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Enabling the 800 V AI Server Era: How YAGEO Group's C0G High-Voltage MLCC Portfolio Supports Next-Generation Power Architectures

AI Servers and the Drive Toward Higher Voltage Power Architectures

Growth of AI Computing and Power Demand

Artificial intelligence workloads are fundamentally reshaping data center design, driving sustained growth in AI processing demand and overall power consumption. The widespread deployment of large-scale AI platforms has expanded AI usage from consumer applications into enterprise and industrial environments, including automotive, healthcare, and manufacturing. This broad adoption is significantly increasing processing power requirements and placing new demands on data center power delivery architectures. By 2028, global electricity consumption for data centers is projected to triple compared to the energy consumed in 2023 [1].

Modern AI systems are built around large groups of GPUs that work together at very high usage levels, behaving more like a single coordinated system than a collection of independent devices. High-speed connections allow these GPUs to operate in sync, enabling efficient scaling of workloads across many processors. This architectural approach results in step-function increases in both instantaneous and average power demand at the rack level in addition to high load transients.

Rack power densities that were once measured in tens of kilowatts are now advancing toward hundreds of kilowatts, with multi-megawatt AI racks under active development. These increases place substantial stress on conventional low-voltage power distribution architectures, which are constrained by current handling capability, copper losses, physical cabling limitations, and overall efficiency. As a result, traditional data center power architectures are increasingly unable to support the rate and scale of power growth driven by modern AI workloads.

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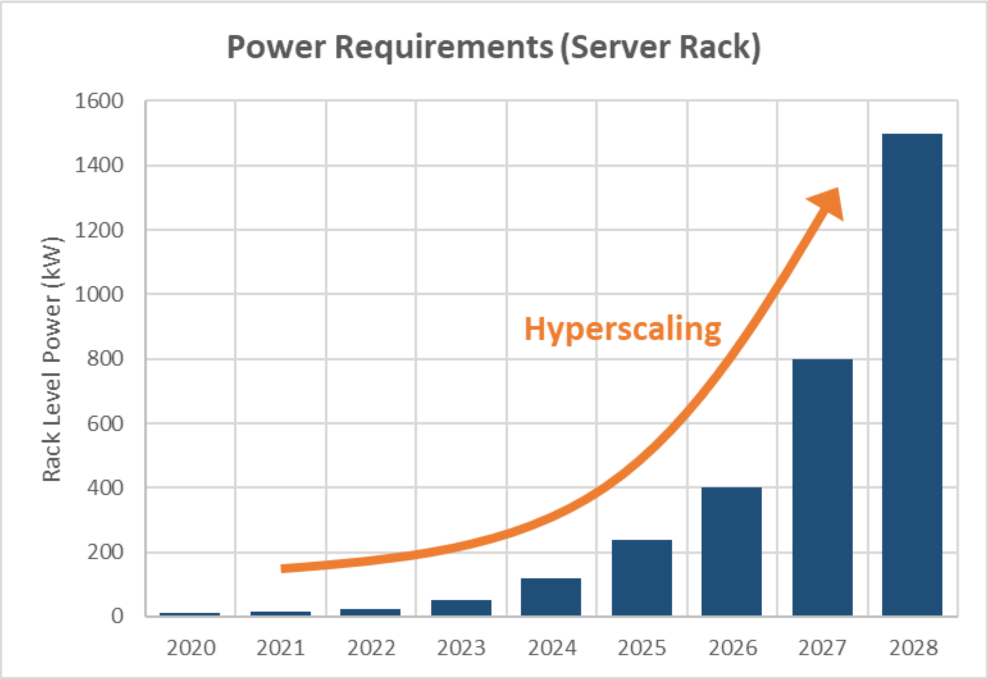

Figure 1 – Sever Rack Power requirement [4]

Why the Industry Is Moving Toward 800 V

As AI platforms scale toward ever higher rack-level power densities, conventional low-voltage power distribution architectures are approaching their practical limits. Traditional in-rack distribution schemes based on 48 V or 54 V DC require very high current resulting in increased I^2R losses, larger copper conductors, and growing challenges in efficiency, thermal management, and physical integration. These constraints make continued scaling increasingly difficult in existing data center voltage-conversion architectures.

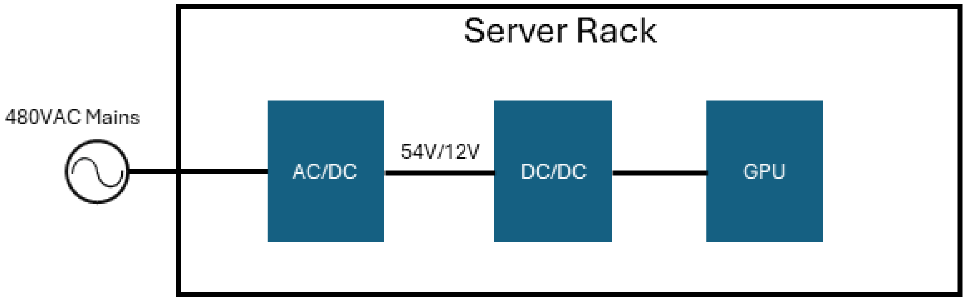

Figure 2 – Current 480VAC to 54V/12V Architecture

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Raising the distribution voltage is a direct and effective means of addressing these limitations. Increasing the distribution level to 800 V DC reduces current for a given power level, enabling significant reductions in copper size and resistive losses. Compared to traditional 480 VAC to 54/12 VDC architectures, 800 VDC distribution allows significantly more power to be delivered through the same conductor cross-section, supporting megawatt-scale rack designs with improved efficiency and scalability.

Higher-voltage DC distribution allows some power-conversion stages to be consolidated and shifted outside the server rack, reducing the number of intermediate AC/DC and DC/DC conversions within the server rack while freeing space for processing hardware and improving thermal management. At the same time, 800 VDC represents a practical balance between performance and integration, leveraging commercially available 1000 V-class components, well-known safety frameworks, and proven design practices from other industries such as electric vehicles. As a result, 800 VDC is emerging as a foundational architecture for next-generation AI power distribution.

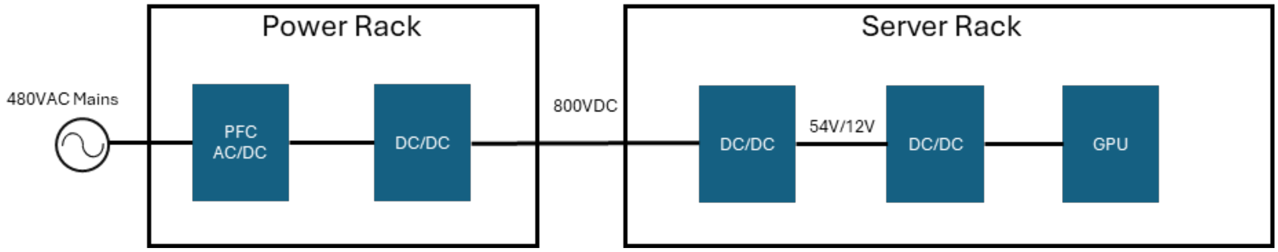

Figure 3 – Next Generation 800Vdc Architecture

The Power Architecture Parallel: EV OBCs and AI Servers

Overview of EV On-Board Charger (OBC) Power Conversion

On-Board Chargers (OBCs) convert AC mains voltage to DC suitable for charging the vehicle's high-voltage battery. OBCs must deliver high efficiency and high-power density while providing robust electrical isolation. At the same time, it must meet stringent requirements for safety, electromagnetic compatibility (EMI), and long-term reliability under demanding operating conditions.

At a system level, modern EV OBC architectures typically consist of an AC/DC power-factor-correction (PFC) stage followed by an isolated high-voltage DC/DC conversion stage. The PFC stage rectifies and conditions the AC voltage, while generating a regulated high-voltage DC output. The subsequent DC/DC stage converts this DC voltage to the appropriate battery-charging voltage, providing galvanic isolation and precise control of the charging current and voltage over a wide operating range.

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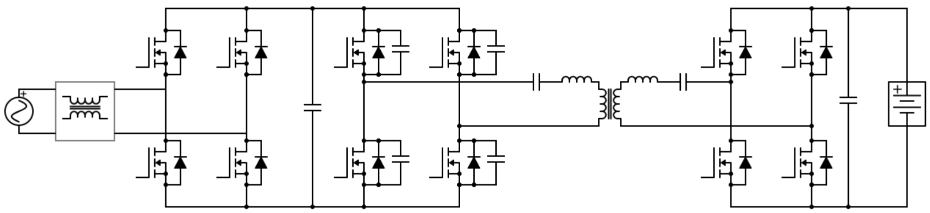


Figure 4 - Full Bridge Bi-Directional OBC Schematic

LLC and CLLC resonant converter topologies are widely adopted in the DC/DC stage of EV OBCs due to their ability to achieve high efficiency, soft-switching operation, and high-power density. These resonant converters typically operate at elevated switching frequencies, enabling compact magnetic designs while minimizing switching losses. As battery voltages and charging power levels continue to increase, particularly with the adoption of 800 V-class EV platforms, the DC/DC stage is subjected to higher electrical stresses. This places greater emphasis on the performance and reliability of passive components used in resonant tanks, snubber circuits, and filtering networks, where stable electrical characteristics are critical.

Architectural Similarities to AI Server Power Systems

With the shift toward higher-voltage power distribution, AI data centers are beginning to converge on power conversion architectures that have long been proven in EV OBCs. In both environments, electrical power needs to be converted from high-voltage AC mains to a regulated DC output while maintaining high efficiency and power density.

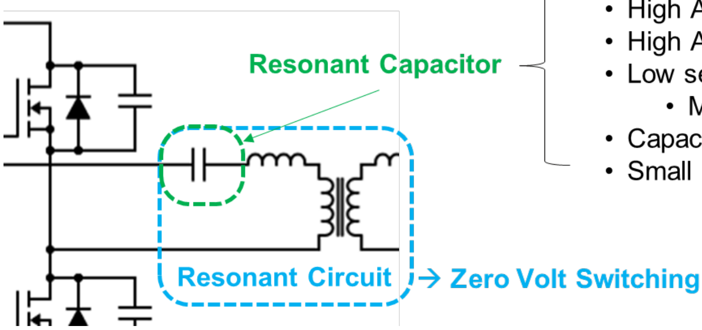
In EV OBCs, an isolated DC/DC stage—commonly implemented using LLC or CLLC resonant topologies converts a high-voltage DC bus from the PFC stage into a controlled battery charging voltage. Similarly, emerging AI server architectures distribute power at higher DC voltage levels and rely on DC/DC converter topologies located at the rack and board level to generate intermediate and point-of-load voltages for GPUs. In both cases, these DC/DC stages operate at elevated switching frequencies to achieve high power density and efficiency, placing demanding requirements on resonant components, snubber networks, and filtering elements.

These similarities between the two architectures lead to closely aligned component-level requirements across EV and AI power systems. High-voltage DC/DC stages in both environments demand passive components capable of withstanding sustained high AC voltages, high ripple currents, and elevated operating temperatures. As AI infrastructure moves toward continuous, high-utilization operation with power densities approaching those encountered in EV charging systems, the design practices and component technologies proven in EV OBC DC/DC applications provide a solid foundation for the next generation of AI server power architectures.

Why This Matters for Passive Components

As power architectures converge toward high-voltage, high-power DC/DC conversion, the electrical and thermal stresses imposed on passive components increase significantly, with important differences in duty cycle. EV OBCs are exposed to high electrical and thermal stress but only operate during the charging cycle. In contrast, AI server power systems must operate continuously, often at high utilization, to achieve, for extended service lifetimes.

In both environments, resonant capacitors used in LLC- and CLLC-based DC/DC stages are subjected to high-frequency AC voltages. These operating conditions produce substantial AC ripple current through the resonant capacitor, resulting in internal heating due to I^2R losses and elevated component operating temperature. If not properly designed, sustained electrical and thermal stress can accelerate aging mechanisms and reduce effective lifetime.



Capacitor Requirements
- High AC Voltages
- High AC Currents
- Low self-heating → Low ESR and Thermal Resistance
  - Mainly 80kHz – 300kHz but as high at 500kHz
- Capacitance Stability with Temperature and Voltage
- Small Size → High Power Density

Figure 5 – Resonant Capacitor Requirements

In AI data center environments, where 24/7 operation is expected and power density continues to increase, these effects become more pronounced. Under continuous high-voltage operation, the performance of the resonant capacitor directly influences converter efficiency, thermal stability, and long-term system reliability. As a result, passive component selection—particularly for resonant and snubber functions—becomes a critical design consideration.

Why C0G (NP0) Matters in High Voltage DC/DC Conversion

Advantages of C0G in High Voltage Applications

C0G (NP0) Class 1 dielectrics offer a combination of electrical and reliability characteristics that make them well-suited for resonant capacitors used in high-voltage DC/DC conversion stages, including LLC- and CLLC-based architectures deployed in both automotive and AI infrastructure. In these converters, the resonant capacitor is subjected to large high-frequency AC voltage swing and elevated thermal loading, placing stringent requirements on dielectric stability, loss characteristics, and ripple-current handling capability.

A primary advantage of C0G dielectrics is their negligible change in capacitance with applied DC or AC voltage. Unlike high-K ferroelectric dielectrics, C0G resonant capacitors maintain essentially constant capacitance across the operating voltage range, even under large AC voltages in resonant tanks. This stability helps preserve resonant frequency and operating characteristics, reducing sensitivity to operating point variation in high-voltage DC/DC stages. C0G capacitors also exhibit very low temperature coefficients of capacitance, typically on the order of ±30 ppm/°C, resulting in minimal capacitance drift over the full operating temperature range.

From a loss and reliability perspective, C0G dielectrics offer very low ESR, reducing I^2R losses in the resonant capacitor under high AC ripple current conditions. Lower resistive losses limit self-heating and reduce the risk of thermal runaway under sustained operation. Combined with non-aging characteristics and robust insulation performance, these attributes support improved long-term reliability of resonant capacitors, particularly in continuously operating environments such as AI data centers.

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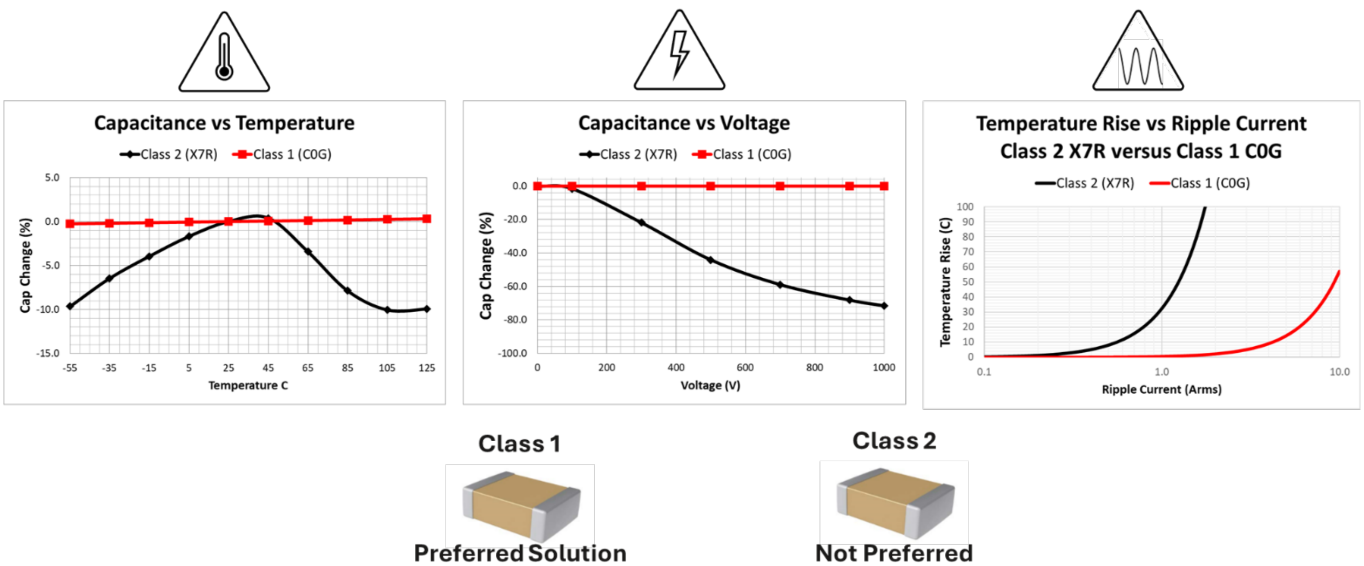

Figure 6 – Comparison of C0G Class 1 and X7R Class 2 Characteristics

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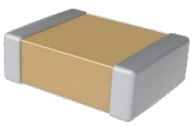
YAGEO Group's C0G High Voltage MLCC Portfolio

YAGEO Group offers a comprehensive portfolio of high-voltage MLCCs aligned with the power architecture requirements of emerging AI systems. Leveraging over a decade of experience in EV on-board charger applications such as resonant, snubber, and DC-link circuits, YAGEO Group provides the industry's most complete high-voltage MLCC platforms for 800 VDC-class systems.

C0G (NP0) High Voltage Offering

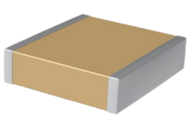
- Commercial and Automotive Grade
- EIA 1206 - 2225 Case Sizes
- 500V – 2000V Rating
- Up to 47nF
- Flexible (Soft) Termination, VW80808
- Resonant, DC-LINK, Snubber



LINK to C0G (NP0) High Voltage MLCCs

KC-LINK^{TM} Series

- For Fast Switching Semiconductor Applications
- Commercial and Automotive Grade
- EIA 1812, 2220, 3640 Case size
- 500V – 2000V Rating
- Up to 220nF
- Resonant, DC-LINK, Snubber



LINK to KC-LINK Series

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KC-LINK with KONNEKT™

LINK to KC-LINK with KONNEKT

- High Density Packaging Solution
- Commercial and Automotive Grade
- EIA 1812, 2220, 3640 Case size
- 500V – 2000V Rating
- Up to 880nF
- Resonant, DC-LINK

U2J with KONNEKT™

LINK to U2J with KONNEKT

- High Density Packaging Solution
- Commercial Grade
- EIA 1206, 1210, and 1812 Case size
- 10V - 100V Rating
- Up to 1.4μF
- Resonant, DC-LINK

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Easy to Design-in (E2Di)

To support customers with design-in activities, YAGEO Group offers a variety of tools and services to reduce design-in cycle time. These include tools such as our Y-SIM for simulation key MLCC characteristics as well as our Power Array Calculator that provides recommendations on part numbers and configurations for resonant solutions.

References:

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