of AI infrastructure.

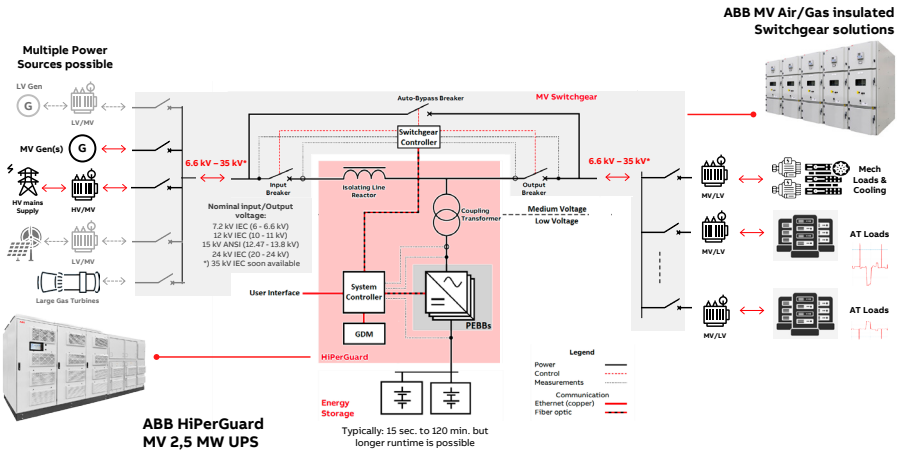
01

Why Medium Voltage for AI?

AI data centers are increasingly characterized by:

- massive compute clusters with tens of thousands of GPUs or AI accelerators.
- high-density power in individual racks and IT rows.
- power exceeding 10 MW per hall.
- stringent uptime and power quality requirements.

Figure 7
HiPerGuard MV UPS Block Diagram

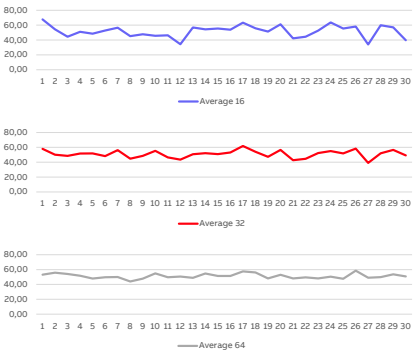


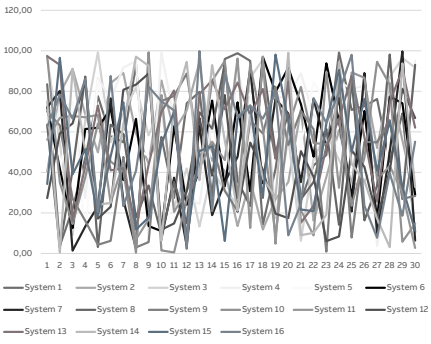
The HiPerGuard MV UPS is specifically engineered to support hybrid power environments, particularly those incorporating large-scale, on-site generation assets such as gas-reciprocating engines and turbine-based systems. Its design addresses the operational challenges posed by these sources through the following key features:

Generator-Friendly Topology

The system incorporates a high-impedance interface and advanced control algorithms that accommodate the slower transient response and frequency variability typical of large, low-inertia generators.

Figure 8
Load diversification impact observed by the grid, depending on the number of different loads





High-Impedance Series Choke

A key component of the system is a 50% impedance series choke, which:

- acts as a current-limiting and filtering element.
- attenuates high-frequency transients.
- smooths out the rate of change of current (di/dt).
- reduces electrical stress on both the UPS and the generator.

Modular Power Conversion Architecture

The UPS is composed of distributed power conversion blocks, which enable:

- fine-grained load segmentation.
- improved fault isolation.
- reduced harmonic propagation upstream.

Load Profile Smoothing

By distributing the load across multiple modules, the system inherently mitigates step-load impacts, resulting in a more uniform and predictable power demand, as the generator observes.

These integrated features collectively enhance the system's ability to maintain power quality and operational stability under volatile load conditions. This makes it particularly well-suited for mission-critical applications such as AI data centers, where uninterrupted and clean power is essential.

02

Medium Voltage UPS AI Load Validation

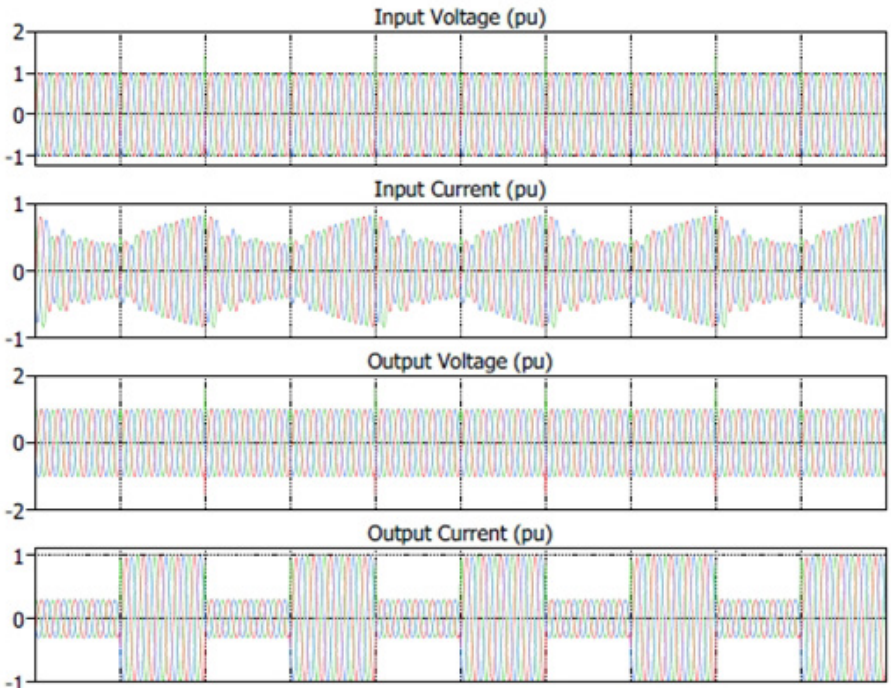
ABB has validated the HiPerGuard MV UPS against real AI load profiles, including:

- dynamic cycles and overload peaks.
- load diversity across multiple systems.
- transformer buffering to smooth load transitions.

Key Findings:

- No performance issues were observed under AI-specific stress conditions.
- Transformers between the MV UPS and the load help dampen peak effects.
- Load diversification across systems improves overall power quality and stability

Figure 9
Input voltage and current vs. output voltage and current on HiPerGuard



03

Installed Base and Growth

The globally installed base, including the ongoing projects of 2025, of medium-voltage UPS systems, represents more than 330 MW of secured power capacity for data centers worldwide. Deployments are distributed across Europe, Asia-Oceania, and North America, with significant concentration in the United States and Canada. This installed power demonstrates the growing adoption of MV UPS technology as a reliable backbone for large-scale, mission-critical data centers.

6. CONCLUSIONS AND FUTURE OUTLOOK

The rise of AI workloads is reshaping the data center power infrastructure landscape. From dynamic load cycles to overload peaks, AI introduces a new class of electrical stress that traditional UPS systems were not designed to handle. ABB's response — through its MegaFlex (LV) and HiPerGuard (MV) UPS families — demonstrates a clear commitment to engineering resilience, efficiency, and scalability into the heart of AI-ready data centers.

Highlights from ABB's approach:

- validated AI load handling through real-world deployments and lab simulations.
- no battery reliance for short-duration overloads, preserving energy storage for true outages
- component-level durability confirmed in collaboration with leading suppliers
- AI load mode optimization is used to reduce grid and generator stress
- MV UPS scalability for hyperscale AI environments, with growing global adoption

As AI models grow in size and complexity, the demands on power infrastructure will only intensify.

Future developments will likely include:

- integration of AI-powered UPS control systems for predictive load management.
- hybrid energy systems combining UPS, batteries, and renewables for sustainable AI operations.
- digital twins and simulation platforms to model AI load behavior before deployment.
- expanded test infrastructure (e.g., ABB Richmond) to support customer-specific AI load validation.

ABB is actively investing in these areas, working closely with data center operators, chip manufacturers, and infrastructure partners to ensure that power is never the bottleneck in AI innovation.

CALL TO ACTION

Whether designing a new AI data center or upgrading existing infrastructure, now is the time to evaluate your UPS systems for AI readiness.

ABB invites you to:

- engage with our R&D labs for custom AI load simulations.
- explore our LV and MV UPS solutions tailored for AI workloads.
- collaborate on future-proofing your power infrastructure for the AI era.

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