

POWER ELECTRONICS EUROPE

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EV CHARGING

Bringing the Cool
to EV Charging



THE EUROPEAN JOURNAL
FOR POWER ELECTRONICS
-----AND TECHNOLOGY-----

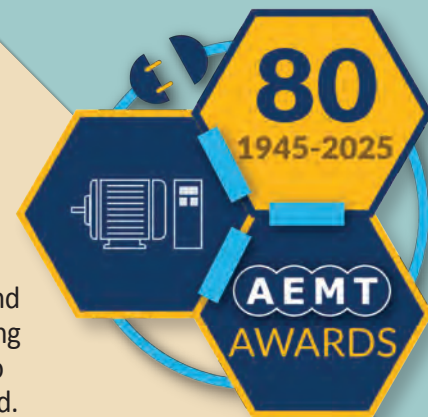
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Make sure you join the celebration...

In this landmark 80th Anniversary year, the AEMT Awards will once again shine a spotlight on the people, companies, and innovations driving progress in the electro-mechanical sector. The awards recognise and reward the products, projects and services that play a crucial role in ensuring our food production, utilities, manufacturing processes, transportation and other essential services are maintained and secured. So whether you have submitted an entry or not, this is an industry event not to be missed.



Thursday 20th November 2025

DoubleTree by Hilton Hotel, Coventry

The awards are a global celebration of business and professional excellence. They recognise the achievements of both individuals and companies manufacturing, distributing, maintaining or repairing industrial machinery such as electrical motors, drives, pumps, fans, gearboxes, generators, transformers, switchgear and ancillary equipment.

Nine awards will be presented during the charged atmosphere of the gala ceremony, including: **Product of the Year, Project of the Year, Supplier of the Year, Service Centre of the Year, Diversity in Engineering Award, Contribution to Skills & Training, Sustainable Organisation of the Year, the Rising Star Award**, and the **AEMT's Special Recognition Award**.

Make sure you book your place today and be part of this celebration of engineering excellence.

The Parachutes

The Parachutes combine impressive voices with a guitar and a drum kit, creating the illusion of a much larger ensemble.

With a floor-filling mix of indie, pop, rock, soul, funk and Motown tracks from throughout the years in their repertoire, they're experts at keeping guests of all ages dancing late into the night.



Kevin Keegan OBE

To help celebrate this year's industry awards evening, we are thrilled to have Kevin Keegan providing the entertainment. An incredibly passionate and renowned communicator, Kevin is one of the most recognisable faces in British football. His illustrious playing career includes stints at Liverpool, Hamburg, Southampton, and Newcastle, as well as an iconic tenure with the England national team, where he captained the side for six years before retiring after the 1982 World Cup. As a manager he held the reins at Newcastle, Fulham, Manchester City, and even the England national team. Beyond his playing and managerial career, he is also a highly respected broadcaster. We're excited to have Kevin with us this year, and we're sure his insights and passion will add a unique spark to the celebration.



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FEATURE STORY**Bringing the Cool to EV Charging**

Steve Drumm, Strategic Marketing Manager – Solutions in Energy, OMRON Electronic Components Europe B.V., explains how consumer, commercial and industrial AC EV chargers can get cooler, smaller, and longer lasting.

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Advancing semiconductor design through wide-bandgap engineering

By Chinmoy Baruah, Founder and CEO at CHIPX

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Highlights at productronica 2025

Just a short while to go before the anniversary edition of productronica. The world's leading trade fair for the development and production of electronics celebrates its 50th anniversary this Autumn. From November 18 to 21, Munich will once again be the meeting place for the international electronics industry. productronica 2025 will focus on advanced packaging, power electronics and trusted microelectronics. As in previous years, SEMICON Europa will be co-located with productronica at the Messe München exhibition centre. The conceptual sponsor of productronica is the industry association VDMA Productronic.

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SPS 2025 to focus on AI and talent development

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Alpha and Omega Semiconductor Supports 800 VDC Power Architecture for Next-Generation AI Factories with Innovative SiC and GaN, Power MOSFET, and Power IC Solutions

Alpha and Omega Semiconductor (AOS), a designer, developer, and global supplier of a broad range of discrete power devices, wide bandgap power devices, power management ICs, and modules, has announced support for the power requirements of the innovative 800 VDC architecture announced by NVIDIA. This architecture is set to power the next generation of AI data centres, which will feature megawatt-scale racks to meet the exponential growth of AI workloads.

The shift from traditional 54V power distribution to an 800 VDC system is a fundamental change in data centre design, aimed at overcoming the physical limits of existing infrastructure. By reducing power conversion steps and enabling more efficient power delivery, the 800 VDC architecture promises significant efficiency gains, reduced copper usage, and improved reliability. This paradigm shift requires advanced power semiconductors, particularly Silicon Carbide (SiC) and Gallium Nitride (GaN), to handle the higher voltages and frequencies with maximum efficiency.

"As a key supplier to the high-performance data centre market, our portfolio of SiC and GaN products is strategically aligned with the core technical demands of next generation AI factories with 800 VDC power architecture," said Ralph Monteiro, Sr. VP, Power IC and Discrete Product lines at AOS. "We are collaborating with NVIDIA to design 800 VDC power semiconductors to provide the high efficiency and power density necessary for the new power distribution modules, from the initial AC-to-DC conversion to the final DC-to-DC stages within the racks."

AOS says its expertise in developing and manufacturing wide bandgap (WBG) semiconductors positions it as a strong enabler for this transition. The company's products are well-suited for the crucial power conversion stages highlighted in the next generation AI factory 800 VDC power architecture:

- **High-Voltage Conversion:** AOS' SiC devices, including the Gen3 AO020V120X3 or topside cooled AOGT020V120X2Q, offer superior voltage handling and low losses, making them ideal for either the power sidcar configuration or the single-step conversion of 13.8kV AC grid power directly to 800 VDC at the data centre perimeter. This simplifies the power chain and enhances overall system efficiency.
- **High-Density DC-DC Conversion:** Within the racks, AOS' 650V GaN FETs, like our upcoming AOGT035V65GA1, and our 100V GaN FETs like AOFG018V10GA1 provide the required density essential for converting the 800 VDC power to the lower voltages needed by GPUs. Their high-frequency switching capabilities allow for smaller, lighter converters, freeing up valuable space for more compute resources and improving cooling efficiency.



- **Packaging Innovations:** AOS' 80V, 100V stacked-die MOSFETs like AOPL68801, and 100V GaN FETs share a common package footprint, allowing designers to trade off cost and efficiency in the secondary side of LLC topologies and also in 54V to 12V bus converters. AOS' innovative stacked die packages enable next-level power density for the secondary side LLC socket.

- **Multiphase Controllers:** AOS also offers high-performance, multi-rail 16-phase controllers for the 54V to 12V and further downstream conversion stages to the AI SoC.

By providing these foundational power technologies, AOS says it is helping to advance the benefits of the 800 VDC architecture, including up to a 5% improvement in end-to-end efficiency, a 45% reduction in copper requirements, and a significant cut in maintenance and cooling costs and this reinforces AOS' commitment to enabling the creation of more sustainable and scalable AI infrastructure.

www.aosmd.com

Molex Announces Availability of Industry-First, Space-Saving Quad-Row Board-to-Board Connectors with EMI Shields

Molex, a global electronics leader and connectivity innovator, has announced availability of the Molex Quad-Row Shield Connector, said to feature the industry's first space-saving, four-row signal pin layout with a metal electromagnetic interference (EMI) shield.

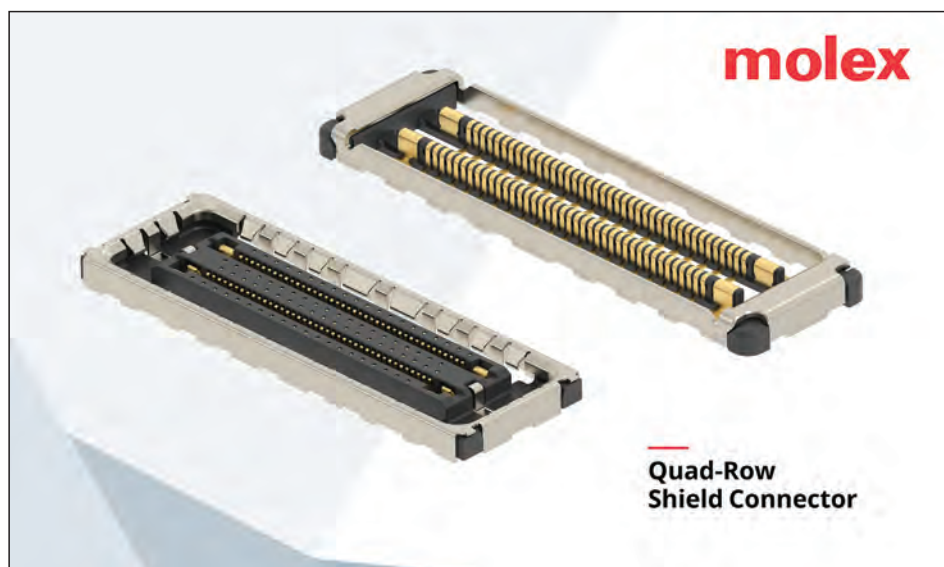
The company says the Quad-Row Shield Connector achieves up to 25dB reduction in EMI compared to non-shielded Quad-Row, and is ideally suited for space-constrained applications, such as smart watches and other wearables, mobile devices, AR/VR

applications, laptops, gaming devices, appliances and more.

"Without shielding, connectors can be vulnerable to external electromagnetic noise from nearby components or far-fielded devices, causing signal degradation, data errors and system malfunctions—especially in high-speed or sensitive applications," said Taekeon Park, Director, Micro Connectors, Molex. "In the past, designers would build additional external shielding or complex grounding solutions into devices to mitigate the issue—compounding complexity, size and

cost. Quad-Row Shield removes those design and performance hurdles by ensuring enhanced reliability and signal integrity, as well as design flexibility and space optimization."

The new Quad-Row Shield builds on the market-proven, Quad-Row layout with the addition of an EMI shield that mitigates both electromagnetic and radio frequency (RF) interference, as well as signal integrity issues that create undue noise, achieving up to 25dB reduction in EMI over the non-shielded Quad-Row solution. The new, built-in EMI



shield is a critical value-add for device designers striving to ensure stable, error-free signal performance in space-constrained device designs.

Molex says its long-standing collaboration

with product developers from major device and gaming manufacturers supports continued enhancements, including the development of the new EMI shielding. Together, Molex and its customer

engineering teams addressed the most significant requirements related to signal interference and incremental power requirements, specifically how best to achieve 80 times the signal connections and four times the power delivery compared to a single-pin connector. The new Quad-Row Shield provides power input and output aligned to a delivery model featuring up to 80 pins within a single board-to-board connector. In addition, S-parameter input specifications may be assigned to a preferred pin layout in an 80-pin signal design.

The highly innovative Quad-Row Shield significantly reduces electromagnetic interference and meets stringent EMI/EMC standards to lower regulatory testing burdens and speed product approvals. The shielding feature also enables error-free communication while seamlessly supporting operations and maintenance requirements to boost overall system uptime.

<https://www.molex.com/en-us/home>

Danfoss Power Solutions launches CAN 2 Current, a solenoid-mounted microcontroller for accurate, efficient component actuation

Danfoss Power Solutions has announced the launch of CAN 2 Current (C2C), a compact solenoid-mounted microcontroller designed to work with Danfoss cartridge valves, hydraulic integrated circuits (HICs), hybrid PVG/HIC valves, and open-circuit pumps. C2C connects the valve, HIC, or pump to the controller area network (CAN) bus, enabling accurate and efficient component actuation as well as simple diagnostics.

The company says C2C is a high-performance device delivering repeatable and consistent control. The device communicates using CAN bus protocols to provide closed-loop current control on one or two outputs. C2C can be used with on/off and proportional solenoids and is available as either a single- or dual-channel device. The single-channel device commands one coil while the dual-channel device can command two coils sequentially. It is compliant with ISOBUS and SAE J1939 communication protocols.

C2C can maximise energy efficiency through peak-and-hold control technology. This feature reduces current in the hold phase to only the power required to maintain the solenoid's position, thus holding the function. Using retention current on extended-hold functions, such as clamping, reduces energy consumption by up to 70%. This minimises cooling needs and may reduce the battery capacity required in some types of battery-electric machinery.

The controller's compact, robust design maximises space efficiency as well as durability. C2C features resin-potted construction that offers protection from dust and dirt, as well as shock and vibration resistance. With its IP67 ingress

protection rating, C2C is built to last in harsh off-highway environments.

By connecting the valve or pump to the CAN bus, C2C simplifies diagnostics. The CAN bus enables real-time communication between the C2C and the machine controller, enabling status messages to be shared with the operator via cabin display. This eliminates the need for manual troubleshooting to identify solenoid issues.

"With CAN 2 Current now part of our portfolio of closed-loop current control actuators, Danfoss can deliver a truly fantastic, complete subsystem with all the benefits of CAN bus. Our full portfolio of solutions addresses every requirement, delivering functionality perfectly matched to the machine," said Michael Hartmann Andresen, Global Product Portfolio Manager, Actuators, Danfoss Power Solutions.

"We aim to develop the strongest actuator platform on the market. We will continue to build out our closed-loop CAN actuator portfolio while not forgetting the need for durable, reliable open- and closed-loop analogue actuators."

C2C offers quick and simple setup. The full Danfoss Power Solutions actuator portfolio features a standardised approach for setup and control, which is applicable across C2C and PVE configurations for various valve solutions. The actuators are configured within the PLUS+1 Service Tool, offering a familiar, easy-to-use setup platform. The C2C device's configurable parameters include communication time guarding, dither, minimum and maximum current, and hold current.

<https://www.danfoss.com/en-gb/>



Anritsu Breaks Bandwidth Barrier with World's First 145 GHz O/E Calibration Module, Accelerating 1.6T Data Center Evolution

Anritsu Company has announced it has launched the MN4765B-0140 O/E Reference Calibration Module, said to be the world's fastest and first traceable solution to support the testing demands of next-generation data centres and the explosive growth of Artificial Intelligence (AI) and Machine Learning.

As data centres transition from 224 Gbps to 448 Gbps per lane to achieve total data rates like 1.6T, the required bandwidth for electrical-optical (E/O) modulators and optical-to-electrical (O/E) photodetectors now exceeds 130 GHz. The new MN4765B-0140 is engineered to meet this critical need, pushing the measurement frontier to 145 GHz.

The company says the MN4765B-0140 is a monumental step forward for high-speed component verification:

- **World's First 145 GHz Reference Photodetector:** It offers the widest commercially available frequency range from 70 kHz to 145 GHz for O/E calibration at the 1550 nm wavelength, enabling the high-confidence characterization of cutting-edge E/O and O/E devices.
- **Traceability to 145 GHz:** Anritsu secured traceability for the new module to a recognized National Metrology Institute. This is a crucial differentiator, as existing standards from NIST are limited to 110 GHz, making the MN4765B-0140 the only solution providing verifiable



measurement accuracy at these extreme bandwidths.

- **Unique, Cost-Effective System Solution:** When integrated with Anritsu's VectorStar ME7838D 145 GHz Vector Network Analyzer (VNA), the combination creates the world's only complete, traceable, and flexible system for testing the entire high-speed opto-electronic ecosystem, including TOSA, ROSA, BOSA, and Coherent Optical Sub-Assemblies (COSA).

Anritsu says its solution provides significant advantages over competing systems, which typically forces customers into a more expensive solution lacking the necessary 145 GHz reference calibration module entirely.

"The AI revolution is demanding a massive leap in data centre interconnect speeds, making the 145 GHz bandwidth non-negotiable for 1.6T

deployment," said a spokesperson for Anritsu Company. "The MN4765B-0140 eliminates measurement uncertainty at these critical frequencies. Coupled with the flexible and future-proof VectorStar VNA platform, our customers gain a powerful, cost-effective tool that secures their investment by offering a simple upgrade path and superior measurement speed."

<https://www.anritsu.com/en-gb/>

Toshiba launches a range of 15 new Zener diodes for protection of power lines

Toshiba Electronics Europe has announced it has expanded its range of Zener diodes with the launch of a further 15 products. These devices will be used to protect the power lines of semiconductor devices and equipment from switching surges and long duration overvoltage pulses. They will be useful in a wide range of applications, including consumer and industrial.

The company says the new CMZBxxA series products feature a planar structure and are designed as successors to the mesa-structured CMZBxx series products, which have been announced as reaching end of life (EOL).

The innovative planar structure enables a low reverse current and high reliability as the PN junction is protected with oxide film. Additionally, fine process adjustments ensure a reduced variation in the Zener voltage between devices.

The new products feature protection against transient overvoltage pulses, and also against long duration overvoltage pulses, which are usually difficult for ESD protection diodes to handle. In power lines of equipment, switching surges with long pulse widths of up to milliseconds may be generated when



the circuit switches. The new Zener diodes can protect semiconductor devices from switching surges and overvoltage pulses close to DC.

Compared to the CMZBxx series, the new products can improve the specification range of Zener voltage from $\pm 10\%$ (typ.) to $\pm 5\%$ (typ.) and the maximum reverse current (I_R) from $10\mu A$ to $0.5\mu A$. These improvements help to simplify equipment design and reduce overall power consumption. Additionally, as the new CMZBxxA devices use the same M-FLAT (2.4mm x 4.7mm x 0.98mm) package as the existing CMZBxx series, upgrading does not require any PCB layout changes.

The 15 products in the lineup cover a range of Zener voltage (V_Z) from 12V (typ.) to 51V (typ.), supporting a wide range of commonly used voltages.

The new products help to improve equipment reliability by providing surge protection for power supply lines.

<https://www.toshiba.eu/>

The Electronics industry and getting ESPR Compliant: Three moments to consider

By Matthew Ekholm, Digital Product Passport and Circularity Specialist at Protokol

In just a few years, the European Commission's Ecodesign for Sustainable Products Regulation (ESPR) has gone from a distant policy discussion to an urgent priority for the electronics industry, one that companies must address now or risk falling behind.

Having originally come into play in mid-2024, with the ultimate goal of making sustainable and circular products the norm in the EU, electronics companies that are due to be impacted (those who either sell into or are based in the EU market) have been getting to grips with the regulations' varied intricacies. In particular, the regulation mandating Digital Product Passports (DPPs).

Given the electronics sector's highly complex supply chains and the heightened scrutiny it faces due to the significant volume of e-waste it produces, achieving compliance represents a considerable challenge.

The EU's strong focus on this industry is understandable when we realise that, in 2022 alone, Europeans generated, on average, 17.6 kg of e-waste per capita, and out of that, approximately 7.5 kg per person was formally collected and recycled. For electronics businesses looking to stay ahead of regulation and position themselves for a more sustainable future, three upcoming milestones are particularly important to track.

With the electronic sector's uniquely complex supply chain considerations and added scrutiny it receives due to the amount of e-waste it generates, the sector has an extensive task ahead when it comes to compliance.

The EU's circularity push and Energy Labelling Working Plan (Released in April 2025)

Since the EU's ESPR came into force last year, affected industries have been navigating a complex path, seeking clarity on next steps. To address this, the EU released its first Energy Labelling Working Plan in April 2025, outlining horizontal requirements across sectors. Key areas include



repairability scores (likely covering consumer electronics), recycled content, and recyclability of electronic equipment.

The Working Plan says that every product for which ecodesign measures will have to be adopted will have a DPP (a digital record of information about the product), to open up data access for businesses, consumers, and public authorities.

Knowing early on that this will be mandatory allows electronics providers to start developing strategies for deploying DPPs, identifying where the necessary data resides, and engaging with DPP solution providers.

The Delegated Acts and Horizontal Requirements (Between 2027 and 2029)

By 2027, the EU is expected to have outlined its first set of delegated acts for certain product groups - these will provide guidelines detailing the

exact requirements for the data needed in DPPs. Timelines will vary by industry; some won't see finalised details until 2028 or later. For electronics providers, it will be the horizontal requirements (due between 2027 and 2029) that will be the most relevant. These rules are expected to cover specifications such as product carbon footprints and instructions for recycling or safely disposing of hazardous components.

Companies that want to stay ahead should already be mapping where the necessary data sits within their business and supply chain, defining an implementation strategy, and preparing to run pilots with trusted partners.

Compliance deadlines are looming (Expected 18 months after the delegated acts)

Electronics manufacturers should anticipate that compliance will be required within roughly 18 months of the relevant delegated act being published. The European Commission may also choose to shorten this timeframe in cases of environmental urgency or to align with broader EU policy goals.

This period should not be seen as a grace window, but as the final phase for perfecting DPP strategies. By then, companies will be expected to move beyond pilots and deliver full-scale implementation with confidence.

Industries earlier in the queue, such as iron and steel, which are likely to see delegated acts in 2026, will serve as valuable case studies. Their experiences will provide useful lessons that electronics businesses can apply to strengthen their own compliance readiness.

Although the deadlines may seem distant, they are expected to take effect approximately 18 months following the adoption of the delegated acts. Each milestone presents an opportunity for the electronics sector to reduce risks, adapt proactively, and ensure regulatory compliance well ahead of the cutoff date.

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Bringing the Cool to EV Charging

Steve Drumm, Strategic Marketing Manager – Solutions in Energy, OMRON Electronic Components Europe B.V., explains how consumer, commercial and industrial AC EV chargers can get cooler, smaller, and longer lasting.

EV-Charger Design Challenges

The ongoing shift toward electrification holds the promise of cleaner and more energy-efficient living. On the other hand, end-user expectations continue to drive demand for more compact equipment that fits neatly and stylishly into lives and living spaces while also delivering higher performance. These demands for smaller, slimmer, and faster apply to everything, from accessories and small appliances to power adapters and chargers including electric vehicle service equipment (EVSE).

High-power EVSE wallboxes are an increasingly common sight in today's homes and businesses. These support Mode 3 charging, which stipulates built-in control and protection functions for safety, and can charge an EV at up to 22kW from a three-phase AC supply. By providing convenient access to safe and secure charging, ideal for use overnight or during the working day, these wallboxes can certainly help dispel the speed of charge and range anxiety often cited as the main reasons for motorists' reluctance to adopt EVs as daily transport.

On the other hand, size and aesthetics are highly important and become a key differentiator between manufacturers. However, cramming the circuitry into the smallest and thinnest possible enclosure brings thermal management challenges that must be addressed to ensure the long-term



reliability of the EVSE as well as user safety.

Wallboxes like these could be in continuous use or may be connected to several vehicles in rapid succession, especially when installed in a workplace scenario, giving little or no opportunity to cool down between charges. In direct sunlight, the internal temperature can easily reach 70-80°C, and cycle through 50-60°C variances within the space of a couple of hours.

While units equipped with temperature sensors can throttle the charging current in overtemperature conditions, which is good for safety, this means slower charging rates and less convenience for the end user. On a particularly hot day, or if a fault is causing the wallbox to overheat, the charger may

not be able to function at all. Addressing these thermal challenges can enhance reliability, safety, and the user experience.

Self-Heating Effects

Within the wallbox circuitry, resistive components, power transistors, inductors, transformer windings, cables, and connectors exhibit self-heating due to power dissipation that increases with the square of the current flowing (I^2R).

A surprising amount of I^2R -related heat in the wallbox is associated with the contact resistance of the main switching device, which is usually an electromagnetic relay or contactor. Unlike power transistors, which can be connected in parallel to distribute load current, paralleling electromagnetic switches is impractical. As the full load current must pass through the relay, the contact resistance when closed has a considerable heating effect. Even a one milliohm increase in the relay contact resistance can equate to as much as *18°C in increased load terminal temperature rise.

Excessive heat dissipation within the enclosure is undesirable, of course, and also mitigates against achieving slimmer and more compact wallbox designs. For a given heat load, a small-sized enclosure has less surface area from which to dissipate heat and so will experience a higher temperature rise. In addition, packing components more tightly in the



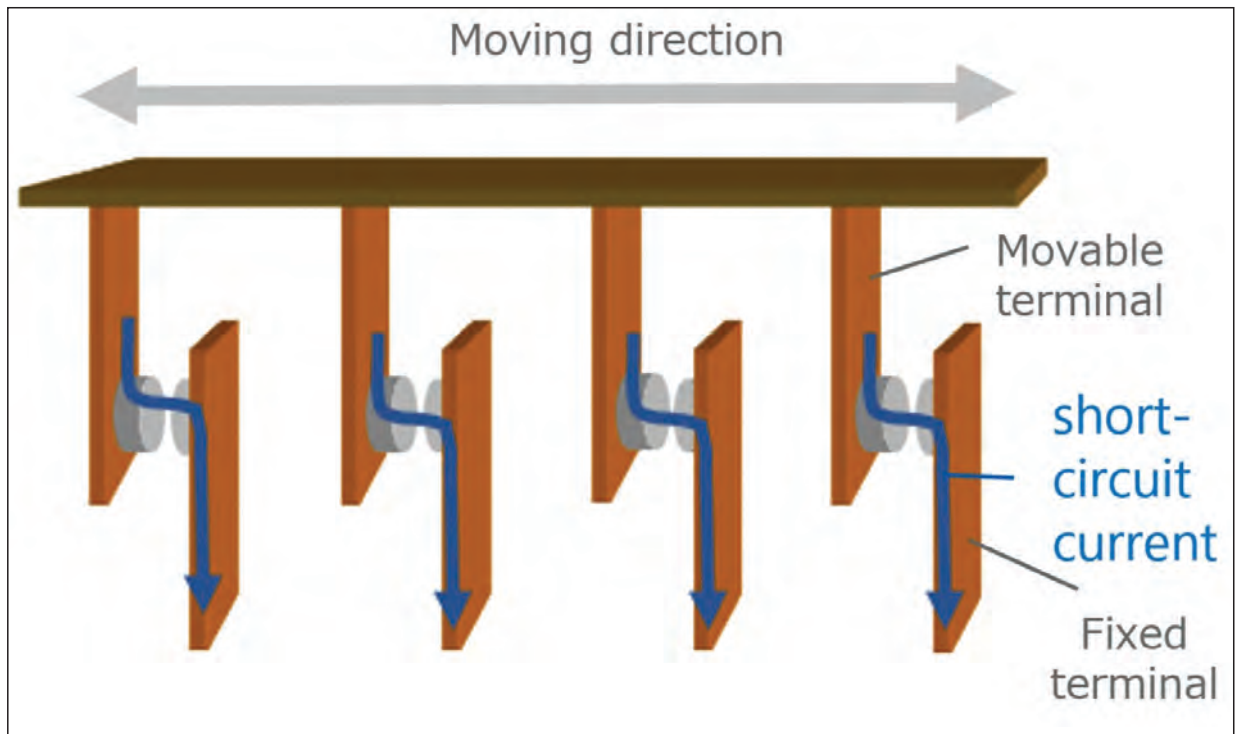


Fig 1_Image of mechanically coupled 4-pole structure.jpg

compact space can restrict airflow and lead to localised hotspots. Extra thermal management, possibly including heatsinks, increased ventilation, or active cooling such as a fan, may be required. However, this will increase the wallbox cost and complexity. Moreover, a fan can be noisy and compromises the overall reliability.

Relay Evolution

Lowering the heat load resulting from the electrical components, including the relay contacts, can break this impasse and allow designers more freedom to reduce the wallbox dimensions. Advancements from the cutting edge of relay design now enable compact new relays in PCB-mount form factors that combine high current capability with low contact resistance, resulting in lower dissipation and reduced temperature rise.

Historically, PCB relays have been best suited to applications up to about 25 A. For higher currents, designers have tended to specify contactors, which are typically off-board, DIN rail-mount components fitted with screw terminals. The latest PCB relays introduce new features to handle current significantly above 25 A and can replace traditional contactors in equipment such as high-power industrial systems and utility-grade power conditioners.

Among new high-power relays emerging as a result of this trend, the Omron G9KC series has a guaranteed initial contact resistance of less than 6 milliohms - roughly half that of any equivalent solution on the market - and contains features

optimised for AC wallbox applications. As well as improving charging efficiency and performance, the ultra-low resistance at full load (32A per live phase) significantly reduces hotspots caused by flowing current and reduces the likelihood of current throttling. The reliability and longevity of the relays themselves, as well as surrounding components are also improved. Crucially, the relay retains a low contact resistance throughout its lifetime. This is particularly important given that wallboxes are typically expected to remain in service for several years or more.

At the heart of the G9KC is a purpose developed mechanically coupled double-break contact design providing class leading endurance due to its enhanced contact card (cradle) structure that significantly improves energy efficiency while reducing heat dissipation. As a result, with good overall charger design, operating temperatures in a typical 22 kW 32 A wallbox can be reduced by as much as 10°C. This not only facilitates faster, more efficient charging, but also unlocks new possibilities for wallbox designers to develop more compact and robust designs.

With a 4mm main contact gap and 10 kA short circuit capability, tested according to IEC62955 (TUV approved), the G9KC exceeds the requirements of the upcoming Electric vehicle conductive charging system Standard IEC 61851 ED4. Moreover, with its compact 4-pole structure, the G9KC can replace larger multi-pole contactors or up to four individual single-pole relays. This useful combination widens the scope of

applications to include Behind the Meter (BTM), inside EV Charger and In Front of Meter (FTM).

Conclusion

While Mode-3 chargers offer convenience and safety to address EV range anxiety, charging infrastructure must continue improving to accommodate the rapidly growing EV market. Using more thermally efficient components could let designers add more functionality, such as extra sensors to monitor charging speeds, while further new developments could include wireless charging.

On the other hand, thermal management will continue to be one of the most critical design challenges governing wallbox size, shape, efficiency, reliability, and safety. The latest developments in relay technology contribute towards enabling new designs to be unobtrusive and easily installed, as well as ensuring more efficient charging.

**Reference Thermal Simulation conditions: 32A carry current on three load terminals. T.Amb.85°. PCB evaluation board (2 layers of 10 mm wide, 0.3 mm depth copper foils)*

For more information on the G9KC, please visit:
<https://components.omron.com/eu-en/products/relays/G9KC>
<http://components.omron.com/eu-en>
<https://www.linkedin.com/company/omron-electronic-components-europe-b-v/>

The importance of hardware emulation when developing a next-generation automotive BMS

In the competitive landscape of vehicle electrification, one thing that original equipment manufacturers (OEMs) cannot compromise on is safety and reliability in hybrid and electric vehicles.

The vehicle's battery management system (BMS) is indispensable for achieving safety and reliability by:

- Avoiding cell failures.
- Detecting and reacting to failures quickly through cell and environmental sensor supervision.
- Continuously monitoring isolation within the vehicle's high-voltage system.
- Estimating the vehicle range.
- Assessing the maximum power for charging or driving.
- Extending the driving range based on battery pack capacity.
- Increasing the amount of battery cycles before a battery pack needs to be replaced or recycled.

While demands for higher levels of BMS reliability have increased, so has the need for faster development cycles. Given the complexity of these types of systems, OEMs are seeking closer collaboration with system developers, semiconductor companies and their third-party partners to streamline development. Figure 1 shows an example of an electric vehicle (EV) BMS.

This collaboration is evident in the software-based simulation capabilities used during BMS development, during which components and systems are tested in both normal and excessive conditions early in the development cycle without physical hardware or an expensive testing space. Tools such as hardware-in-the-loop simulators can emulate a battery module or pack, enabling accelerated development, compact test setups, virtual prototyping, automatic testing, and the ability to develop software for the BMS without a physical battery pack.

By simplifying the testing process, emulators can play an important role in accelerating innovation in the BMS field.

The advantages of using emulators when developing an automotive BMS

Hardware-in-the-loop solutions provide a safe way to simulate the two-pole behavior of battery cells, modules or packs. The output of real, high-precision voltages



Figure 1. Typical BMS and battery in an EV

for all cells is referred to as voltage-level hardware-in-the-loop testing.

It is also possible to test the BMS main controller at the signal level and simulate the battery cells and cell supervision units (CSUs). The focus in this approach is to test the functions of the BMS controller and its interaction with the vehicle network (or any other environment) without using actual high voltages. This provides a deeper representation toward the final hardware and is referred to as an emulator.

Emulation of both the entire battery pack (or module) and the cell and pack monitors allows for deep and repetitive testing. For example, you could test in the very early development stages using a simulated integrated circuit like the

BQ79616-Q1 battery monitor. Another potential use case for testing the BMS controller at the signal level is integration testing with other control units, such as motor controllers or onboard chargers.

The functionality of a BMS emulator

The dSPACE Cell Controller Virtualization (CCV) can perform comprehensive signal-level BMS testing of cell controller functions without the need for complete hardware, and without high-voltage safety equipment (as shown in Figure 2).

One of the advantages of a BMS testing emulator like the dSPACE CCV is that it enables you to conduct tests outside of an expensive, often-booked high-voltage lab environment. Compared to high-voltage

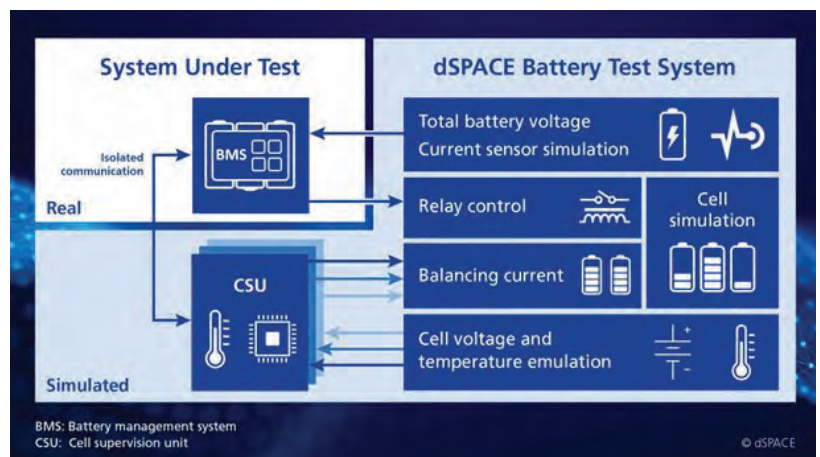


Figure 2. Diagram of battery cell, CSU and communication with the main BMS controller simulation when using the dSPACE solution for signal-level BMS testing

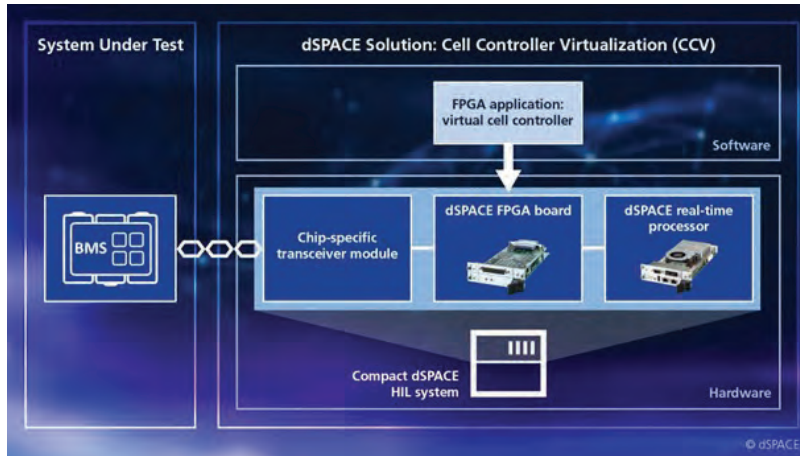


Figure 3. Overview of dSPACE CCV solution for testing BMS at the signal level

BMS testing, a signal-level approach provides benefits in terms of price efficiency and a more compact test system footprint. Since signal-level testing doesn't require any real cell voltages, the test systems are less complex and require fewer safety installations.

Signal-level testing also offers design flexibility. Testing system functions early allows designers to focus on optimization even before the real battery or battery pack monitoring hardware (like the CSU) becomes available. And beyond just

simulating the cell controllers, the dSPACE solution can also emulate communication with the main BMS controller, the vehicle electronic control unit, real-time test computers, or vehicle hardware.

Typical use cases of the dSPACE cell controller virtualization solution include running integration tests on the main BMS controller to validate its communication with other vehicle control units, such as the e-motor controller (inverter) or the onboard charger in hybrid and electric vehicles. You can also test state-of-charge

and state-of-health algorithms for fault detection and reaction, and conduct integration tests on a system or on a full vehicle hardware-in-the-loop simulator.

These emulators are based on powerful field-programmable gate arrays (as shown in Figure 3) and are able to meet demanding timing requirements. They support a wide range of communication protocols, for fast, safe and isolated communication. This enables more flexible testing capabilities, such as connecting the emulated battery pack to the battery management unit in a hybrid emulated/real hardware environment.

Conclusion

After two decades of automotive BMS innovations, it's exciting to see corresponding advancement in emulation solutions. By emulating TI battery management ICs, the dSPACE cell controller virtualization solution helps facilitate system development earlier in the design process. An expedited process enables software to progress before hardware is available and tests real-life or extreme conditions to help enhance system safety and reliability.

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Power modules simplify creepage and clearance design solutions for electric vehicles

Why overmolding is the key to solving arcing issues in 48V automotive power systems

Arcing is not a new problem for electrical engineers, but if overlooked it can have

next five years. Emerging as a front runner for this new architecture, the higher voltage

of an 800V battery demands greatly increased creepage and clearance distancing, generating challenges in the size and spacing of electrical systems. Higher voltage power drives increases in component spacing necessary to prevent electric breakdowns (arcing). Vehicle life expectancy is about two decades with proper creepage and clearance design, but much shorter if arcing is not properly accounted for in the design phase. Arcing can cause electric components to degrade over time possibly creating safety issues.

OEMs now face two key issues related to creepage and clearance requirements that must be addressed.

- 1: New creepage and clearance considerations for 48V
- 2: Greater risk caused by 48V architecture compared to the legacy 12V architectures

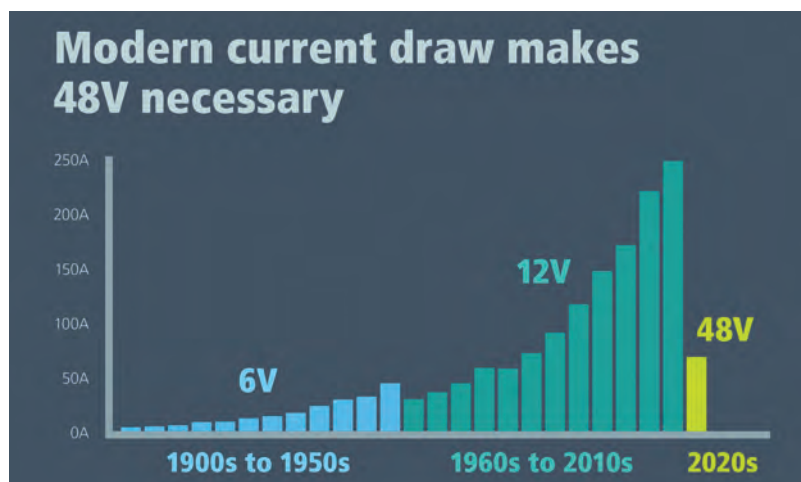


Figure 1 Conversion to a 48V bus reduces the vehicle's total current draw from over 250A to under 75A without impacting the electrical content of the vehicle. Since 1908, the current demand in automobiles has grown exponentially with the addition of vehicle electronics. In the 1960s OEMs increased voltage from 6V to 12V, causing current to drop for the first time in 60 years. Today, most OEMs still use the 12V bus but are rapidly converting to 48V out of necessity to accommodate an influx of high-power electronics.

tragic consequences. Earlier this year a cargo ship carrying automobiles from China to Mexico caught fire, sparked by what observers believe to be a malfunction within the vehicles' electrical system, raising concerns around safety standards regarding EVs. The industry has relied on 12V power systems to supply power to their vehicles since the 1950s; however, as technology advances, so must the industry. With automakers requiring more power for EVs and PHEV models, the transition to 48V power systems and high-voltage batteries is inevitable.

However, this move requires deep consideration concerning creepage and clearance safety requirements. In addition to upgrading the 48V bus, OEMs are moving to higher voltage batteries and further complicating creepage and clearance specifications. According to Market Report Analytics (MRA), the projected compound annual growth rate for 800V batteries will exceed 30% in the

What should design engineers be aware of for proper creepage and clearance in a 48V PDN?

Creepage and clearance requirements are extremely important safety measures that

High voltage requires 60% greater distance between components

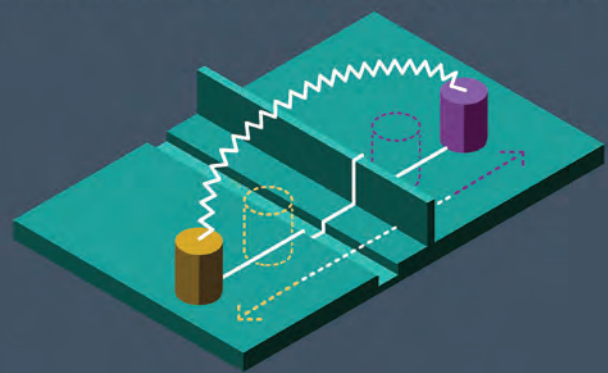


Figure 2 Creepage and clearance requirements are international safety measures to mitigate the risk of arcing. These requirements must be met to ensure safety and functionality. Lack of proper distancing may result in excess heat, directly damaging or compromising the power delivery network. Higher voltage requires up to 60% greater space in between components. This additional spacing can consume substantially more board space, enlarging the entire power system design which is problematic for most systems with a pre-defined footprint.

must be accounted for in automotive applications. The requirements prevent undesired consequences resulting from electric current jumping through air gaps, better known as electrical arcing. The effects of arcing can destroy components in the vehicle, causing loss of functionality within the vehicle if severe damage is done. In vehicles with legacy 12V power systems, arcing was accounted for through modest, but very measured component rubrics, but with EVs and PHEVs beginning the transition to 48V architecture, all forms of powertrains are facing this challenge. Design requirements must adjust to ensure safety, increasing the distance between conductors to reduce the risk of arcing.

Why is a 48V architecture more risky for creepage and clearance design?

48V architecture introduces new challenges for the design engineer because of the increased voltage. Voltage increase creates higher potential for arcing. According to the IPC-2221 Standards, transitioning from a 12V architecture to one based on 48V can require upwards of a 60% increase in creepage and clearance distancing.

Adhering to proper creepage and clearance standard ensures safety

In 2024, The National Highway Traffic Safety Administration (NHTSA) reported 6.3 million vehicle recalls impacted by electrical systems, accounting for 33% of all recalls, highlighting the significance of component-related safety concerns. Many of these concerns can emanate from electric arcing, causing severe power system problems for OEMs. With the implementation of an 800V battery pack in a 48V architecture, the risk of arcing increases.

Traditionally, when addressing this requirement within a design, engineers allowed for adequate spacing between conductors throughout the PCB. Voltage range, material properties and intended application dictate how the standards are established. Thorough calculations are required to properly space conductive parts to ensure compliance with these safety standards. Higher voltages require further distancing.

While discrete component solutions can fulfill these requirements, their off-the-shelf components often consume a large footprint, as akin to a silver box power supply. These larger components demand up to a 60% size increase within the PDN framework, posing design challenge for OEMs to accommodate greater spacing needs within the same footprint. This is nearly impossible to achieve without

design tradeoffs or innovating the approach.

Overmolded packaging virtually eliminates the problem of arcing and improves thermals

Solving the challenge of high-voltage arcing while taking into consideration the size and space constraints is not something many discrete components can do well. What can help is a traditional packaging process called potting. Potting encapsulates components to protect them from external vulnerabilities. However, potting restricts heat dissipation, causing elevated component temperatures that accelerate material degradation, further contributing to component failures and reduced lifespan.

A more efficient approach to eliminate air gaps that enable arcing is through a proprietary overmolding process. With Vicor innovative packaging, the overmolding process neutralizes the risk of arcing while allowing for better heat dissipation. It also reduces size, enabling a high-density power source. The molding compound creates a solid insulation within the product, reducing creepage and clearance distances. The complete seal not only

prevents pollutants from entering and causing an arc, but also reduces the size, further allowing for more space within the vehicle's chassis to store components.

Solving space constraints with high-density power modules

The matrix of transitioning from a 12V to 48V power system coupled with 400/800V batteries causes increased complications for the design engineer, demanding extra caution in PCB system design standards for EV and PHEV applications. This evolution of automotive architecture creates challenges to the OEM that needs to add more spacing between components within that same footprint. From larger battery packs to various powertrain components, OEMs must look for efficient solutions in accommodating space limitations inside the vehicle's framework.

With EVs and PHEVs rapidly adopting a 48V architecture where high-voltage batteries are used, OEMs must step down the voltage as efficiently and safely as possible. Bridging these gaps requires greater component distancing. This is where many discrete module suppliers

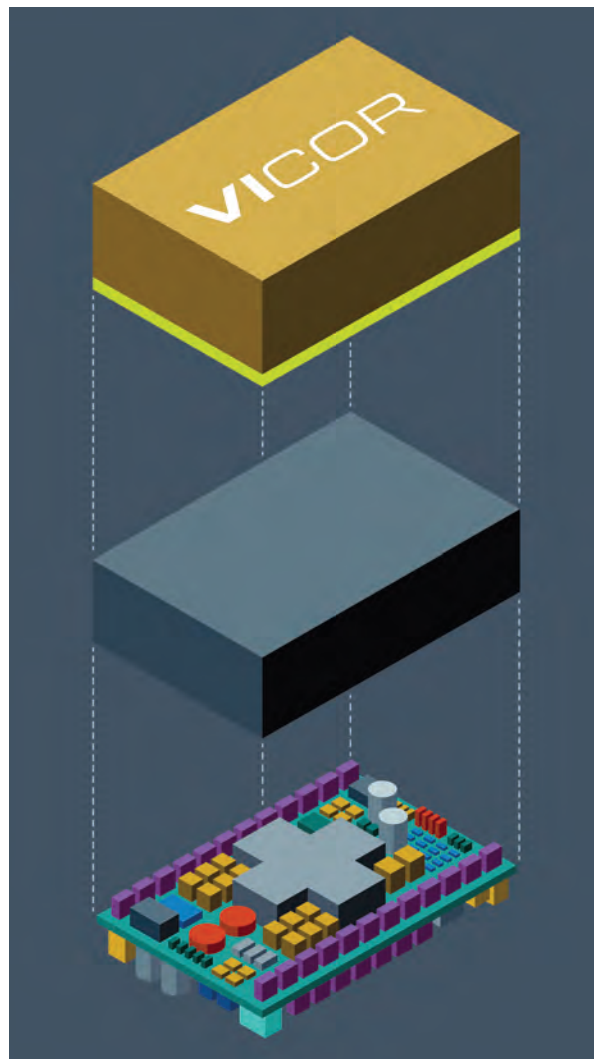
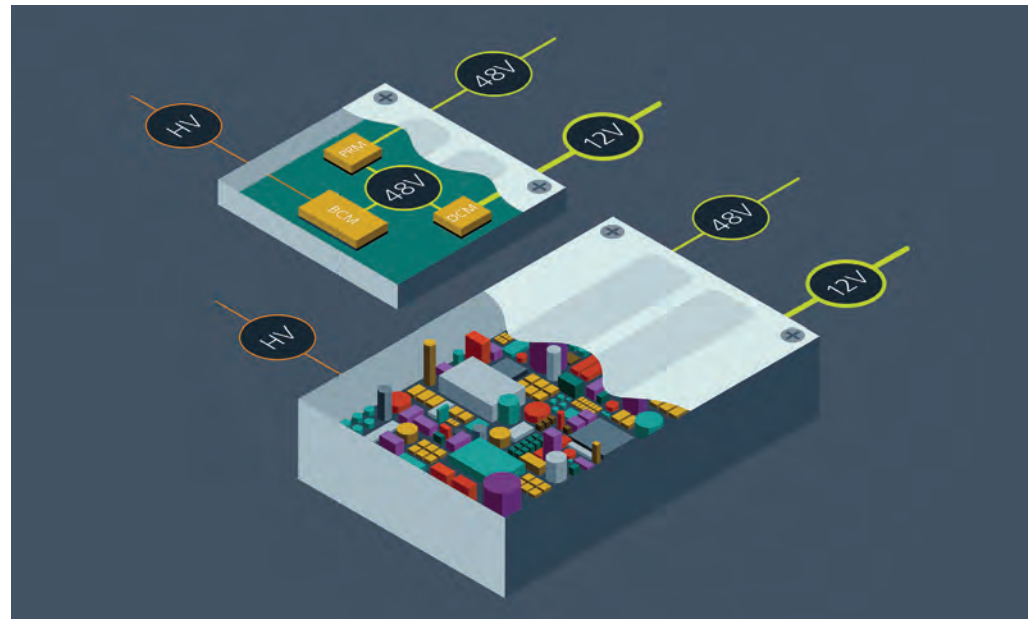


Figure 3: The Vicor ChiP™ package uses a proprietary overmolding (middle layer in gray) which completely encapsulates components. These modules are therefore free from risk of arcing, while delivering high efficiency and advanced heat dissipation to cool components more effectively.

Figure 4: The ability of Vicor's solutions to efficiently address coverage and clearance requirements has important residual benefits. With Vicor products, the industry can transition from a hefty silver box, filled with hundreds of components, to a smaller, lighter more efficient enclosure. The smaller power modules enable the DC-DC converters, on board charger and inverter to be housed in a small box.



struggle. Discrete systems have trouble delivering high-power-density conversion that meets these safety requirements. For discrete solutions to adhere to proper spacing standards, they need to have a larger footprint. This increase of vehicle package space is what OEMs are keen to avoid.

Vicor innovative high-density power modules are compact and lightweight, offering a lot more flexibility in solving the issue of space especially for 400/800V battery application. By reducing DC-DC converter weight by as much as 50% and package volume by 60%, Vicor power modules free up space, reduce system mass and improve design efficiency. With an 80% smaller packaging size than typical bus converters, the Vicor BCM6135 has many benefits for automotive applications. It offers leading power density of 20.8kW/L and design flexibility to meet challenging creepage and clearance

standards. With a peak efficiency of 98%, input range varying from 800 to 48V, and an output range of 2.4 – 55V, the BCM6135 converts high voltage to SELV (48V) very effectively.

Vicor high-performance BCM® bus converters, PRM™ regulators and DCM™ DC-DC converters help OEMs easily solve creepage and clearance challenges. These modules are capable of being used in parallel to scale power when needed. With high power density and compact size, these modules can be placed in tight areas. Conversely, discrete power components that are much bulkier and less efficient cannot provide the same versatility.

Overmolded power modules enable safer, smaller designs in EVs

The automotive industry is in a new era of innovation that requires a fresh approach

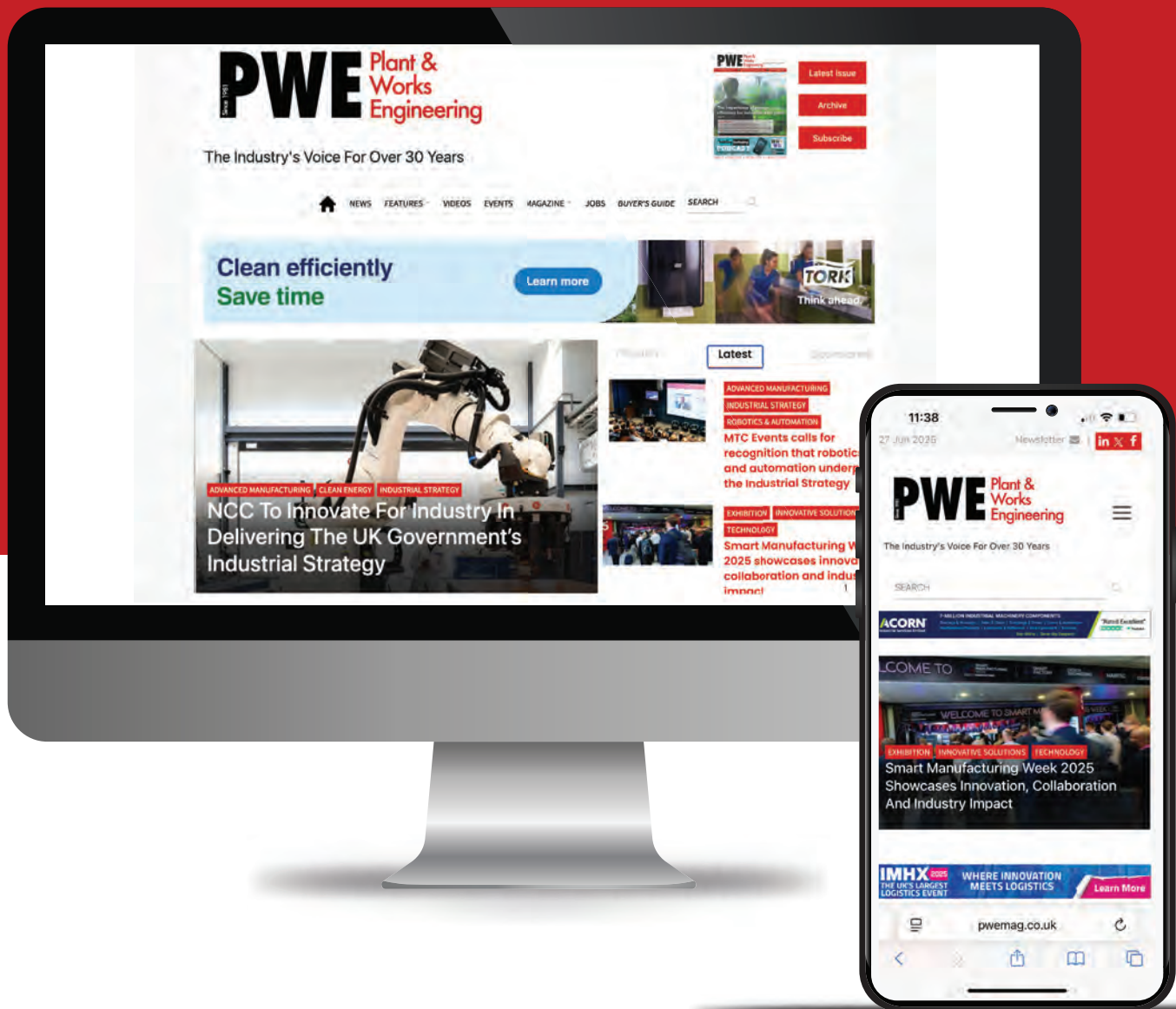
for designing for higher voltage applications such as a 400 or 800V battery pack. If not addressed properly, arcing will hamper power designs and become a safety issue. The industry challenge is to do more (adding high voltages) but within the same space. Legacy discrete solutions are not able to achieve safe distancing for higher voltages and it's important to innovate using Vicor's patented overmolded power modules. With power modules, the challenges stemming from creepage and clearance are eliminated.

From their proprietary overmolding processes to their miniaturized dimensions, Vicor high-density power modules are simplifying design challenges for creepage and clearance requirements. They are also able to deliver reliability and high efficiency while simultaneously downsizing designs and broadly eliminating arcing concerns for the OEM.



Figure 5: BCM®, PRM™ and DCM™ power modules effectively address safety requirements while delivering high efficiency and minimising space consumption

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Advancing semiconductor design through wide-bandgap engineering

By Chinmoy Baruah, Founder and CEO at CHIPX

The global demand for energy and compute is rising exponentially, largely driven by data-intensive AI workloads, electrified transport and the exponential growth of data centre infrastructure. This presents new challenges for power electronics engineers tasked with the design, development, testing and improvement of systems that control the critical flow and transformation of power.

There are a lot of important conversations happening about how to secure energy, keep the lights on, and continue to meet these computational demands. An area within this that is often overlooked, are the big developments happening at the tiny, semiconductor-level – with silicon chips having been an essential building block for all the technology and power infrastructure we take for granted today.

The need for new building blocks

The silicon chips that have powered this digital growth now face constraints in speed, efficiency and sustainability. Meeting the demand for ever-greater compute density while reducing power consumption requires a rethink at the material and system-level. Chip designers are now turning to wide-bandgap (WBG) and compound semiconductors that promise higher performance and lower emissions – a quiet revolution redefining how power is generated, converted and delivered - from grid infrastructure and EV charging systems to renewable converters and industrial drives

Silicon-based semiconductors have clear performance limitations in today's AI and data-led world. As power, thermal and switching demands soar, silicon's narrow band-gap restricts the ability for chips to operate efficiently at high voltages, frequencies and temperatures. To sustain the trajectory of performance and efficiency, chip designers are increasingly turning to compound materials.

At the same time, the opportunity is enormous. The UK government's National Semiconductor Strategy highlights



compound semiconductors as critical to industrial competitiveness and energy resilience. The future of compute and the systems that it powers, will depend on how effectively we can navigate the limitations of silicon and adopt materials that enable both speed and sustainability.

While there will always be a role for silicon to play, but there is a clear demand for a new class of devices based on WBG chips that are physically able to deal with modern power requirements.

Power at the core of the next generation of devices

Devices powered by WBG semiconductors are capable of sustaining higher voltages, switching at higher frequencies and using materials that are more resistant to high temperatures. These characteristics translate directly into lower energy losses, reduced dependence on liquid or direct-to-chip cooling systems, and higher power density and performance at the device-level.

In data centres especially, WBG devices support power-supply units and conversion modules that handle heavier loads while consuming less power and

producing less heat - a critical advantage as the UK faces grid-connection constraints and cooling bottlenecks. But their impact extends far beyond the server rack. In electric-vehicle inverters, renewable-energy converters and industrial automation systems, WBG semiconductors enable smaller components and more efficient power control.

Semiconductors perform multiple core functions to this end: processing and memory (CPUs, GPUs, DRAM), networking (photonic and optical interconnects for high-speed data transfer) and power management (voltage regulation, DC-DC conversion). WBG devices enhance each of these layers - improving efficiency, reducing heat and ultimately cutting total power usage effectiveness (PUE).

To understand how these device-level improvements are achieved, we need to look a little deeper at the specific materials and compounds that make such performance gains possible.

Inside the materials that make it possible

The two compounds underpinning this performance leap are primarily Gallium Nitride (GaN) and Silicon Carbide (SiC). Their wide-band gaps enable higher electric-field strengths, faster switching and greater thermal resilience than silicon. Though these materials have existed for decades, their relevance is accelerating quickly as power and performance demands grow.

As ever, with opportunity comes new challenges. China accounts for roughly 98 % of gallium production, creating supply-chain and geopolitical dependencies. GaN and SiC devices have tended to carry higher upfront costs but their lifecycle economics tell a different story: higher efficiency and lower cooling requirements translate to reduced operating costs and extended component life.

In the UK, a recent Power Semiconductors Landscape Report

highlights domestic capability and the opportunity to scale compound semiconductor production. This type of national and regional capability is important, but alongside this we should consider how to develop a decentralised and accessible global value chain, that provides companies with access to GaN and SiC at an affordable price.

Meanwhile, innovations taking place at the back end including assembly and packaging of chips into wafers, is helping to reduce heat generation at the source. Rather than relying on energy-intensive direct-liquid cooling, advanced chip-stacking and substrate design enable ambient-temperature operation - achieving stability and efficiency through architecture rather than auxiliary systems. The result is lower energy use, lower water consumption and a significant cut in total system cost.

These same properties that improve data centre and compute efficiency are also transforming how power is controlled, converted and delivered across conversion and energy storage systems.

Powering the hydrogen and clean-energy transition

WBG semiconductors are central to the

clean-energy transition. In renewable energy conversion, storage and hydrogen systems, GaN and SiC deliver compact, efficient and robust power electronics.

In green-hydrogen production for example, where renewable electricity powers electrolyzers to split water molecules, GaN/SiC devices increase efficiency by minimising switching and conduction losses. Their higher switching frequencies allow smaller, more affordable power modules, reducing balance-of-plant cost and physical footprint. In fuel-cell vehicles and hydrogen refuelling stations, the ability to handle high voltages and temperatures improves conversion performance and system reliability.

A recent report from the Compound Semiconductor Applications (CSA) Catapult identifies compound semiconductors as "critical enablers across the hydrogen and energy value chain," highlighting their importance in high-efficiency power conversion for electrolysis, grid integration, and energy storage. Meanwhile, the UK's £11 million REWIRE Innovation & Knowledge Centre, led by the University of Bristol and funded through UK Research and Innovation (UKRI), is advancing wide- and ultra-WBG

semiconductor technologies for high-voltage, low-energy-loss applications spanning electric vehicles, renewable-energy converters and data-centre systems

As these innovations scale across sectors, they signal a wider transformation. One where material science, system design and sustainability converge to define the next era of global compute and energy.

Looking ahead

The story of semiconductors has always been one of constant reinvention and right now, that story is entering its next chapter. Wide band-gap materials like GaN and SiC are changing we think about power itself. The push toward data centre efficiency, green transport and renewable infrastructure all depend on the same principle: doing more with less. The companies and research centres driving this change are building a foundation for an economy that can grow without overheating the planet.

There is a mindset shift taking place across the semiconductor value chain and adjacent sectors, and the next generation of chips are set to make our world more sustainable - one watt at a time.

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Highlights at productronica 2025

Just a short while to go before the anniversary edition of productronica. The world's leading trade fair for the development and production of electronics celebrates its 50th anniversary this Autumn. From November 18 to 21, Munich will once again be the meeting place for the international electronics industry. productronica 2025 will focus on advanced packaging, power electronics and trusted microelectronics. As in previous years, SEMICON Europa will be co-located with productronica at the Messe München exhibition centre. The conceptual sponsor of productronica is the industry association VDMA Productronic.

For its 50th anniversary, productronica can look forward to well-booked exhibition halls. Over 1,600 companies from more than 50 countries will present solutions and products for the future of electronics manufacturing. Alongside productronica, which will occupy seven halls and a total area of 80,000 m², SEMICON Europa, taking place at the same time, will focus on innovations and trends in the field of semiconductors, spread over an area of 25,000 m² and three halls.

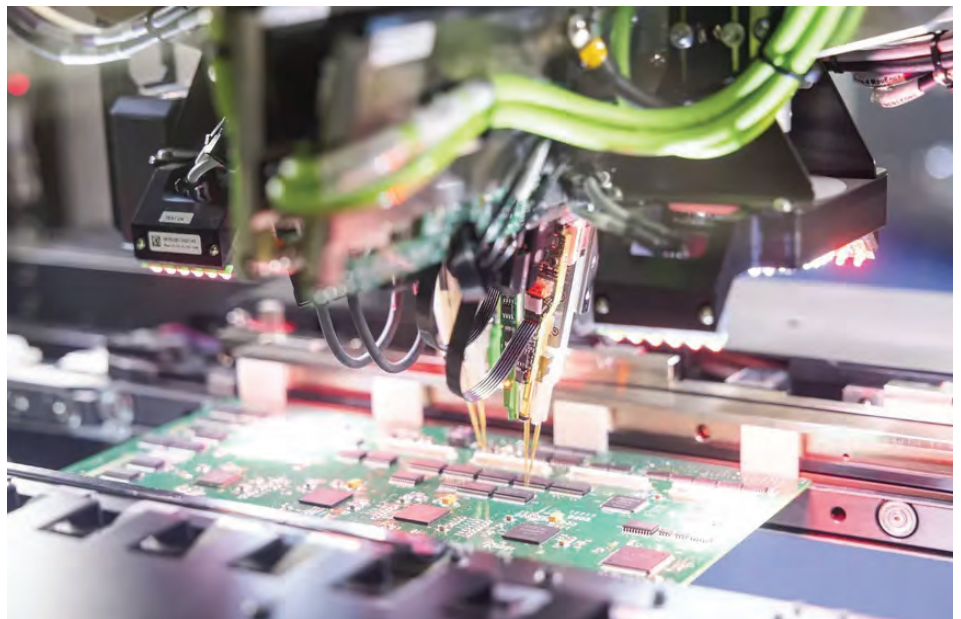
Messe München CEO Dr. Reinhard Pfeiffer is very satisfied shortly before the start of the trade fair: "We are delighted to see a significant increase on the exhibitor side. Compared to the previous event, the number of exhibitors has grown by 16 percent. productronica and SEMICON Europa are once again underlining Munich's status as a top international location for electronics manufacturing."

Special shows focusing on key productronica topics

In addition to the exhibition area with its six topics PCB& EMS, SMT, Cables, Coils & Hybrids, Semiconductor, Future Production, and Overall Production Support, the productronica's supporting program will also focus on the three key topics.

The VDMA Productronics Special Show (Hall B2, Stand 461), together with eight exhibitors, will feature exhibits, live demonstrations on chip development, advanced packaging, and power electronics for the drive concept of electromobility and electric aviation. Among the highlights in the special area will be an electrically powered aircraft. In addition, Kaiserslautern University of Applied Sciences will be presenting the "skills4chips" project and the national training academy Microtec Academy, which was founded as a result. The PhoenixD Cluster of Excellence for optical technologies will also be taking part in the special area. Schweizer Electronic will be presenting the printed circuit board of the future at the special show.

Autonomous driving will also feature in the VDMA special show. The Volkswagen test vehicle ID. Buzz, part of the Fraunhofer IDMT joint project "KI4BoardNet", will provide insights into multisensory solutions that improve the experience and safety inside the vehicle. They include voice interactions between driver and vehicle, and AI-based processes for acoustic monitoring of the vehicle status.



At the Fraunhofer IZM Future Packaging Live Production Line (Hall B2, Stand 261), 21 companies will demonstrate all the steps involved in PCB manufacturing over an area of 360 m² to visualize the current possibilities of modern technologies and processes in this area. These include aspects such as board labelling or laser versus panel milling separation. The real-world laboratory also records the actual consumption values of the production line, allowing visitors to follow the carbon footprint of assembly production live.

Other live demonstrations will be provided by the well-established supporting programme elements Event Stage Cleanroom and the IPC Hand Soldering Competition. The Cleanroom Event Stage (Hall B2, Stand 358), organised by mycleanroom, will show trade visitors what the cleanroom of tomorrow will look like and how high tech, ergonomics, and flexibility will interact in controlled environments in microelectronics manufacturing in the future.

In cooperation with the Global Electronics Association, productronica will once again this year crown the world champion in hand soldering. The qualifying rounds will take place on the first two days of the trade fair in Hall A1, Stand 321. The final decision on the World Championship title will be made on Friday, November 21. All competitors will have 60 minutes to assemble a complex

printed circuit board in accordance with IPC-A-610 Class 3 criteria.

Accompanying forum programme discussing electronics manufacturing of the future

productronica will offer more than 70 presentations, round tables and discussion panels on current and future industry topics on its three stages: productronica Forum, Innovation Forum and PCB & EMS Marketplace. Among the many sessions are two highlights:

On Wednesday, November 19, at 13:15, the panel discussion in the Innovation Forum (Hall B2, Stand 441) will focus on the question "Microelectronics for security-relevant technologies—what measures are necessary for secure supply chains?" Using concrete examples and experiences, the participants will discuss, among other things, what secure electronics basically means and how important it is for mechanical engineering in Europe.

A day later (Thursday, November 20, 10:15), a panel of experts will also discuss the topic "What opportunities are there for mechanical engineering through innovative applications in electromobility?" in the Innovation Forum. The focus will be on different perspectives with regard to possible requirements due to new power electronics components and the successful transfer of new technologies and research results into industrial practice.

Altus Group Adds Scienscope's Newest Flagship X-ray Inspection System to its Portfolio

Scienscope is located in Hall A1 Stand No.151

Altus Group, a leading distributor of advanced electronics assembly equipment in the UK and Ireland, will be adding the Xspection 6600 to its inspection portfolio as its flagship Scienscope offering, supporting Scienscope as they unveil the system at Productronica 2025. The system's advanced feature enables allow Altus to cater to applications that need a stronger penetration, larger magnification and a larger board size, representing a significant leap forward in non-destructive testing capabilities for high-density PCB and advanced package inspection.

Designed for manufacturers requiring the highest levels of detail and reliability, the Xspection 6600 unit features a powerful 160 kV open X-ray tube with 1000 ?A current and a spot size down to 1 ?m, delivering exceptional imaging precision. With geometric magnification of 200x, a 65° tilt range, and a ?890 mm inspection table (circumference 2798 mm), the system provides comprehensive analysis capabilities across a wide range of board and component sizes.

Joe Booth, CEO at Altus Group, said: "We have had a great history with Scienscope and have been very effective over the years with many installations locally. While most customer needs are met by the Xspection 3000 (a 110-130kV closed tube unit), the Xspection 6600 addresses a real need in the market for some customers for deeper, more accurate inspection of increasingly complex assemblies. The combination of high-power X-ray imaging and larger magnification gives our customers unprecedented insight into their products. We're excited to see it showcased at Productronica and look forward to supporting its introduction to the UK and Irish markets."

To further enhance inspection performance, Scienscope has integrated self-learning AI software for faster interpretation, fewer false calls, and simplified programming. The enhanced BGA tool specifically reduces false alarms, while AI-driven image processing supports manufacturers looking to increase

productivity and consistency in complex inspection tasks.

The Xspection 6600 will make its debut at Productronica 2025 in Munich. To find out more or to make an appointment to view the new systems contact Altus, www.altusgroup.co.uk



Smart Manufacturing Pavilion, Booth B1734, (SEMICON Europa)

ASMPT Booth, A3.377 (productronica)
<https://www.criticalmanufacturing.com/>

Critical Manufacturing Brings the Factory of the Future to Life with AI and Intelligent Operations at SEMICON Europa and productronica 2025

At SEMICON Europa and productronica, in collaboration with ASMPT, Critical Manufacturing will show how the factory of the future operates as one connected system where people and AI collaborate seamlessly. The company's Manufacturing Operations Platform unites MES, connectivity, automation, analytics and AI to help

manufacturers master complexity, accelerate decisions, and gain the trust and speed they need to compete.

Visitors will see a live demonstration of the Factory of the Future in action. Data from a reflow oven will be connected, contextualised, and analysed to show how information flows seamlessly across machines, materials, and quality systems. By identifying correlations between process parameters and defect patterns the system is enabling prediction and prevention of quality issues. Users can interact with the data through an AI copilot, asking natural-language questions to reveal insights directly

from production data. This demonstrates how manufacturers can move from digital transformation to intelligence transformation, where AI and automation turn insights into real-time decisions that optimise performance and prevent issues before they occur.

"Electronics and Semiconductor manufacturing demands speed, precision, and the ability to learn at every stage of production," said Pedro Oliveira, Industrial Solutions Engineer for Electronics/SMT at Critical Manufacturing. "We know today that AI is only as strong as the data behind it. At productronica, our visitors can explore how

by connecting machines, MES, and the IoT Data Platform, we are helping our customers build the factory of the future, one where AI continuously learns from data to drive better outcomes."

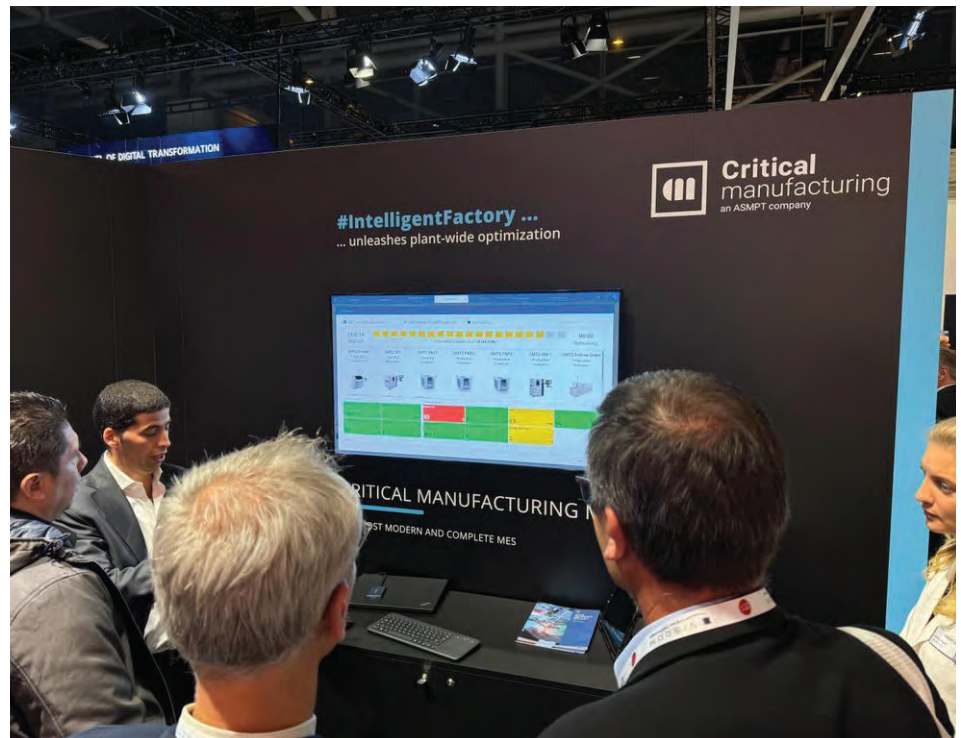
For the Semiconductor demonstration, visitors will see how the Manufacturing Operations Platform ensures complete materials traceability, in line with E142 standards, uniting MES, IoT, and AI to deliver contextualised, real-time insights. These capabilities give chipmakers the agility and confidence to optimise throughput, prevent variability, and sustain yield especially in complex, data-rich environments.

Complementing these capabilities is c-Alice, the company's AI-powered image classification tool, which improves process control through the analysis and classification of images acquired in production. "Manufacturers across semiconductors and electronics face unprecedented complexity but also enormous opportunity," said Tom Bednarz, Managing Director for Germany at Critical Manufacturing. "We will show how our platform transforms that complexity into a strategic advantage and enables continuous innovation in industries that are evolving faster than ever."

Visitors are invited to meet Critical Manufacturing experts at the Smart Manufacturing Pavilion, Booth B1734, (SEMICON Europa) or at ASMPT Booth, A3.377 (productronica) to explore how the

company's Manufacturing Operations Platform can future proof their operations.

<https://www.criticalmanufacturing.com/>
<https://www.asmpt.com/>



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Hall A2, Booth 445 (productronica)
<https://www.plasmatreat.com>

Hall B1136 (SEMICON Europa)

Plasmatreat GmbH, a global leader in the development and manufacturing of atmospheric pressure plasma systems and equipment, will showcase state-of-the-art solutions for particle-free, contactless, chemical-free, and inline-compatible surface pretreatment in semiconductor and electronics manufacturing at SEMICON Europa in Hall B1136 and at productronica 2025 in Hall A2, Booth 445. The focus will be on new nozzle solutions for Openair-Plasma technology and processes for flux removal and rapid oxide reduction. Potential-free plasma reliably removes organic and inorganic residues, selectively activates surfaces, and reduces oxides inline. Using plasma increases yield and process stability, improves adhesion, and enables resource-saving, VOC-free manufacturing processes.

Electronics manufacturing is under significant pressure due to miniaturisation and increasing power densities. These factors require surfaces that are absolutely clean, oxide-free, and wettable, and that are reliably prepared for hybrid/chiplet bonding and wafer-level packaging. At the same time, flux residues and oxide layers must be removed without chemicals, cleanroom specifications must be met, and cycle times must be reliably achieved. Potential-free, low-particle, and dry processes that can be integrated inline are needed. These processes must be both locally precise (selective) and homogeneous over large areas. These processes result in stable interfaces, higher yields, and sustainable process chains without VOCs or aggressive media.

SEMICON Europe: Contactless Plasma Treatment for Maximum Purity in Semiconductor Manufacturing

At SEMICON Europe 2025, Plasmatreat will present cutting-edge solutions for particle-free, contactless surface treatment in semiconductor production. The focus will be on new nozzle solutions based on Openair-Plasma technology that have been specially developed for hybrid bonding, wafer-level packaging, and advanced assembly requirements.

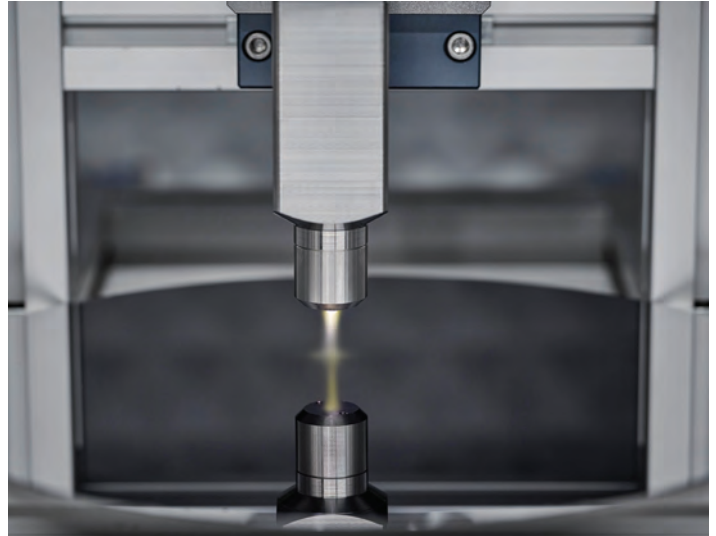
World premiere – new nozzles specially designed for the challenges of semiconductor manufacturing

The presentation will focus on two new plasma nozzles. First is the new DBD nozzle, PDW100, which is a flat, atmospheric plasma application with a treatment width of up to 100 mm. It enables the uniform activation of large areas of sensitive substrates and removes organic residues and oxides without generating particles, ensuring high process stability.

Second, Plasmatreat will present the PFA10 plasma nozzle. It provides a low-particle, potential-free, and precise local plasma treatment. The PFA10 removes organic residues and oxide layers, activates metallic and polymer surfaces, and creates optimal conditions for hybrid bonding and chiplet stacking.

Plasmatreat uses a compact demo unit to show how wafers are precisely moved between two plasma process stations using a contactless transport system (XPlanar from Beckhoff), eliminating mechanical abrasion and particle formation. This creates an ideal environment for the contamination-free pretreatment of sensitive substrates under cleanroom conditions.

“With the expansion of our plasma nozzle range, we can take purity and process reliability in semiconductor manufacturing to a new level,” explains Nico Coenen, Plasmatreat’s Global Director of Electronics Markets. “The PFA10 and PDW100 enable uniform, contamination-free surface treatment, which is essential for reliable electrical and mechanical connections — even in cleanroom class 1 environments.”



Plasmatreat’s Openair-Plasma Technology is dry, chemical-free, and inline-capable. It reliably removes organic contaminants, silicones, and electrostatic dust while increasing surface energy to over 72 mN/m—ideal for subsequent processes such as die bonding, wire bonding, or underfill. The treatment takes place in a matter of seconds, delivers consistent results, and uses cost-effective process gases, such as compressed air or nitrogen.

productronica: Broad and Flexible Portfolio of Solutions for Electronics Manufacturing

At productronica 2025, Plasmatreat will present its comprehensive range of Openair-Plasma solutions for electronics manufacturing, including applications for PCB assembly, coating, and the treatment of leadframes and power modules. Depending on the process step and application, Plasmatreat offers customized systems for cleaning, activation, coating, or reduction — always dry, VOC-free, and inline-capable.

A notable highlight is the REDOX-Tool, which removes oxide layers from metal surfaces inline and in sync with production — without the use of formic acid. This process is chemical-free, reproducible, and automatable. PlasmaPlus will also be on display as a nanolayer technology that promotes adhesion for overmolding, sintering, and bonding processes. This process prevents delamination in epoxy mold compounds and achieves excellent adhesion up to MSL 1. Another trade fair highlight is HydroPlasma, which removes flux residues from the soldering process using water, compressed air, and electricity. This process is solvent-free and particle-free, forming the basis for fluxless TCB and clean PCB assemblies.

Visitors to the Plasmatreat booth can experience these applications live. Modular systems with static or rotating nozzles, generators, and plasma control units demonstrate the reliable treatment of sensitive components. Trade visitors can discuss individual solutions directly with plasma experts.

“Our portfolio of solutions covers all manufacturing steps — from front-end to back-end, lead frame treatment to PCB manufacturing, assembly, and conformal coating,” says Nico Coenen. “Whether it’s activation, cleaning, coating, or reduction, our plasma technologies ensure reproducible, efficient processes, improved adhesion, and greater reliability and durability.”

Plasmatreat supports manufacturers around the world as a reliable partner for process-reliable plasma solutions with its global sales and service network.

<https://www.plasmatreat.com>

SPS 2025 to focus on AI and talent development



From 25–27 November 2025 the Nuremberg Exhibition Centre will host SPS – Smart Production Solutions. For more than three decades the event has been a point of reference for the automation industry, bringing together decision-makers, developers, and engineers to present advances, debate challenges, and identify emerging directions in technology. It remains one of the most established fixtures in the international industrial calendar.

This year's edition will see around 1150 companies exhibiting across 15 halls. Large international names such as Siemens, Beckhoff Automation, Phoenix Contact and Bosch Rexroth will be present, joined by a strong group of British firms including Analog Devices, Motortronics, and Mechan Controls. The range of participants reflects the breadth of the sector and the mix of long-established players and newer businesses that continue to shape automation.

Artificial intelligence will be one of the most prominent themes. AI is already being embedded into process engineering and predictive maintenance, as well as quality assurance and adaptive production control. These applications are influencing the design of both hardware and software and raising questions about efficiency,

flexibility, and resource use. "In many production environments, industrial AI is no longer a topic for the future, it is already a reality. At the SPS 2025, our exhibitors will be showing how AI is already being used in practice today and its potential for future automation applications," said Sylke Schulz-Metzner, Vice President SPS.

For visitors wanting to see how these ideas are being put into practice, SmartFactory Kaiserslautern will run guided tours twice daily. Led by specialists, they will cover companies working in both hardware and software and examine the difficulties currently encountered in implementation. "The aim of our tours is to provide targeted insights into key technologies such as artificial intelligence, digital twins, and security in system architecture. A key priority for us is facilitating the transfer of technological expertise into industrial practice," said Dr. Ingo Herbst, press spokesperson for SmartFactory Kaiserslautern.

The event is expected to draw international visitors, continuing the trend seen in previous years. In 2024, 51,291 people attended in total, 29% of them travelling from outside Germany. The UK accounted for 463 attendees, roughly 3% of all non-German guests. The appeal lies not only in the exhibition stands but also in the

opportunities for exchange. Visitors can attend discussions on digital transformation, cybersecurity, Industry 4.0, and sustainable production. Speaker sessions are followed by informal conversations at neighbouring zones where questions can be pursued further.

Shared booths in Hall 6 will showcase different aspects of collaboration. Automation meets IT will look at the intersection of traditional industrial systems with digitalisation and cybersecurity. The International Start-up Area will provide space for young companies from around the world to present disruptive ideas. The young INNOVATORS booth, supported by the Federal Ministry for Economic Affairs and Climate Action, will highlight the work of emerging German firms.

A strong emphasis is also placed on supporting younger participants. The Makeathon, running throughout the exhibition, will invite pupils, students, apprentices, and young professionals to work in interdisciplinary teams to design prototypes in 2.5 hours, engaging directly with companies. The programme concludes with Young Talents Day, offering guided tours and one-to-one career advice for those considering a role in automation.

<https://sps.mesago.com/nuernberg/en.html>

Rotary Encoders and Motor Feedback Systems: The New System-on-Chip for Optical Absolute Encoders

SPS 2025 (Hall 4A, Booth 146)

The iC-RT2624 from iC-Haus is the new System-on-Chip for optical absolute encoders. Its powerful interpolation circuit detects the angle of a code disc with 26-bit resolution. Thanks to contamination-tolerant scanning and high mounting tolerances, the iC-RT2624 is said to be ideal for housed and kit encoders.

Precise, innovative, and flexible in application: that is the new System-on-Chip (SoC) for optical absolute encoders from iC-Haus. The iC-RT2624 has state-of-the-art photodetectors and robust, contamination-tolerant scanning. The microelectronics integrated in the compact 7 mm x 5 mm optoQFN package delivers accurate measurements within high mounting tolerances. The powerful interpolation circuit with filtering at the heart of the system reliably detects the angle of a 26 mm code disc with 26-bit resolution, even in demanding, dynamic applications. Digitised angle information is available to the BiSS, SSI, or SPI serial interfaces in less than one microsecond. A programmable ABZ generator with FlexCount quadrature resolution easily adapts to any controller and provides sharp edges for excellent control quality.

Thanks to auto-calibration and eccentricity compensation, encoder systems with the iC-RT2624 can easily achieve an angular accuracy of less than 0.01°. On-chip calibration can be performed via the BiSS and SPI serial interfaces or at the push of a button. This simplifies the production of encoder systems and saves time

when commissioning modular kit encoders. The dimensions of the code disc can be freely adjusted with a FlexCode design starting at an outer diameter of 20 mm. This allows compact motor feedback and larger hollow shaft encoders to be developed with the same sensor.

Another new feature is the programmable sin/cos generator, which can be set to 2n CPR ($n = 0..15$) regardless of the base resolution of the code disc. The native sin/cos resolution is simultaneously available for output and routed through a separate, safety-ready signal path. The integrated Absolute Data Interface (ADI) completes the diverse interfaces of this flexible sensor platform and is compatible with established multiturn sensors from iC-Haus, such as the battery-buffered iC-PVL, the gear scanner iC-MV, or

energy harvesting systems with Wiegand wire.

The iC-RT2624 can be operated within 3.0 V to 5.5 V and is sensitive to blue, red, and infrared light. The LED control integrated in the chip adjusts the illumination for an optimal operating point. The encoder SoC is suitable for an operating temperature range of -40 °C to 125 °C. A comprehensive monitoring and diagnostic architecture constantly checks the operating conditions. For instance, a digital contrast measurement detects when condensation or precipitation from outgassing ball bearing grease impairs the optical projection before the angle detection is critically disrupted – for permanent condition monitoring

<https://www.ichaus.de/product/ic->



Watlow Showcases Edge Intelligence and Power Control Innovations at SPS

SPS 2025 (Hall 7, Booth 370)

Watlow, a global leader in industrial thermal systems, will present its latest intelligent control and power management technologies at SPS 2025 in Nuremberg. As part of its vision for the Factory of the Future, Watlow will demonstrate how its Edge Process Management (EPM) Data platform and PowerNode controller enable manufacturers to simplify control architectures, improve process efficiency, and achieve smarter, data-driven production.

Central to Watlow's vision for the Factory of the Future is a commitment to decarbonisation through the electrification of industrial heating. By replacing fossil fuel-based systems with advanced electric solutions, manufacturers can significantly reduce energy consumption and carbon emissions while enhancing process reliability and control. At the centre of Watlow's stand, visitors will discover EPM Data, a cutting-edge, data-centric, and distributed platform that connects machines, people, and processes. By bringing intelligence to the edge, where information is generated, EPM

Data empowers operators to make faster and better-informed decisions while maintaining robust data integrity and cybersecurity.

EPM Data provides an integrated environment for data management and process visibility. With intuitive touchscreen HMI, the platform supports real-time monitoring and control, helping manufacturers enhance efficiency and ensure compliance across regulated and industrial environments. Designed to support digital transformation, it combines modular I/O, a common configuration environment, and multi-

protocol connectivity to integrate seamlessly across plant and enterprise networks.

Key features of EPM Data include ease of compliance with global regulations such as AMS2750, CQI9, FDA 21 CFR Part 11, EudraLex Annex 11, and ISPE GAMP 5 Second Edition, Category 3. Data accuracy and integrity are maintained through patented precision input technology and a tamper-resistant file format that supports full audit trails to meet the requirements of standards such as FDA 21 CFR Part 11 and SAE AMS2750. Real-time analytics and batch validation functionality are designed to simplify compliance and improve process performance. Visitors will be able to experience interactive demonstrations of the platform's data visualisation and diagnostic capabilities.

"EPM Data represents a major step in connecting process data and operational control," said Sébastien Girard, Industrials Commercial Director Europe at Watlow. "By combining edge intelligence, real-time analytics, and a secure digital framework, manufacturers can improve productivity, reduce downtime, and enhance product quality across their operations."

Complementing the EPM platform, Watlow will also introduce its new PowerNode controller, an integrated multi-loop temperature and smart power controller designed to simplify system



design, reduce wiring complexity, and minimise panel footprint. Featuring four independent temperature control loops and power control outputs, the PowerNode controller merges temperature and power control in one compact device. Daisy-chained Ethernet communication supports supervisory control and inter-module data sharing, reducing build time and wiring errors. The Ethernet also provides PoE (Power over Ethernet), further reducing wiring requirements.

"Together, the EPM platform and PowerNode controller form a unified approach to process and power management," added Girard. "They exemplify Watlow's commitment to simplifying automation while enabling greater connectivity and control for customers in complex manufacturing environments."

Watlow will also feature its integrated thermal

loop, illustrating how data, control, and heating technologies work together to create a responsive and efficient system. The display will show how coordination between the controller and heating elements delivers greater accuracy, consistency, and energy efficiency in demanding industrial environments. It will include several of Watlow's high-performance heaters

Watlow invites attendees to discover how its integrated control, power and heating solutions are enabling a new era of connected, efficient manufacturing at SPS 2025, Hall 7, Booth 370.

For further information, visit
www.eurotherm.com/events/sps-2025-nuremberg-germany-25-27-nov or
www.watlow.com

SPS 2025: Moxa Presents a Broad Product Portfolio for Future-Proof, Secure and Reliable OT Networks

SPS 2025 (Hall 5, Booth 419)

Moxa Europe, a leader in industrial communications and networking, will present solutions for building future-proof, safe and reliable machines, systems and OT networks at SPS 2025 (November 25-27, 2025 in Nuremberg) in Hall 5, Booth 419.

Under the motto "Manufacturing connected. Securely. Since 1987" Moxa will be showcasing its comprehensive portfolio of switches, next-gen firewalls, intrusion prevention systems and serial-to-Ethernet gateways that comply with IEC 62443-4-2. This allows industrial cybersecurity requirements such as NIS-2 and the Cyber Resilience Act (CRA) to be implemented in a practical way. With support for numerous protocols (e.g. PROFINET, MRP, EtherCAT, OPC UA FX), the Moxa portfolio stands for interoperability, scalability and flexibility. With an expanded Serial-To-Ethernet gateway portfolio, Moxa creates the possibility of integrating brownfield into modern OT networks in retrofitting projects. Moxa responds to the growing demand for real-time

performance with gateways and junction boxes for EtherCAT.

OT Cybersecurity in Focus

With the NAT (Address Translation & Access

Control) devices of the NAT-102/108 series, Moxa resolves IP conflicts in production. Even if several machines have the same IP, they can be integrated into the OT network securely with little effort. The series accelerates machine onboarding



and supports role-based access control. The hardened design in accordance with IEC 62443-4-2 Security Level 2 (SL2) includes e.g. secure boot, signed firmware updates, traffic logging and MAC/IP/port filtering and supports key requirements from CRA Annex I Part I.

The industrial IPS (Intrusion Prevention System) EDF-G1002-BP-Series combines Deep Packet Inspection (DPI) and virtual patching with up to 500Mbps and 45,000 packets/s for real-time protection in machine or plant networks. It strengthens network security through hardened access control, defence against known threats, and comprehensive logging for complete traceability, and helps machine builders implement key requirements from the CRA. Whether in passive detection mode or active prevention, the firewall increases the visibility of threats.

The device works in transparent mode, so it can be integrated directly into the network topology without changing existing IP addresses. The management interface can be operated in a separate VLAN and thus enables the segmentation

of access and monitoring without affecting production. The EDF-G1002-BP series is certified according to IEC 62443-4-2 SL2, EN 50121-4, NEMA TS2 and IECEx and is also suitable for use in railway, traffic and explosive environments.

CRA Alignment over the Product Lifecycle

In addition to secure-by-default devices that cover CRA Annex I Part I, Moxa also supports CRA Annex I Part II with an IEC 62443-4-1 aligned Secure Development Lifecycle (SDL). This includes systematic, portfolio-wide threat modelling, secure coding, and continuous testing. Moxa's Product Security Incident Response Team (PSIRT) coordinates responsible vulnerability reporting in accordance with international standards. As an official CVE Numbering Authority (CNA), Moxa assigns CVE identifiers to its own products and consistently publishes entries for high traceability. Security advisories and SBOMs (Software Bill of Materials) ensure transparency. In addition, Moxa supports the fulfilment of CRA documentation requirements for third-party components and the

implementation of secure OT networks in accordance with the IEC 62443 and NIS-2 frameworks with solutions for zoning and network segmentation, access control, auditability and long-term resilience.

Transparency in the Network: Live Demo MXview One

With a live demo of the Network Management Platform MXview One, visitors will experience real-time monitoring and diagnostics in industrial networks. The software automatically detects and visualises network and SNMP/IP devices in subnets. Administration and configuration are carried out centrally via the web browser. A dynamic topology view shows the connection and redundancy status at a glance: Comprehensive reports and notifications of events, detailed device information, complete visibility of redundant LAN connections and numerous other functions ensure end-to-end transparency at all times.

www.moxa.com

Advantech at SPS 2025: intelligent and connected ecosystems that drive real-time insights and innovation

SPS 2025 (Hall 7, Booth 380)

Advantech, a global leader in edge computing and intelligent systems, will be exhibiting at SPS 2025 under the theme "Edge Computing & WISE-Edge in Action", the company will demonstrate in hall 7, booth 380 how its WISE-Edge platform can unify edge computing, AI, and implementation to enable intelligent, real-time operations in a wide variety of industrial sectors.

"SPS is a key event for Advantech" says Jash Bansidhar, AVP of Industrial Automation Sector, Advantech Europe. "It offers an ideal platform to showcase our innovation in edge computing, AI and industrial IoT." Bringing together decision-makers, engineers, and system integrators, SPS helps Advantech to

demonstrate real-world solutions, and to strengthen partnerships within its growing ecosystem, which includes leading technology partners such as NVIDIA, Intel, AWS and Qualcomm.

According to Bansidhar, today's customers are looking for more than just technology. "They want us to understand their pain points – and their growth areas. It means moving from being a supplier to becoming a strategic partner. And what makes Advantech unique is that we offer both the hardware and the software expertise to achieve true IT/OT convergence. We cover everything from data acquisition, communication, edge computing, certification and protocol conversion to edge computing and IoT software frameworks, making us a strong enabler of digital transformation."

Visitors to the booth will have the opportunity to explore ten different application areas. These include: Edge AI for digital human interaction on a shop floor; Edge AI for both AMR solutions and the Jetson Thor Platform; Edge controller with Codesys for software-defined automation; how to make brownfield secure and ready for CRA; effortless traceability in smart manufacturing with vision intelligence; and more.

During SPS, Advantech will also unveil the new AMAX IoT control platforms, a series of innovative solutions that combine PLC, HMI, and IoT functions into a single software-defined platform, simplifying traditional system integration while ensuring deterministic real-time performance for precision automation applications.

Visitors will have the opportunity to discuss specific applications and use cases with Advantech's teams of technical specialists, industry specialists, and product specialists, led by Anis Aroua, Alicja Strzemieczna and Marco Zampolli respectively.

As in previous years, participants are also warmly invited to join Advantech's traditional wine tasting session at the booth on Wednesday, 26 November, from 3 p.m. onwards. The event will feature local Franconian wines from Weinbau Peter Schmidt of Nuremberg.

<https://www.advantech.com/en>



Protection Needs for Uninterrupted Power Supply Sub-Circuits

Introduction:

Essential elements in the latest data center topologies, Uninterruptible Power Supplies (UPS) are indispensable for ensuring continuous network availability and resilience. Because data centers operate as the backbone of today's digital infrastructure, even milliseconds of downtime can result in service disruptions leading to possible financial loss or data corruption. UPS are not only used to bridge momentary outages, they also shield sensitive equipment from harmful transients, surges, and fluctuations that would otherwise compromise performance or trigger costly downtime.

To better understand the level of circuit protection that is needed in these mission-critical environments, this article presents the internal design basics of UPS systems, examining the sub-circuits and component technologies that enable uninterrupted operation. The latest protection component technology and capability advancements are also highlighted giving UPS designers their protection scheme options. Taking a proactive circuit protection approach provides the safeguards needed to achieve the performance, safety, and redundancy required to support the evolving demands of data centers and other high-value applications.

UPS System Operational Basics:

UPS systems are designed around several common-used topologies. These include standby (offline), line-interactive, and double-conversion online architectures. While standby and line-interactive designs

are typically sufficient for less critical load environments, data centers and other high-availability facilities almost exclusively rely on double-conversion architectures due to their superior power conditioning and fault tolerance.

In a double-conversion UPS, the input AC is continuously rectified to DC. This configuration is capable of supplying the inverter and maintaining the charge of the energy storage system, which is typically a battery bank. The inverter then reconstructs a regulated AC output, effectively decoupling the load from disturbances on the utility line. Because the inverter is always online, there is no transfer time when the input source fails to help maintain a seamless continuity of power.

This topology provides more than just ride-through capability. The rectifier stage filters voltage sags, surges, harmonics, and frequency variations from the incoming AC. The inverter stage delivers a clean sinusoidal waveform within tightly controlled voltage and frequency tolerances, independent of the input condition. Advanced systems also integrate static and manual bypass paths, galvanic isolation (required in some designs), and redundant power modules to support fault tolerance and maintainability without compromising uptime.

For data center applications, double-conversion UPS systems can be further configured in parallel or distributed redundant topologies, enabling 2N+1 resilience. These architectures minimize single points of failure and allow for scalable capacity while meeting Tier III and

Tier IV uptime requirements.

Power Protection Requirements

To be effective, UPS systems need to deliver a stable, clean AC output waveform, regardless of disturbances on the input line. An essential role in maintaining this level of stability is protecting against overcurrent and overvoltage events. These disturbances—whether caused by lightning strikes, switching transients, short circuits, or rapid load changes—can inject thousands of amps or dangerously-high voltages into the system. Unless effective protection is integrated, such events would quickly destroy sensitive power electronics within the UPS.

To mitigate these risks, it is advised that UPS designs incorporate multiple layers of circuit protection. Devices such as traditional fuses, metal-oxide varistors (MOVs), and gas discharge tubes (GDTs) each provide targeted defense against specific fault conditions. MOVs and GDTs clamp or crowbar excessive voltage transients to safe levels, absorbing or diverting surge energy away from critical components. Because these devices offer reusable operation, they are good solutions to handle recurring transient surges.

While MOVs and GDTs safeguard against transient overvoltage events, traditional fuses safeguard against destructive overcurrent conditions. Unlike clamping devices, fuses permanently disconnect the circuit when fault currents exceed rated thresholds, providing the ability to localize the damage to the fuse itself. Adding fuse protection helps prevent widespread

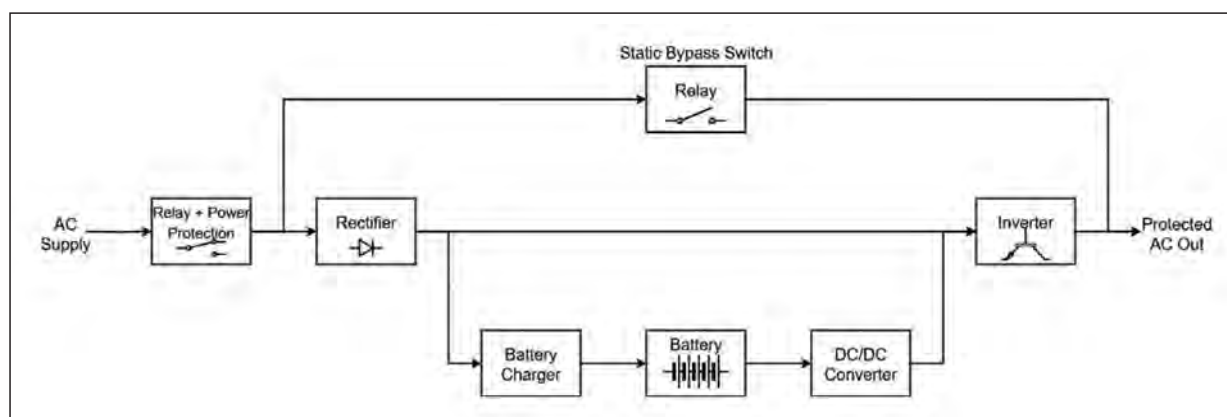


Figure 1. Block Diagram of a double-conversion UPS



Delivering the benefits of both MOV and GDT technologies, Bourns® IsoMOV™ protectors provide low capacitance, low leakage, and high surge-handling capability, streamlining surge protection while improving reliability.

failure within the UPS and shields downstream loads. In data center applications where the consequences of power loss are especially harmful, fuses provide extra defense against worst-case

transient threat scenarios.

Rectifier Power Factor Correction

To maximize efficiency and reduce stress on the electrical grid and UPS

components, rectifiers in UPS systems integrate power factor correction (PFC). The rectifier is a key sub-circuit in a UPS responsible for converting AC from the electrical grid into a stable DC voltage. This conversion also filters out waveform irregularities and fluctuations from the incoming AC supply. A clean DC output is essential for both charging and discharging the UPS battery and establishes a stable foundation for the subsequent DC-to-AC inversion stage.

Without PFC, the rectifier is not in compliance with regulatory standards in high-power installations. PFC is also needed to align the input current with the AC voltage waveform to help minimize total harmonic distortion (THD) and enhance the effective power factor of the UPS.

Implementing PFC and rectification requires a suite of high-performance components. A key solution is with Silicon Carbide (SiC) Schottky diodes that enable high frequency switching with low conduction losses to improve efficiency and reduce harmonic content. Also, current sense resistors can be implemented to provide precise real-time current monitoring for control loops, overcurrent detection, and system diagnostics, helping to ensure stable operation under varying loads.

Another PFC solution to consider is with power transient voltage suppression (TVS) diodes that protect sensitive rectifier and PFC circuitry from voltage spikes. Together, these components enable UPS rectifiers to deliver reliable DC output, optimize energy efficiency, reduce stress on both the UPS and the electrical grid.

Battery Control Protection

UPS devices not only protect against electrical grid fluctuations but also safeguard against flickers and temporary power outages. This is typically accomplished with a rechargeable battery. In most UPS designs, the battery is connected in parallel with the power bus, positioned between the AC-DC rectifier and the DC-AC inverter. During normal operation, the power bus charges the battery. In the event of a power interruption, the battery seamlessly discharges to maintain continuous operation for critical systems such as servers.

This article has highlighted the complexities of UPS designs that call for a multi-stage protection approach. This also applies for auxiliary control circuits like the Battery Management System (BMS). Each component has an essential role: PTVS diodes and surface-mount multilayer varistors (MLVs) provide compact, high-

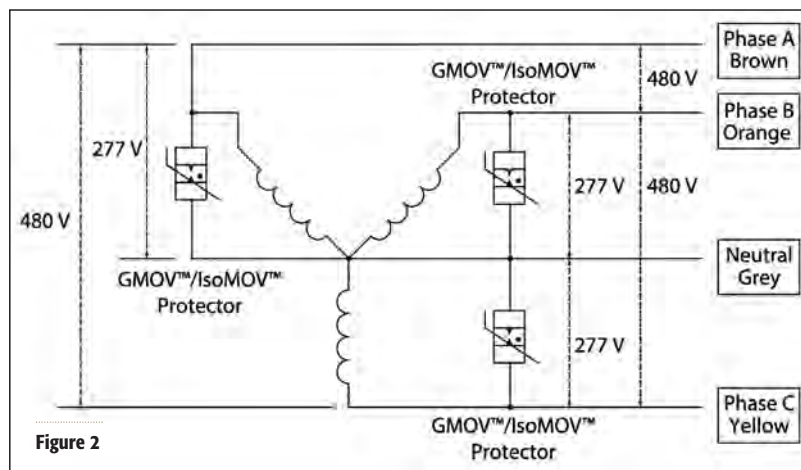


Figure 2

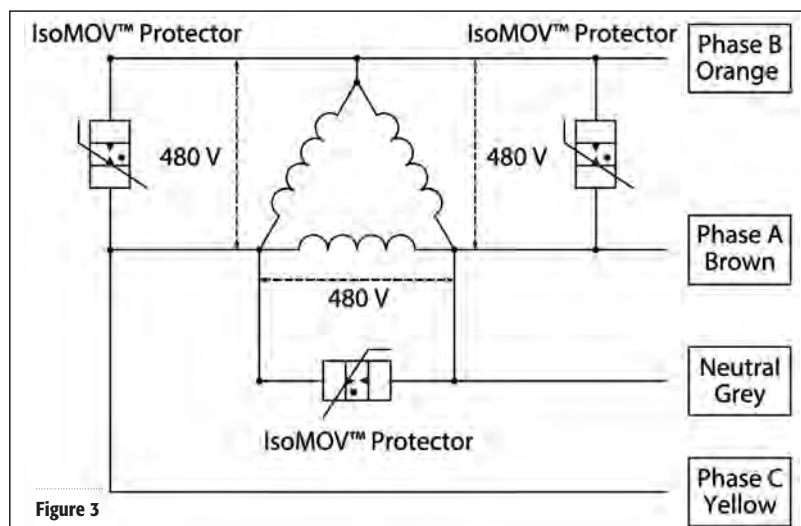


Figure 3

Figure 2 and Figure 3. Examples of AC mains protection using a space-saving Bourns® IsoMOV® protector for a UPS system 3-phase wye and delta input.

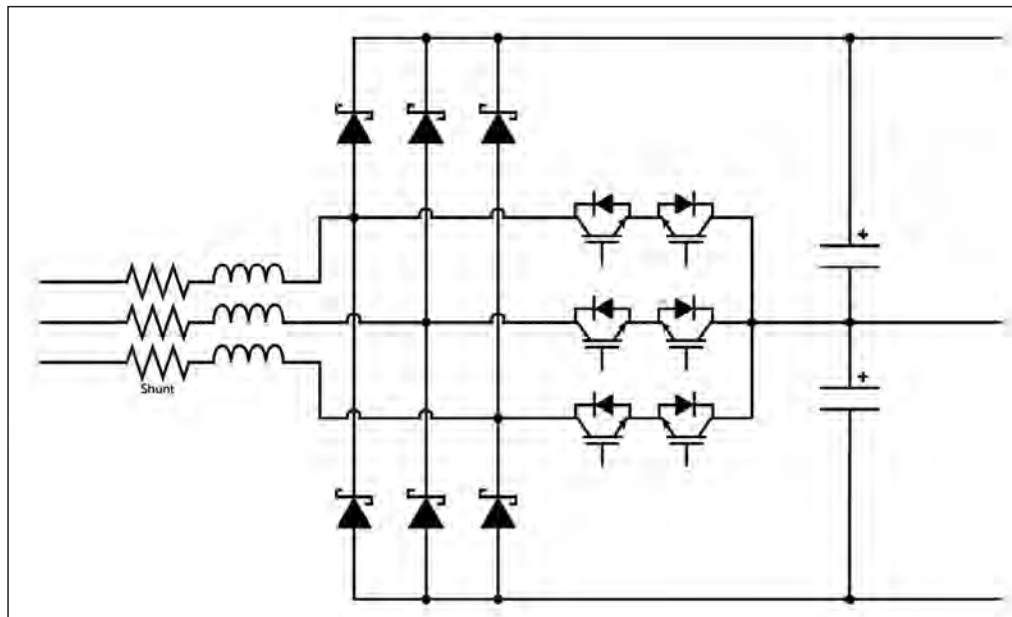


Figure 4. Example rectifier and PFC topology for 3 phase systems – Termed a “Vienna Rectifier”

density overvoltage protection for DC busses against transient voltage spikes, and positive thermal coefficient (PTC) resettable fuses that help prevent overcurrent events by temporarily increasing resistance during fault conditions. In addition, precision current sense resistors and integrated current sense modules deliver needed reliable real-time measurement, enabling the BMS to regulate charging, detect faults, and optimize battery utilization. Also beneficial are transient blocking units (TBUs) that supply high-speed protection against rapid voltage transients for critical communication lines, ensuring system integrity under abnormal operating conditions.

Uninterrupted Inverter Safeguards

The DC-AC inverter is the second stage in an online double-conversion UPS. It is responsible for transforming the stable DC voltage from the rectifier and battery stages back into a high-quality AC waveform. This stage ensures that the output voltage and frequency match the characteristics of the input grid while providing complete isolation from disturbances such as sags, surges, or momentary outages. Therefore, it is a vital element for maintaining uninterrupted, clean power to sensitive

loads, including servers, networking equipment, and medical or industrial systems.

Inverters operate by rapidly switching the DC voltage through power transistors to reconstruct an AC waveform. The precision of this switching directly impacts the fidelity of the output waveform where any imbalance or timing error can lead to harmonics, voltage distortion, or even system failure. In order to meet the demanding UPS performance and reliability requirements, high-quality switching devices are necessary.

Insulated Gate Bipolar Transistors (IGBTs) offer an effective switching choice for inverter applications. IGBTs deliver the features that enable high energy operation, reduce thermal losses, and maintain consistent performance under heavy loads. In addition to IGBTs, other supporting components such as precision trimming potentiometers and resistors, TVS diodes, and current sense shunts that enhance inverter protection, should also be included in any switching control design to further optimize overall UPS reliability.

The Necessity for Broadline Protection Support

The ability of a UPS to maintain clean, continuous energy hinges on

sophisticated circuit design, high-quality components, and comprehensive protection strategies. From the rectifier and PFC stages to battery management and DC-AC inversion, every sub-circuit needs to perform with precision and resilience to safeguard sensitive loads. So, given all the sub-circuits in a UPS that require some sort of protection, it is advised to evaluate component suppliers that offer a broad line of circuit protection products. This way, designers have multiple component options that allow them to select the optimal solutions to safeguard the myriad of sensitive components from voltage and current anomalies.

As the demand for greater uptime and energy efficiency from modern power infrastructures and data center topologies continues, so does sourcing high-quality components that meet UPS extended battery life, higher voltage and reduced operational risk goals. Trusted broadline suppliers such as Bourns have built their protection portfolios to deliver the advanced capabilities complex double-conversion architecture UPS sub-circuits require to withstand voltage transients, overcurrent conditions, and grid anomalies while maintaining optimal performance.

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