

ENGLISH

C O D I C O[®]

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AI-READY:

New MCU from SYNAPTICS

Power Converter – More Power in Less Space

Reduce Costs: GXT[®] Plating from AMPHENOL

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As demands for AI and real-time processing continue to grow, computing power is increasingly shifting from the cloud to the edge, where data can be processed locally and decisions made instantly. To support this development, SYNAPTICS has launched its first integrated MCU with Wi-Fi & Bluetooth.

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What You Can Rely On

»The only constant is change.«

Heraklit

Business conditions are changing faster than ever. Global crises and geopolitical tensions regularly put supply chains to the test. For us as an Austrian distributor, this raises one key question:

How can we provide reliability for our international customers – even in uncertain times?

One crucial factor is close and dependable cooperation with our selected suppliers. Because supply chain stability means more to us than smooth operations under normal circumstances. It truly shows when it matters most.

Over the past year, our partners demonstrated exactly that – through high delivery reliability, a strong service focus, innovative strength, and a high degree of flexibility and responsibility.

These criteria also formed the basis of our 2025 supplier evaluation as part of our supplier management in accordance with ISO 9001.

We are therefore all the more pleased to recognize our TOP Suppliers for their outstanding performance with a Quality Award.

Thank you for your committed cooperation, your trust, and your continuous support.

Looking ahead, we will continue to focus on carefully selecting, developing and strengthening our partnerships. That's something you can rely on.

Would you like to learn more about our supplier management?

Please contact our Quality Management team or visit our website: www.codico.com.

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Karin Krumpel
CEO CODICO

CODICO
Quality Award
2025: SILVERTEL



Editorial

Europe Needs Us. Now.

Dear Impulse readers,

As we prepare for electronica 2026, one question is on my mind in particular: How can we secure Europe's industrial and technological strength for the future? International competition is intensifying, technology is evolving faster, and many decisions affecting our industry are no longer made in Europe.

Europe has a strong industrial base, enormous technological expertise and, above all, people who develop new solutions every day. But simply talking about the need for Europe to remain strong will not be enough. What matters is what we make of it now: how we invest, drive innovation, share knowledge and work together to develop new solutions.

At CODICO, we see this as »Enabling Success«: helping our customers turn their ideas into successful solutions. In doing so, we also want to contribute to a strong European economy. Rather than waiting for others to create the right conditions, it is about taking responsibility ourselves and making the most of the opportunities we have – that is what matters now.

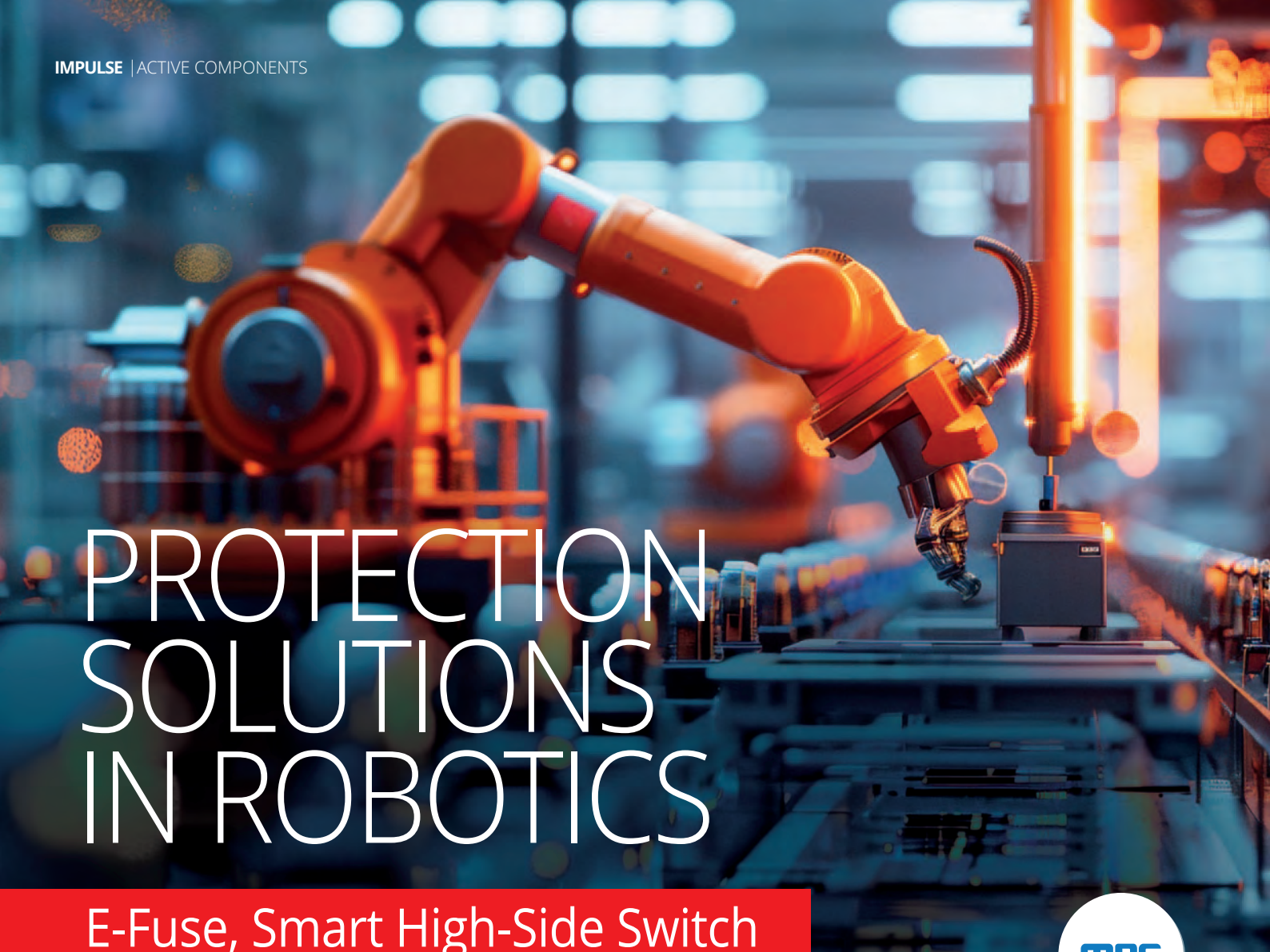
electronica 2026 is the perfect opportunity to do just that. This is where the international electronics industry comes together, where new projects, ideas and partnerships take shape. It is where we can show what we are capable of.

I look forward to meeting you there in person, discussing your projects and discovering new opportunities together.

Visit CODICO in Hall C3.558.

Because Europe's future will not be decided someday. It is shaped by what we develop, invest in and set in motion today.

▶ Karin Krumpel, CEO



PROTECTION SOLUTIONS IN ROBOTICS

E-Fuse, Smart High-Side Switch or Hot-Swap?

MPS

As complexity increases in robotics, industrial, and AI applications, so do the requirements for protecting electronics and power supplies. E-Fuses enable space-saving, controlled, and reversible protection and often provide valuable diagnostic information and intelligent additional functions as well. The lines between E-Fuses, smart high-side switches, and hot-swap controllers are becoming increasingly blurred. Modern devices combine protection, diagnostic, and switching functions, allowing them to be optimally adapted to the specific application.

What Is an E-Fuse?

An E-Fuse is connected in series with the load, just like a fuse. It continuously monitors the current and interrupts the circuit in the event of a fault. With E-Fuses, both the threshold value and the time delay can be adjusted. More advanced E-Fuses distinguish between overcurrent and short circuits. When a short circuit is detected, the E-Fuse trips immediately. E-Fuses can often be connected in parallel or expanded with hot-swap controllers to create more intelligent systems.

What Is a Hot-Swap Controller?

Hot-swap controllers extend the E-Fuse concept to include active inrush current limiting (soft

start), which also enables the controlled connection of large input capacitances without causing a drop in the supply voltage. Thanks to their excellent scalability, they are ideal for large server installations or other electronic assemblies that need to be replaced or connected while the system is running.

Hot-swap controllers can be dynamically adapted to changing conditions during operation and feature a digital interface that allows data to be read and threshold values to be programmed. This makes it possible to monitor changes in the system and identify early signs of failures (keyword: predictive maintenance).

What Is a Smart High-Side Switch?

A smart high-side switch is an intelligent load switch that, in addition to turning a load on and off in the positive branch of the power supply, also integrates protection, diagnostic, and monitoring functions and often includes precise current measurement. Unlike a traditional E-Fuse, the focus here is on the safe switching of individual loads.

As a high-side switch, it also enables various protection and diagnostic functions, such as detecting whether the load or battery has been connected with reversed polarity or whether a ground connection has been lost. Short-circuit and overload shutdown are often additional functions integrated into the IC.

What Advantages Do These Components Offer?

Aside from the fact that an E-Fuse, smart switch, or hot-swap controller is significantly smaller than a traditional fuse, they offer the major advantage that they are not damaged after tripping and do not need to be replaced. They often replace relays and fuses.

For E-Fuses and hot-swap controllers, a distinction is made between latch-off and auto-recover mode. In latch-off mode, the circuit remains interrupted after an overcurrent or short circuit until the user or the electronics manually reactivate it. In auto-retry mode, the system periodically attempts to restore the circuit. This minimizes the downtime of a device or system and reduces failure and associated costs.

Monolithic Power Systems (MPS) offers a wide range of interesting products in this area. Most are optimized for specific applications and combine the functionality of an E-Fuse, a smart load switch, and a hot-swap controller. The table below

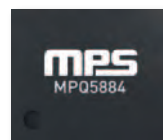
compares three interesting product series that are well-suited for compact designs up to 60V for robotics controllers, motor controllers, or 48V loads. Some of the products can be combined with a classic hot-swap controller, such as the MP5920, to enhance diagnostic capabilities via PMBus.

The following section will discuss the MPQ5884 in greater detail.

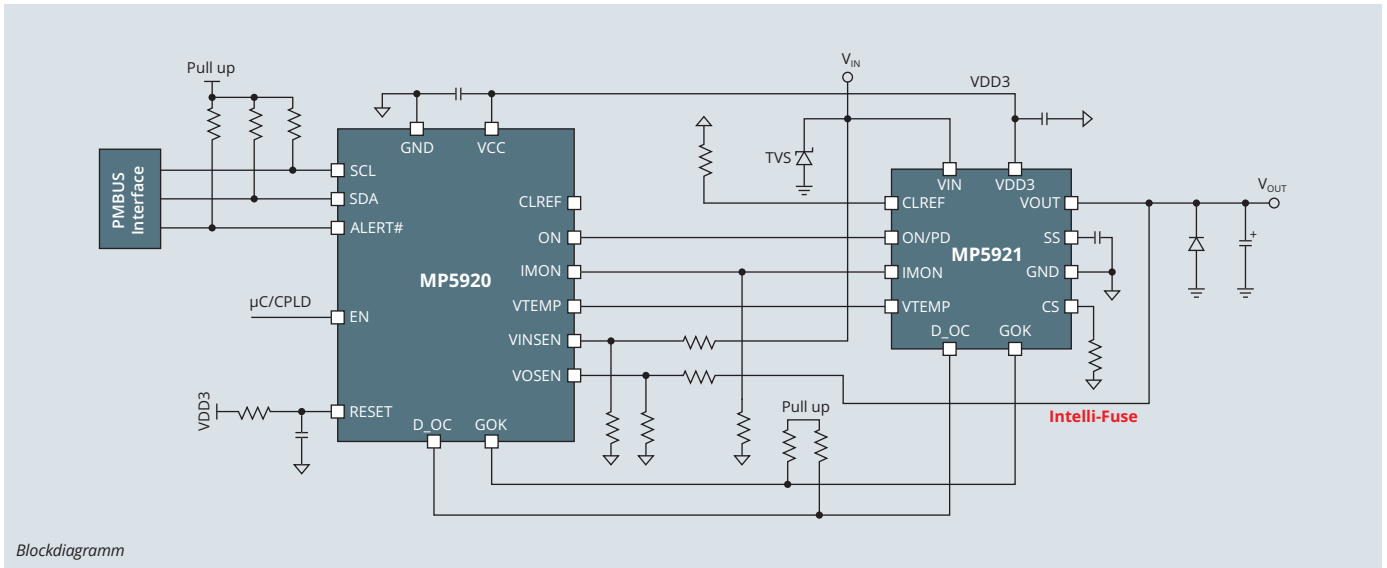
MPQ5884 – Smart Switch + E-Fuse

The MPQ5884 is a smart load switch designed to meet automotive requirements. It replaces the relay and fuse and is ideally suited for decentralizing switching and protection systems.

This makes the MPQ5884 ideal for decentralized protection of individual actuators such as motor drives, valves, pumps, cameras, or sensors. Faults are detected and reported locally without shutting down the entire power supply.



FEATURE	MP5048(A)	MP5921	MPQ5884
Typical Function	Protection of a power supply	Hot-Plug of complete module/subsystem	Switching and protecting loads
Nominal Current	MP5048A: 4A (14mΩ), MP5048: 15A (7mΩ)	50A, 60A with airflow (1mΩ)	15A (4.5mΩ)
Input Voltage	24–60V	4–16V	6–60V
Paralleling	Yes	Yes	No
OCP (Overcurrent Protection) SCP (Short-Circuit Protection) OTP (Overtemperature Protection)	Yes	Yes	Yes
Short-Circuit Level	MP5048A: 6.85A, MP5048: 26A	100A	50A
UVP (Undervoltage Protection)	Yes	Yes	Yes
OVP (Overvoltage Protection)	Yes, 64V	Yes, 18.5V	No
Latch-off / Auto-Retry	Latch-off or auto-retry mode	Latch-off	Latch-off (auto-recover for reverse polarity or load dump)
Inrush Control / Soft-Start	Yes	Yes	No
Hot-Swap	Yes	Yes	No
Diagnostics / Fault Output	Yes	Yes	Yes
Interface	PMBus with MP5920 Controller	PMBus with MP5920 Controller	No
Package	QFN-30 (5×5mm)	QFN-28 (4×5mm)	QFN-30 (5×6mm)
Key Features	• Standalone operation • Optional control by hot-swap controller (MP5920) with PMBus • Configurable OC limit • Soft-start • Fuse health diagnostics	• Built-in fuse health reporting • Output power-down control • Configurable soft-start • Programmable OC value • Provides current & temperature to external controller	• Fuse-like I_{pt} • Configurable OC limit • Open-load and loss-of-IC-GND detection • IC protection against reverse polarity and reverse load • Survives load dump in combination with TVS • Low-I_q mode: 1μA • Supports capacitive loads up to 60μF • Automotive AEC-Q100 • MPSafe supporting documentation for ISO 26262
Application	Robotics, Industrial PCs, power supplies, 48V modules, industrial applications, servers, networking	AI servers, data centers, PC cards, disk drives	Robotics, AMR/AGV, automotive, battery loads, actuators



The MPQ5884 emulates the behavior of a traditional fuse (Fuse-like Overcurrent Protection). The trip characteristic can be optimally adjusted to the application using an external capacitor.

Key Features

- Operating range of 6V–60V
- 4.5mΩ $R_{DS(on)}$ for nominal current of approx. 15A
- Immediate short-circuit shutdown at 15–50A (adjustable)
- Fuse-like I^2t
- Current limiting adjustable via external circuitry
- Open-load detection, ground loss detection (e.g. cable break or damage)

- IC protection against: reverse polarity, load dump, overtemperature
- Charging of capacitive loads up to 60µF
- Latch-off in case of overcurrent & short circuit
- Auto-recover in case of reverse polarity, loss of ground
- Fault diagnosis via FAULT pin
- 4 power-saving modes
- Automotive qualified to AEC-Q100
- MPSafe support documentation for functional safety
- At 5mm×6mm, significantly smaller than Mini or Maxi fuses

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CONCLUSION

Requirements vary significantly depending on the application. While E-Fuses primarily protect power rails, smart high-side switches are particularly well-suited for decentralized protection of individual loads. Hot-swap controllers complement this portfolio wherever high input capacities or hot-plug capability are required. With the MP5048, MP5921, and MPQ588x product families, MPS offers suitable solutions for all three application areas.



VENTUNO™ Q

Open Source, Rapid Prototyping Platform for Advanced Robotics, Drone and Edge AI Applications

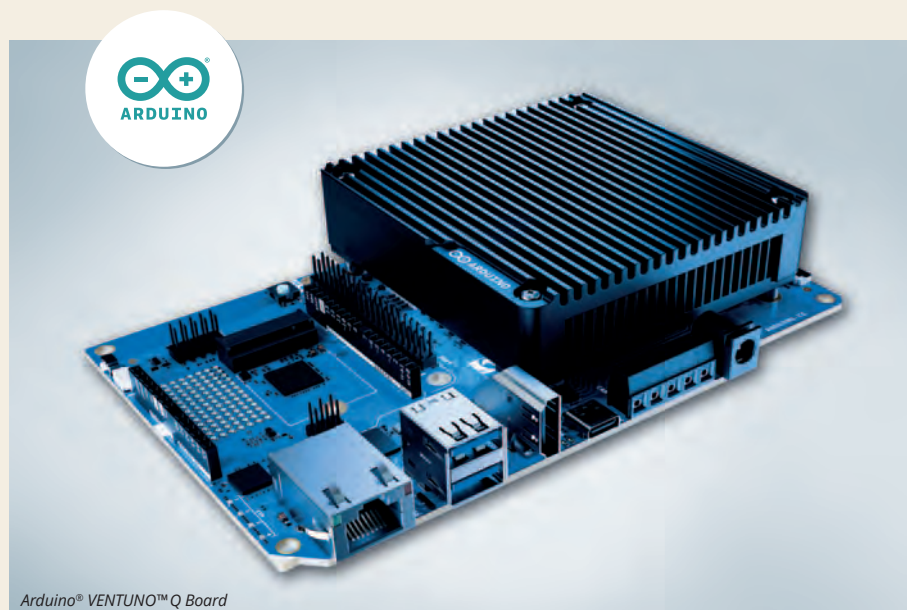
With the unique Arduino® VENTUNO™ Q platform, you combine high-performance AI compute, real-time actuation and control with a comprehensive software stack and tools to rapidly prototype advanced robotics, drones, and Edge AI use cases.

According to the latest estimates, Europe today accounts for nearly 28% of robot installations globally. The total market in the region is expected to grow from \$16 billion to \$37 billion by 2031. While industrial robots continue to dominate the market, we now see double-digit growth for robotics in logistics, warehousing, healthcare and a host of other industries due to many factors including an aging workforce, regulatory trends and the expansion of the digital economy. In an age of exploding robotics demand, engineers need innovative solutions to move advanced robotics and Edge AI concepts from prototype to production quicker than ever before. The newly launched Arduino® VENTUNO™ Q was created solely with this purpose in mind.

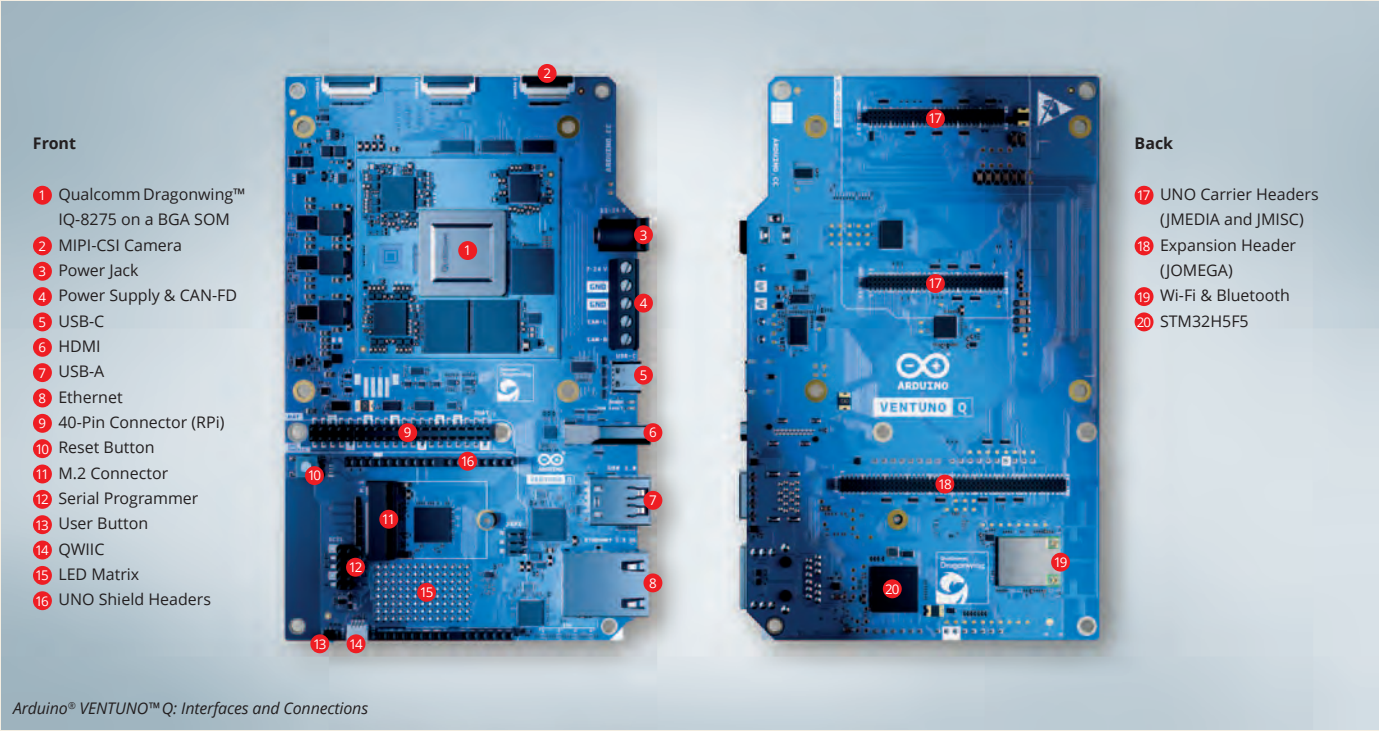
The Arduino® VENTUNO™ Q is the second Qualcomm Dragonwing™ SoC-based platform launched by the renowned Italian IoT experts since their acquisition by Qualcomm in October 2025. Its name is derived from the Italian word for 21, which commemorates the 21 years Arduino has been supporting the IoT market with accessible electronic platforms. This launch is part of Qualcomm's strategy to put its market-

leading computer vision and Edge AI devices in the hands of millions of IoT developers. The Arduino® VENTUNO™ Q also represents a world's first in terms of delivering all of the major hardware and software components required for a typical robotics developer in a single, highly integrated and cost-effective platform. Let's take a closer look.

We will start by looking at the unique hardware setup of the Arduino® VENTUNO™ Q. It follows the same approach Arduino took with the UNO™ Q solution. A dual-brain architecture combines a powerful and highly integrated Qualcomm Dragonwing™ IQ8 SoC to run the complete robotics, computer vision and Edge AI use cases under Ubuntu or Debian Linux. Paired with the Qualcomm Dragonwing™ IQ8 is an STM32H5F5 MCU running the Zephyr OS, which is responsible for the real-time control, actuation and safety requirements of an Arduino® VENTUNO™ Q-based system. To enable communications between



Arduino® VENTUNO™ Q Board



these subsystems, Arduino developed a dedicated messaging interface and protocol (RPC) to enable the powerful Linux-based environment to communicate with the real-time environment and vice versa. The Arduino® VENTUNO™ Q IQ8 SoC provides high-performance compute leveraging the octa-core ARM CPU for Linux, while the integrated NPU offers a dedicated 40 dense TOPS of processing power for local multimodal AI workloads such as a complete autonomous stack. The STM32 operates the real-time subsystem independently from Linux, which means the Arduino® VENTUNO™ Q can handle sensing, control and actuation operations that require sub-millisecond latency to manage deterministic control loops for robotics via GPIO, PWM and/or CAN.

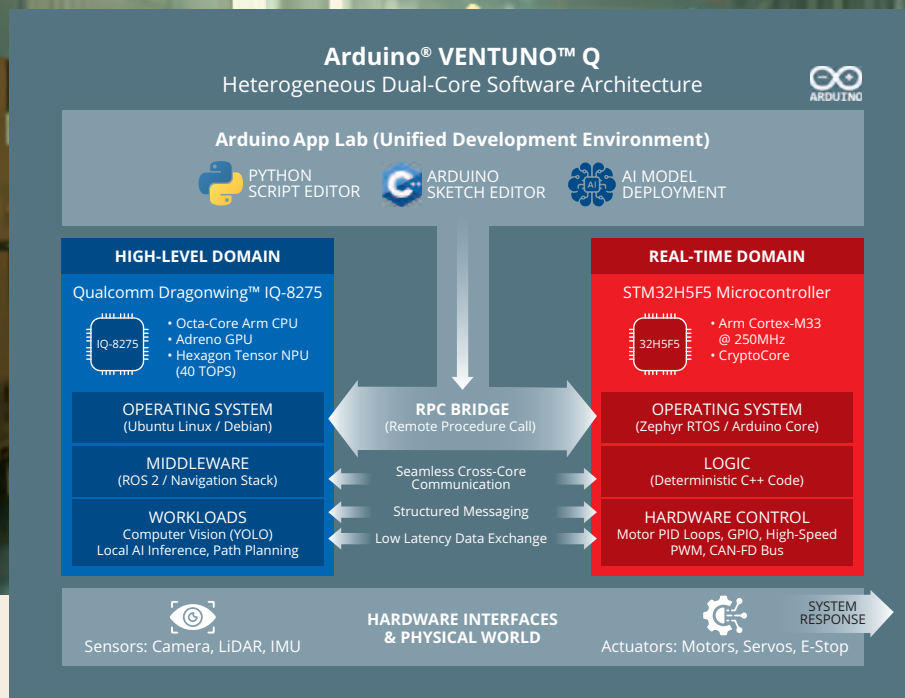
Attached below is an overview of the Arduino® VENTUNO™ Q capabilities and the rich set of interfaces available.

What sets the Arduino® VENTUNO™ Q apart, however, from its competitors is the software development environment, pre-built sample applications and other resources available to engineers to realize advanced product concepts quickly.

The foundation of this is the Arduino App Lab, which was created as a unified development environment that allows engineers to program the high-performance compute and AI capabilities of the Dragonwing™ IQ8 SoC, its CPU, GPU and NPU under Linux within the same environment as the

STM32 MCU, which hosts the real-time capabilities of the Arduino® VENTUNO™ Q. Python is used in the Linux subsystem to control complex tasks including graphics and multimodal AI workloads, while C++ is used to program real-time motor control and sensing capabilities from the STM32 real-time subsystem. While the Linux and Zephyr subsystems operate independently, the remote procedure call bridge (RPC) mechanism between the IQ8 and STM32 means, for example, that a machine vision model running in the Linux subsystem is able to trigger a real-time hardware event on the STM32 in response to external stimulus and vice versa. The RPC mechanism is presented as a service-oriented API or function call to both subsystems within the Arduino App Lab.

Overview 1: Arduino® VENTUNO™ Q Capabilities		
FEATURE CATEGORY	COMPONENT	KEY DETAILS
Primary AI SoC	Qualcomm Dragonwing™ IQ-8275 (IQ8)	Octa-core CPU (2× Gold Prime @ 2.35GHz, 2× Gold @ 2.1GHz, 4× Silver @ 1.95GHz) (runs Ubuntu or upstream Debian Linux)
Graphics & Vision	Adreno 623 GPU @ 877MHz	Supports hardware video encoding/decoding and display pipelines
Edge AI NPU	Hexagon Tensor AI Processor	Up to 40 dense TOPS for local machine learning inference
Image Signal Processor	Qualcomm Spectra™ 692 ISP	Multi-camera vision processing support
Real-Time MCU	STM32H5F5 Microcontroller	Arm Cortex-M33 @ 250MHz, 4MB Flash, 1.5MB RAM (runs Arduino core on Zephyr OS)
Memory & Storage	RAM & Internal Storage	16GB LPDDR5 RAM and 64GB eMMC onboard storage
Expansion Storage	M.2 NVMe Slot	Supports Gen4 external high-speed storage
Wireless Connectivity	Wi-Fi6 & Bluetooth	Tri-band Wi-Fi6 (2.4/5/6GHz) and Bluetooth 5.3 with onboard antenna
Wired Networking	Ethernet	1× 2.5Gbit RJ45 Ethernet port
USB & Video	Ports & Display	1× USB-C (with DP Alt mode/video output/role switching), 2× USB 3.0 Type-A
Camera Interfaces	MIPI-CSI	3× MIPI-CSI camera connectors for multi-angle computer vision
Industrial Interfaces	CAN-FD	Includes CAN-FD physical layer connections on terminal blocks and expansion headers
Prototyping Compatibility	Hardware Footprint	Compatible with traditional ARDUINO UNO shields and standard 40-pin RPI HAT accessories
Power Input	Options	USB-C (5V @ 3A max), 5.5×2.1mm Power Jack (12–24VDC), or Screw Terminal (7–24VDC)



This hides the complexity of inter-process communication from the user.

Arduino® VENTUNO™ Q builds upon the solid foundations established by the Arduino App Lab with a rich set of pre-built sample applications and other software resources that significantly simplify the task of prototyping advanced robotics and Edge AI concepts. Within the Arduino App Lab, an engineer can leverage some or all of the resources listed below and/or customize them for their own purposes. The adjacent overview provides a short summary of what is available when you install the Arduino App Lab.

While pre-built and curated resources are provided to simplify evaluation and later prototyping, the Arduino® VENTUNO™ Q software environment can also be extended by engineers developing their own custom bricks or by leveraging external editors and tools such as Edge Impulse. This end-to-end AI model environment can be used to develop, train and deploy custom models, which can then be incorporated into the Arduino App Lab environment as a custom brick.

To maximize flexibility, Arduino offers two development modes to address the Arduino® VENTUNO™ Q: as a standalone single-board comput-

er (connecting monitor, keyboard and mouse) or a tethered PC setup that leverages USB-C.

If your team is looking for a single, unified and rapid prototyping platform for robotics and Edge AI applications, one that already bridges the gaps between advanced AI applications and real-time sensing, motion control and actuation, look no further than the new Arduino® VENTUNO™ Q platform.

With the Arduino App Lab and the pre-built, zero-code resources provided, it dramatically reduces the time it takes to go from concept to working prototype.

Please ask CODICO if you want to know more about how to get started with the Arduino® VENTUNO™ Q. For more details, please contact:

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Overview 2: Arduino® VENTUNO™ Q Software Resources

RESOURCE	DESCRIPTION
Sample Applications	Zero-code curated sample applications that include: • Computer vision and tracking • Generative and multimodal AI • Robotics and motion control • Industrial sensing and maintenance
Bricks	Pre-built, reusable code blocks that can be »snapped« together within App Lab. Categories include: • Robotics and control • AI & machine learning • Interface and UI • Hardware and sensors
Sketches	Real-time control resources for the STM32 MCU include: • Standard libraries to address sensors • HW peripheral control for high-speed, zero-jitter PWM and GPIO • Industrial protocols such as CAN-FD • RPC communication handler simplifies inter-process communications • Shields and drivers for Uno shields / Modulino and Raspberry Pi HATS
AI Models	Ready-to-run models include: • YOLO-X / PoseNet / MobileNet / EfficientNet • Text-based LLM assistants • VLMs such as Qwen VLM • Voice assistants including Whisper and Melo TTS
Autonomous Navigation	Nav2 and SLAM toolkits can be run within the ROS2 environment built directly into the VENTUNO™ Q Linux subsystem. Users can leverage the robotics bricks to get started quickly.



ChargeBridge

The Building Block for the Next Generation of EV Chargers



PIONIX has distilled years of hands-on experience with the open-source EVerest stack into a compact, pre-certified hardware module that gives charger manufacturers a faster, safer path from prototype to production.

A Problem Built into Every Charger

Every modern AC and DC charging station rests on a two-layer architecture. A Linux-based processor handles the high-level tasks: OCPP communication, energy management, user interfaces, and the ever-evolving protocol stack around ISO 15118. Below that there is a microcontroller with a simpler job but far more critical: real-time control of the pilot signal, relay switching, and all the safety functions that keep the charging session from going wrong. If Linux crashes, the microcontroller must still hold the station in a safe state.

That low-level layer is where most of the development pain lives. Routing a PLC chip correctly, getting the CP/PP circuitry right, writing safety firmware that can be certified: these are problems that teams solve repeatedly, company by company, with predictable results. Lengthy board spins, late certifications, and products that slip to market six to twelve months behind schedule.

PIONIX, the original creators and key maintainers of LF Energy EVerest, the leading open-source EV charging software stack, decided to solve this once and make the solution available as a module.

What ChargeBridge Actually Does

ChargeBridge is a System-on-Module measuring just 46×22mm and is based on the Qualcomm QCA-7006AQ PLC chip. Despite its small footprint, it contains everything required for one charging port at the low level: control pilot and proximity pilot handling for CCS and Type 2, PLC modem, relay drivers, temperature monitoring via PT1000 sensors, overvoltage protection per IEC 61851-23, safety I/O for isolation monitors and RCDs, plus CAN, RS485, I2C, UART and GPIO interfaces.

The module comes with preloaded firmware. Safety-critical code runs on a dedicated execution context that is fully isolated from the non-safety partition handling WireGuard VPN, remote management, and over-the-air firmware updates. This separation is central to the certification story: the safety firmware can be audited and certified independently of the Linux system above it. Manufacturers can update Linux, change their OCPP stack, or swap out UI frameworks without touching anything inside the safety boundary.

All the hardware interfaces on the module are tunnelled transparently over Ethernet or USB to the Linux host. From Linux's perspective, CAN

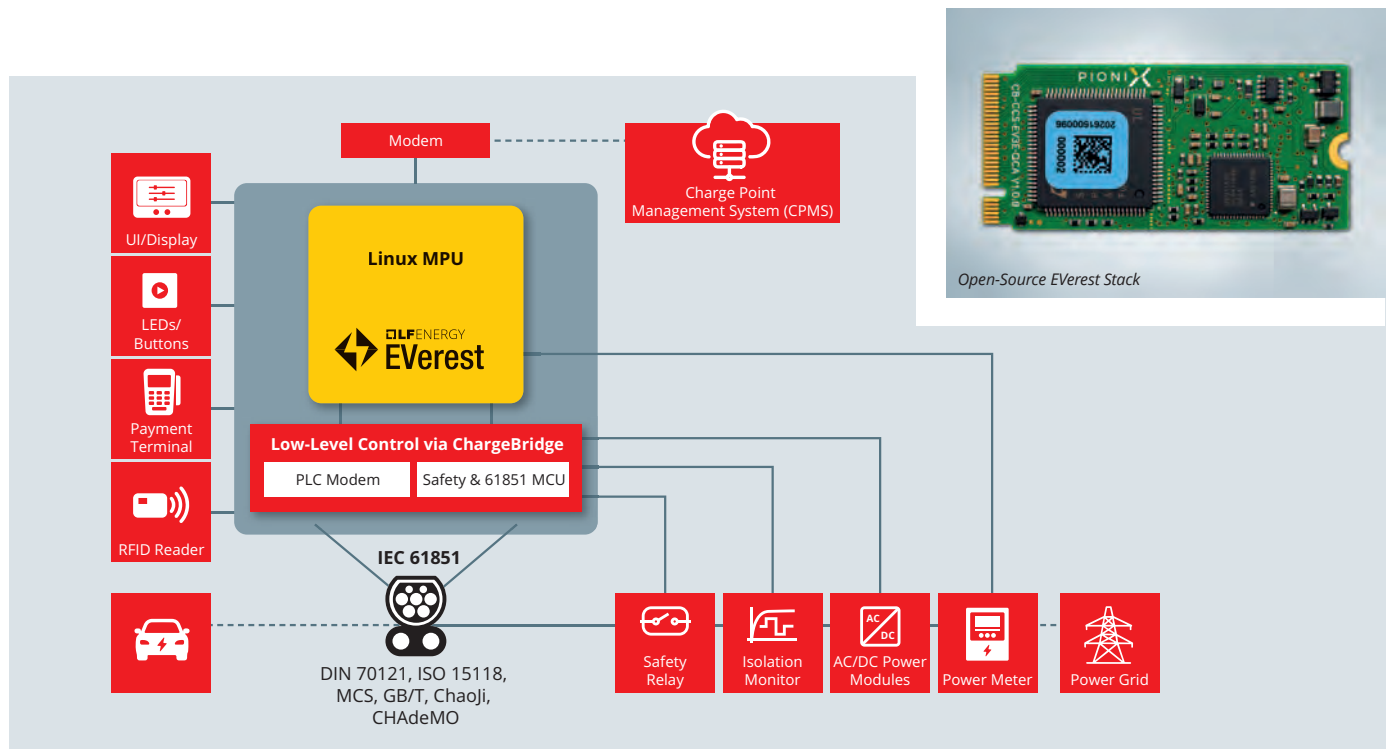
just shows up as a socketCAN device, RS485 as a standard serial port, with no custom drivers needed and no vendor lock-in. This transparency also means ChargeBridge is not tied to EVerest; any charging software stack can use the virtual local interfaces it presents.

Scaling from One Port to Thousands

One of the more unusual aspects of the ChargeBridge architecture is how it scales. Because the Linux host communicates with each module over Ethernet, the host does not have to be physically co-located with the charging port.

A single Linux controller (or a virtualized cluster) can manage dozens or even hundreds of ChargeBridge modules spread across a site. In a large parking garage scenario with 2,000 ports, running the high-level logic on a small rack server cluster costs a fraction of what 2,000 individual embedded Linux boards would add to the bill of materials.

This so-called satellite architecture also enables high-availability designs. PIONIX has demonstrated the approach using Proxmox virtualization clusters, where the virtual machine running EVerest can migrate between physical hosts during planned maintenance without dropping an active DC charging session. For bus depots, fleet operators, or large public charging hubs, that kind of resilience has real commercial value.



Certification Risk Removed from the Design Phase

ChargeBridge modules come pre-certified. The CCS variant is available today; modules for MCS, CHAdeMO, Chaoji, and GB/T are currently in testing and expected to follow. For a manufacturer targeting multiple regional markets, the ability to swap in a different certified module rather than redesign and re-certify the entire controller board changes the economics of multi-market product development considerably.

The module also addresses a newer compliance requirement that has caught some teams off guard: the overvoltage monitoring function mandated by the 2023 revision of IEC 61851-23, which is now becoming mandatory. This is included in the preloaded firmware and applies immediately.

From Evaluation to Production

PIONIX offers different evaluation kits through CODICO's Sample Shop, each targeting a different phase of development. The EVSE-side breakout board exposes all module interfaces via standard connectors and supports both AC and DC CCS scenarios up to 1,000V when connected to external high-voltage components, making it a practical starting point for prototyping and fast development cycles directly on the developers desk. A dedicated AC satellite evaluation board targets teams building wallboxes or multi-socket AC installations.

Open carrier board reference designs and schematics are published on GitHub, and PIONIX provides schematic reviews and bring-up support as part of its engineering services. Documented reference designs, accessible support, and a module that handles the certified hard part: together, these are what PIONIX is positioning as the shortest path between concept and a compliant, shipping product.

The Broader Picture

PIONIX ChargeBridge and Everest are the first building blocks for Software-Defined Charging currently available on the market.

ChargeBridge is PIONIX's answer to a pattern the company saw repeatedly while working with charger manufacturers: teams spending months re-solving the same low-level problems, each at their own expense, each carrying the same certification risk. Packaging that layer into a reusable, pre-certified module let manufacturers focus engineering effort on the things that differentiate their product, such as the user experience, the energy management logic, and the cloud integration, rather than on infrastructure.

With Everest now running on over 100,000 charging stations across AC home chargers, public AC, and DC fast chargers, and with silicon manufacturers showcasing the stack at events like Embedded World, the ecosystem around this approach is growing quickly. ChargeBridge Eval Kits

are available soon via the CODICO Sample Shop. Volume pricing enquiries can be directed to the CODICO Sales Team.

Developing Chargers for All Global Standards

After successfully launching ChargeBridge and scaling the production with first customers, PIONIX already takes the next step: completing the ChargeBridge Family. At this year's Power 2Drive in Munich, PIONIX showed ChargeBridges for MCS and for all CAN-based Standard (GB/T, CHAdeMO and Chaoji). With these additions, ChargeBridge in combination with LF Energy Everest Open-Source Charge Controller opens up many more possibilities to have chargers support different standards in one charger as well as using the same hardware and software architectures for a global portfolio. With that charger manufacturers can shorten time-to-market for their new products as well as lowering TCO for their whole portfolio.

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PIONIX GmbH, headquartered in the Karlsruhe region, Germany, initiated the LF Energy Everest open-source charging software stack and offers engineering, certification, and enterprise services to charger manufacturers worldwide.

SMART

Ag59800-ULP PoE++ .bt Power Module in an Ultra-Slim Form Factor

With the development of new display technologies, the efficiency associated with these technologies is increasing, and power consumption reducing, methods of powering smart screens, monitors, touch panel displays and alike are available from existing and developing power technologies.

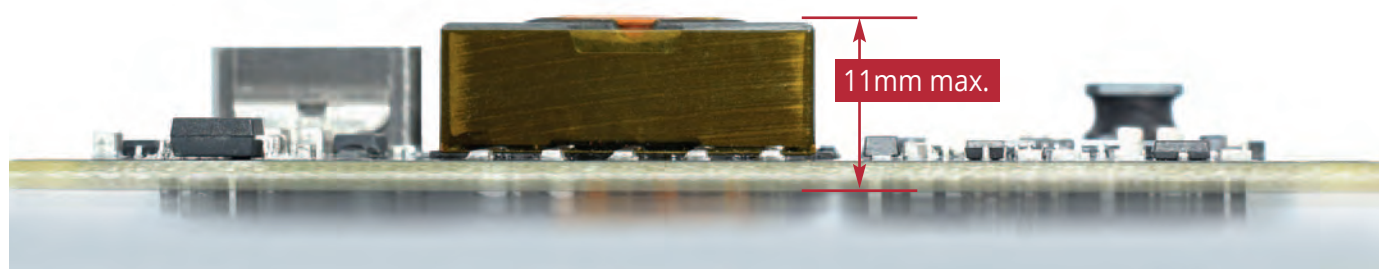
Driven by legislative and consumer expectation, power budgets that can be met using Power-over-Ethernet and USB solutions are available to meet this development in the market. SILVERTEL has developed, and is developing products allowing designers and system integrators to embed power modules into display

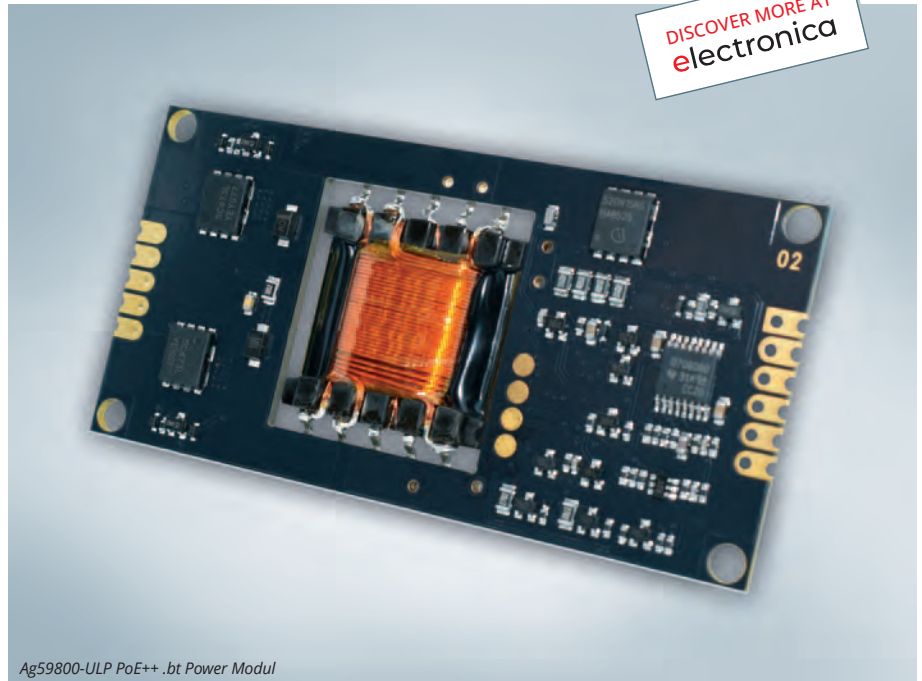
screen equipment, providing very cost-effective and easily installed solutions for smart advertising, retail, access control and many other applications.

Since 2019, when the IEEE ratified the 802.3bt standard for PoE, allowing just under 100W of

power transfer over 100 metres of Cat5e cable. With SILVERTEL's Ag59800-ULP, a 2nd Generation PD module, embedded into a peripheral device, just under 90W of power can be transferred between PSE and the PD. This now makes the installation of monitors and display screens extremely straightforward and totally flexible when it comes to siting the display screen equipment, requiring a single Ethernet connection over which to deliver power and Audio/Video data.

In 2025, SILVERTEL launched its High Efficiency, PoE++ PD module, the Ag59800-LPB (available



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Ag59800-ULP PoE++ .bt Power Modul

 Silvertel

via the CODICO Sample Shop) and now follows this with the addition of a new format, the »-ULP variant« (Ultra-Low-Profile). Aimed at smart display equipment such as monitors, touch screen displays, HMI screens used in digital signage, process automation and thin-client networks, the new Ag59800-ULP format features 11mm maximum height allowing it to be embedded inside display screen equipment. In doing so, the display screen can now be PoE-powered without the need for a »power bulge«, doing away with mains cabling and providing greater installation flexibility at reduced cost – Cat 5/6 cabling can be routed anywhere without the need, and associated expense, of electricians having to install mains outlets.

The Ag59800-ULP series is the latest addition to SILVERTEL's advanced PoE module portfolio. It is equally at home in other applications within the Security, Retail, A/V, Communications and Transport sectors where high power and optimized

efficiency are a necessity in today's operating environment. The module is available with a dedicated 12V (Ag59812-ULP) or 24V (Ag59824-ULP) output and the ability to adjust the output voltage for commonly-used monitor and screen operating voltages. The ultra low-profile height of typically 11mm lends itself perfectly to applications with limited »headroom« for example in smart display screens to power internal processing devices, where length and width dimensions are a constraint but less so than in the depth (or height) dimension.

The Ag59800-ULP also has provision for output adjustment which is set via an external resistor to adjust upwards or downwards. The downward adjust allows trimming to 18.5V on the 24V variant which will accommodate operating voltages for display equipment and laptops.

One of the main features of this new module is the »flexi-format« method of interfacing to the module; »castellations« at the termination pads around the edge of the PCB means that it can be flush-mounted to a host PCB – allowing it to be surface mount reflowed. Alternatively, it can be connected to a header with through-holes providing both the mechanical and electrical connection to the host PCB, or similarly can be connected by a custom connector or flying leads.

The Ag59800-ULP PD module identifies to an IEEE 802.3bt-compliant PSE as a Class 8 device

capable of digesting typically 90W at either 12V or 24V. The module is available as an Industrial Temperature Range device, as is standard for SILVERTEL products.

With efficiency figures of typically 95% at 12V and 93.5% at 24V, the Ag59800-ULP series is a compelling choice offering high power at high efficiency for space-constrained applications. Additionally, the module is thermally protected on-board, shutting down the output in the presence of high ambient temperatures, until the temperature drops to a safe operating point, when the device will return to normal operation without damage.

Measuring 70×35×11mm (L×W×H), the module provides the necessary Identification, Classification, Isolation and DC-DC Conversion features required of a PoE PD. Simplicity of integration and ease of use are synonymous with SILVERTEL's products, and this module is no different, requiring very few, low-cost, external components.

Applications support in the form of evaluation boards, rapid email support, application notes, schematic and layout checks and a wealth of knowledge in this field are readily available.

A04

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AI-READY

New MCU with AI and Wi-Fi/Bluetooth to Enable Edge AI in IoT



From the early days of the Internet of Things (IoT), connected devices have been key to sense and process real-world inputs. As AI workloads move closer to the devices and grow more demanding and real-time responsiveness becomes critical, the value is no longer in collecting data – acting on it and having an inference engine right at the edge is mandatory. This shift is pushing AI-native compute out of the cloud and onto the Edge, where decisions can be made in the moment. To address these challenges, SYNAPTICS has released the first member of a new MCU family, the SRW1500 Series.

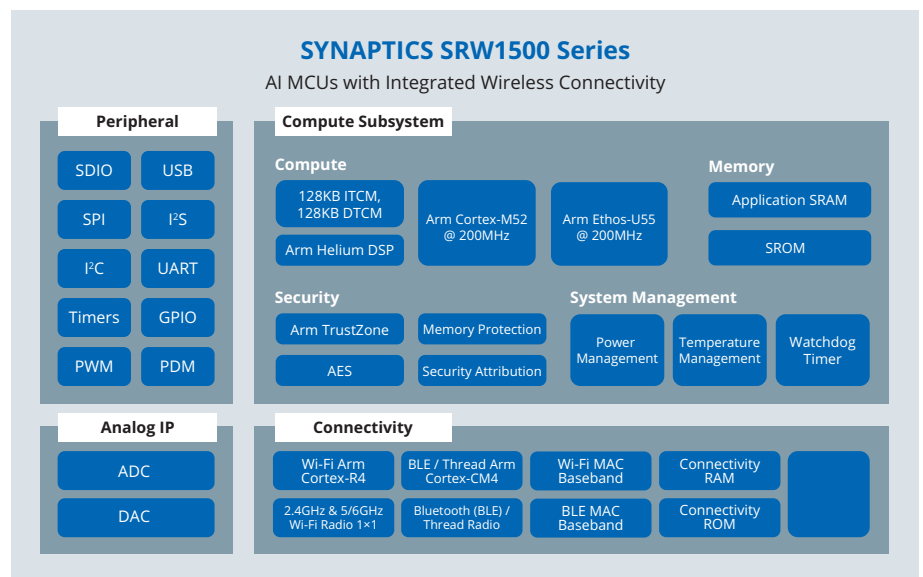
Powerful Edge AI with Integrated Wireless Connectivity

To keep up with – and innovate – at the edge, it's essential to do more than connect devices to the cloud for intelligence. Real-time responses to data require embedded intelligence in connected devices. As the IoT continues to scale, power budgets will keep shrinking, and latency requirements will get tighter. A single-chip AI MCU platform addresses these challenges while also improving device intelligence and security.

For IoT systems that demand this kind of real-time inference, low-latency responsiveness, and advanced wireless connectivity, the SRW1500 Series is the answer: a single-chip AI MCU platform that integrates an Arm® Cortex®-M52 processor, 1MB of on-chip SRAM, an Arm® Ethos™-U55 NPU for efficient on-device inferencing, and Wi-Fi 7 connectivity into a single device – purpose-built for real-time Edge AI inference in connected IoT applications.

This tightly integrated architecture delivers optimized Edge AI performance for always-on sensing, contextual awareness, and on-device decision-making. By coupling the MCU and AI archi-

ture at the silicon level, the platform enables advanced workloads like voice trigger detection, sound event classification, and AI-enhanced Wi-Fi® sensing for presence and motion detection.



The SRW1500 Series balances compute efficiency, low power consumption, and system cost optimization, while integrating multi-protocol wireless connectivity within a single device, making it a perfect fit for intelligent edge applications.

Benefits of a Single-Chip AI MCU Platform for Connected IoT

First and foremost, it simplifies system architecture by removing chip-to-chip communication between separate components, unifying MCU, NPU (for AI), and wireless radios into a single, tightly coupled platform. This on-chip AI inference reduces latency, enables faster decision-making, and lowers overall power consumption.

As mentioned, single-chip architecture reduces latency by keeping sensor data, AI inference, and the resulting action all on the device. Compared to sending data to the cloud, this allows for real-time decision-making.

Naturally, multiple chips and interconnect components lead to higher costs and larger PCB footprints. They can also add bottlenecks at chip interfaces due to limited coordination between compute and connectivity. A single chip is not only more cost-effective as an integrated device, but it's more efficient with AI, MCU, and connectivity co-designed to optimize data paths and scheduling.

Security is equally critical. The SRW1500's single-chip architecture raises the bar at the silicon level, reducing the attack surface that exists when data moves across chip boundaries in multi-chip designs. With security and compute co-located on one device, sensitive inference data stays on-device, supporting compliance with increasingly stringent IoT security standards. The SRW1500 includes a Secure Island with PSA Level 3 certification, simplifying security validation to a single auditable platform rather than multiple discrete components.

Reducing Design Complexity with a Unified AI MCU SDK

One of the greatest advantages of moving to a single-chip MCU is how it streamlines designs to shrink development times and associated costs. By removing chip-to-chip interface design and offering a unified, open SDK, engineers gain a consistent developer experience across standalone and connected compute implementations. This

frees them to focus on their core specialties without being slowed by compute or connectivity concerns.

For example, smart fridge designers can prioritize end-user experiences like air quality applications that can detect spoilage, knowing they have an AI-native MCU that includes connectivity to enable richer, more personalized intelligence managed on-device and across IoT networks. The SRW1500 Series SDK supports FreeRTOS™ and Zephyr®, and provides a developer-friendly environment with pre-integrated firmware and middleware for AI-accelerated connectivity stacks.

A Unified Platform for Faster, Smarter Edge AI Development

As AI continues to drive innovation, consumers expect new capabilities across smart homes, appliances, home security, and consumer electronics. Edge AI is accelerating this shift by enabling developers to create smarter, more responsive, and differentiated user experiences – from predictive industrial sensing to context-aware smart home automation. The potential of Edge AI is limited only by developers' imaginations.

Success in this space requires more than just Edge AI capability – it depends on efficient tools that simplify model creation, optimization, and deployment. The SRW1500 platform delivers this combination, helping developers accelerate innovation while reducing complexity.

By delivering compute and connectivity in a single chip – and from a single vendor – engineers can reduce complexity and focus on bringing these innovations to market faster. With best-in-class processing, the SRW1500 extends the Astra MCU portfolio as one of the industry's first single-chip AI MCU platforms with integrated Wi-Fi 7 connectivity, supported by open, developer-friendly software for continuous AI at the far edge of the IoT network. The SRW1500 provides engineering teams with a faster, more efficient path to intelligent edge products – backed by the Astra portfolio's proven AI MCU architecture.

Modules Based on SRW1500 from AMPAK

The long-term Wi-Fi and Bluetooth module supplier AMPAK, a Taiwanese company, has released its AP72312 based on the SRW1500 and is sampling now. SRW1500 Eval board from SYNAPTICS and AMPAK AP72312 Module are available in our CODICO Sample Shop.

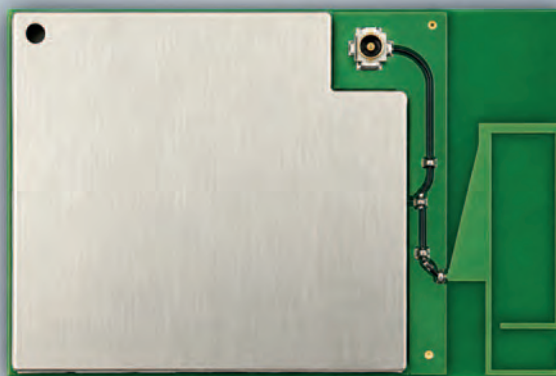
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Key feature of this module include:

- LGA Package: 35×23mm
- MCU Subsystem
- Arm MCU: Cortex-M52
- Arm NPU: Ethos-U55
- PSA Level 3 Security
- Memory 1MB SRAM
- Peripherals: USB, UARTs, I²C Host/Target, SPI, PWM, ADC, SDIO and up to 32 GPIOs (max.)

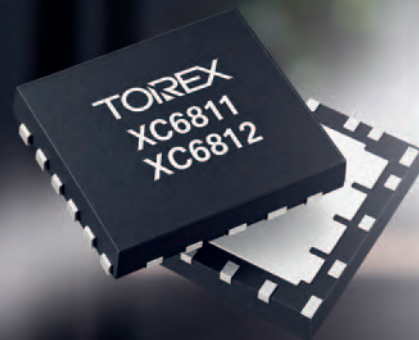
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AMPAK AP72312 Module

COMPACT

XC6811/XC6812: Multi-Function Li-ion Charger ICs Enabling Efficient Power Path Management



As electronic systems become increasingly integrated and the demands for energy efficiency and functional safety continue to rise, the design of battery charging and power management circuits is becoming increasingly complex. Compact systems, such as IoT devices, wearables, and industrial backup modules – require not only efficient charging but also seamless power distribution, minimal standby consumption, and robust system control.

The XC6811 and XC6812 series from TOREX Semiconductor address these challenges with a highly integrated multi-function Li-ion charger IC, combining charging control, system power management, and uniquely, integrated push-button control, in a single compact device.

Simplifying System Control with Integrated Push-Button Functionality

A standout feature of the XC6811/XC6812 is the built-in support for push-button control, enabling

intuitive and reliable system operation without requiring additional external components.

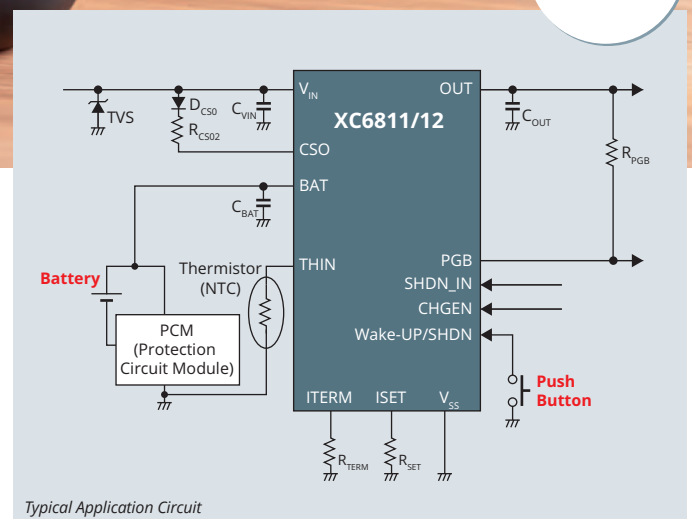
This functionality allows for wake-up via push button or VIN input and shutdown via MCU or long-press operation. It also facilitates forced shutdown and recovery in the event of system freeze.

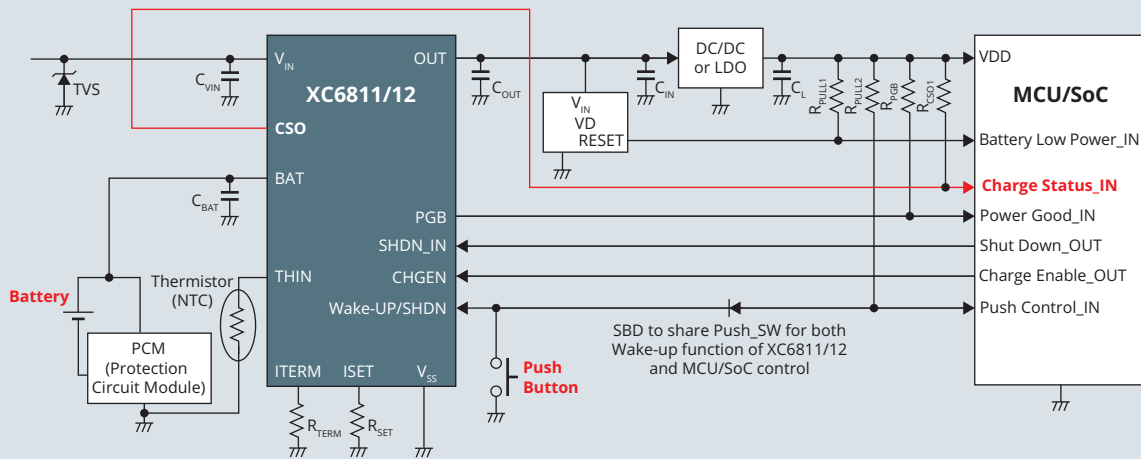
By integrating this capability directly into the charger IC, the XC6811/XC6812 significantly simplify system design while improving usability and

robustness, particularly in compact, battery-powered devices.

Efficient Power Management with Current Path Architecture

The XC6811/XC6812 incorporate a current path architecture, enabling independent control of battery charging and system power supply. The system load is powered directly from VIN via the OUT pin (~4.8V) when available and charging current is automatically adjusted depending on





Typical Application: CSO Pin for Direct MCU Monitoring

system demand. Seamless transition between input supply and battery ensures uninterrupted operation. This approach ensures stable system operation during charging while optimizing overall power efficiency.

Ultra-Low Power Operation with Ship Mode Capability

The XC6811/XC6812 series is designed for extremely low power consumption in standby and storage conditions, with shutdown current as low as 10nA and battery-mode consumption ~30nA. This enables an effective »ship mode«, preventing battery discharge during storage or transportation and ensuring devices are ready for use even after extended periods.

Flexible Charge Configuration for Diverse Li-ion Applications

The XC6811/XC6812 provide flexible charge con-

trol, supporting a wide range of Li-ion battery types and capacities:

- Charge voltage: 3.10V to 4.50V
- Adjustable charge current and termination current via external resistors
- Charge current ranges:
XC6811: 1mA to 50mA
XC6812: 25mA to 400mA

A full CC/CV charging profile is implemented, including trickle charge, constant current, constant voltage, termination, and automatic recharge.

Built-In Protection and Monitoring Functions

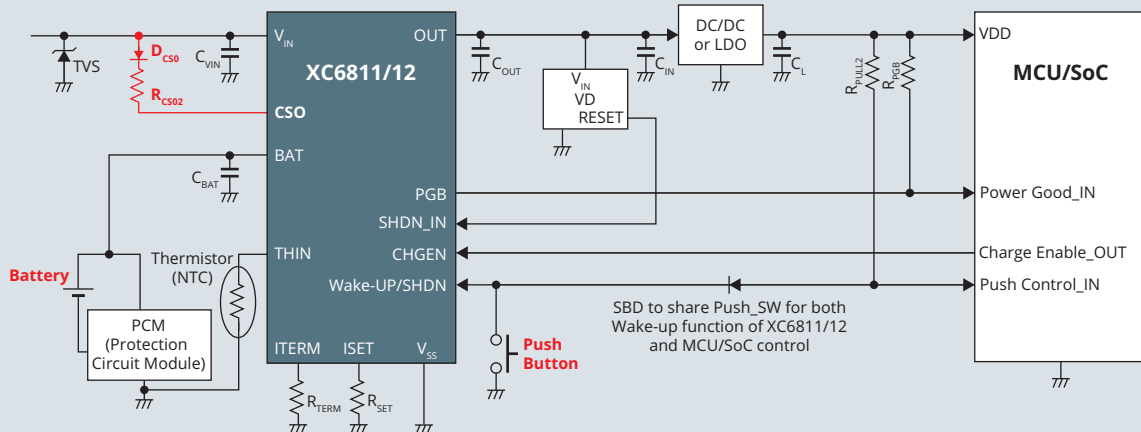
To ensure reliable operation in real-world environments, the XC6811/XC6812 integrate a comprehensive set of protection features:

- Input current limiting (typically 480mA) to protect upstream supplies
- Reverse current protection to prevent battery backflow
- Thermal control limiting junction temperature (~130°C threshold)
- UVLO (under-voltage lockout) for stable operation
- Battery temperature monitoring (JEITA-compliant) via NTC thermistor

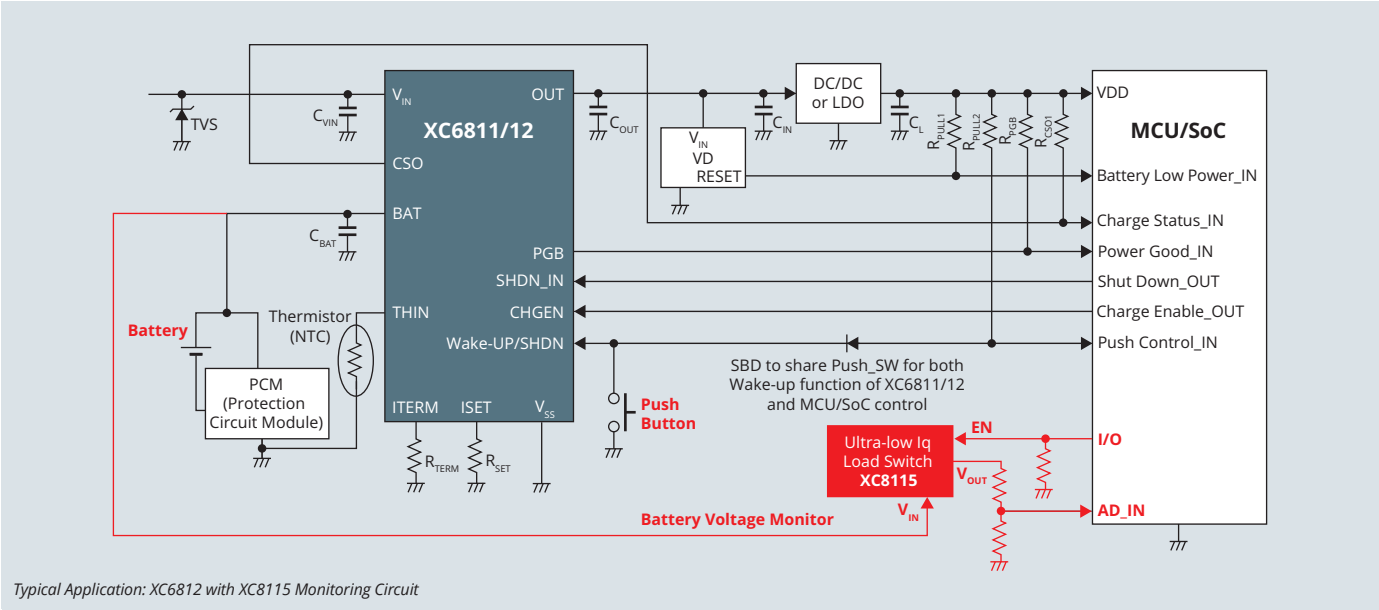
Charge status is available via the CSO pin, enabling straightforward monitoring by an MCU or LED indicator.

Enhancing System Monitoring with XC8115 Load Switch

The integration of TOREX's XC8115 ultra-low I_q load switch further enhances system-level power management. In a typical configuration, the



Typical Application: CSO Pin Enabling LED Indication



Typical Application: XC6812 with XC8115 Monitoring Circuit

XC8115 connects the battery voltage to the MCU ADC only during measurement. The load switch consumes 0µA in standby, eliminating monitoring-related drain.

This approach allows for accurate battery voltage monitoring with zero impact on standby battery life and flexible software-controlled measurement timing.

Compact Packaging for Space-Constrained Designs

To support applications ranging from ultra-compact wearables to industrial systems, the

XC6811/XC6812 are offered in two package options, allowing designers to balance size, thermal performance, and manufacturability.

The WLP-15-01 (1.27×1.97×0.33mm) wafer-level package is optimized for extreme miniaturization, offering an ultra-small footprint and ultra-low profile for highly space-constrained designs. The DFN3030-12A (3.0×3.0×0.75mm) provides a more robust solution, with a larger footprint that enhances thermal performance and power dissipation, making it well-suited to a broader range of applications.

Applications

The XC6811/XC6812 series is designed for applications requiring compact, low-power, and highly integrated charging solutions, including Industrial MCU backup systems, wearable and hearable devices, IoT sensors and edge nodes and battery-powered communication modules.

Just order samples for your tests from us.

A06

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CONCLUSION

The XC6811 and XC6812 provide a highly integrated solution for Li-ion charging and system power management. By combining push-button control, current path architecture, ultra-low standby current, and flexible charge configuration, these devices simplify design while improving efficiency and reliability.

When paired with ultra-low power load switches such as the XC8115, they enable advanced power architectures ideally suited to next-generation compact electronic systems.

ePaper

An Introduction

Electronic price tags have become an essential part of many stores. Our particular interest lies in the display they use – the so-called »electronic paper«, or ePaper, as it is not entirely accurate to call it. That alone is reason enough to take a closer look at this innovative display technology and its advantages.

History

After TFT-LCDs reached mass production, researchers began looking for a way to create displays that were thin, offered high contrast, and, above all, consumed extremely little power. The goal was to produce paper-like displays for content that did not need to be updated frequently.

As early as the 1970s, Nicholas Sheridan, a research scientist at Xerox in Palo Alto, developed »Gyricon«, the first electronic paper. It is considered the ancestor of all modern ePaper displays.

It had paper-like properties, was thin and flexible, offered an excellent viewing angle, and could be rewritten thousands of times. A thin, transparent plastic film contained millions of tiny, two-colored spheres inside oil-filled cavities. When an electrical voltage was applied, the spheres rotated and displayed one of their two colors depending on their orientation. This created images or text that remained visible even after the voltage was switched off. However, high production costs prevented the technology from becoming commercially successful.

In the 1990s, Joseph Jacobson and his team at MIT (Massachusetts Institute of Technology) developed microcapsules containing white, electrically charged particles suspended in dark oil. An electric field moves the particles up or down, making either the white particles or the black oil visible. This principle is known as electrophoresis – the movement of electrically charged particles. Based on this technology, E Ink, an MIT spin-off founded in 1997, developed the electrophoretic displays (EPDs) used today. In 1999, the first electronic-ink display went into mass production.

Structure and Operating Principle

Electrophoretic displays (EPDs) are currently the most widely used technology for paper-like displays. The mature and cost-effective technology comes very close to the appearance of real paper.

Matrix ePaper displays use a TFT substrate, just like LCDs, usually made of glass and increasingly of plastic. On top of it is the »electronic ink«, containing millions of tiny microcapsules. The structure is completed by the VCOM pad, a transparent ITO electrode on PET film, and protective layers. The display controller and interface are integrated and connected to the outside world via an FPC (Flexible Printed Circuit) (Figure 1).

The heart of the technology consists of microcapsules approximately 40µm in size. They contain negatively charged white particles and positively charged black particles suspended in a clear liquid. Depending on the polarity, an electric field moves the particles up or down, causing a pixel to appear either white or black. Once the particles reach their position, they remain there without requiring any additional power (Figure 2).

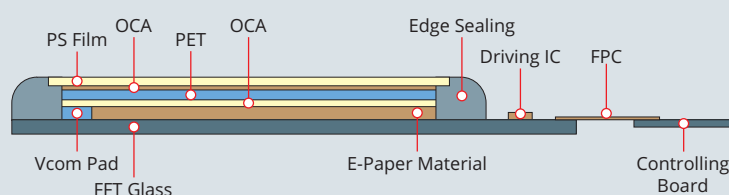


Figure 1

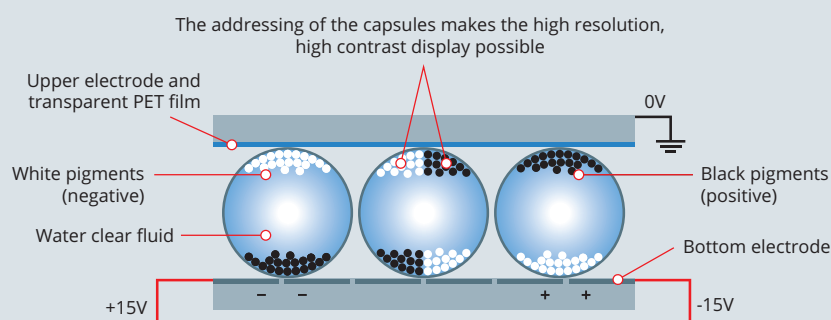


Figure 2



E Ink Holdings uses black carbon and white titanium dioxide for its »electronic ink«. The composition of the liquid remains a company secret.

Advantages of ePaper

Power Consumption

The particles remain in place when the voltage is switched off. As a result, power is only required when the image is updated. This makes ePaper displays particularly energy-efficient and significantly extends battery life. eBook readers can often be used for weeks or even months on a single charge.

Display Quality

ePaper reflects ambient light in a similar way to paper. This diffuse reflection produces a glare-free image that is easy to see from virtually any viewing angle and is easy on the eyes. According to research data, readability in bright light is around 30 to 40% better than with LCD displays.



Mechanical Properties

At just 1 to 2mm thick, ePaper displays are very thin and therefore extremely lightweight, making them ideal for portable devices. Flexible versions with a plastic substrate are around 80% lighter, bendable, and resistant to breakage. The goal is not only to develop displays that can be rolled up like paper, but also to enable innovative product designs.

Disadvantages of ePaper

Where there are advantages, there are also disadvantages. These should not go unmentioned.

Image Refresh

ePaper displays have a slow refresh rate. The main reasons are the interface and the color particles.

SPI, a serial interface, is used for communication. With the resolutions commonly found in ePaper displays today, a large amount of data has to be transferred. The color particles then have to be moved into the correct position. Moving them with the help of an electric field also takes time. The image is first cleared and then the new data is written. A full image refresh takes several seconds. This makes the technology unsuitable for dynamic video.

A major advantage nowadays is the so-called »Partial Update«. Only individual areas of the image are updated, which saves both time and energy, especially when most of the content remains unchanged. At the same time, new materials and driving technologies are being developed to significantly reduce response times. Initial solutions already make it possible to display video on monochrome ePaper displays.

Color Display

Most ePaper displays are still monochrome, but the transition to color is gaining momentum. There are two ways to achieve this.

A color filter can be placed over a black-and-white ePaper display, similar to the approach used with LCDs. Alternatively, new types of »electronic ink« can be used that contain microcaps instead of microcapsules and hold multiple colors. By varying the strength of the electric field, the individual color particles are moved into the correct position. The most common version currently contains black, white, yellow, and red.

Since ePaper works by reflecting light, the color-filter approach is the less effective option. Brightness and color accuracy are somewhat muted, and the colors have a slightly pastel appearance. The version using colored electronic ink performs better. The current generation of four-color displays looks very good.

There is also intensive research into »ink« with more colors. A six-color version is already available and is being used for electronic posters.

Durability

In principle, EPDs are durable. However, anyone who has ever looked at an ePaper datasheet will notice that there are limitations. Depending on the model, the typical operating temperature range is between 0°C and 40°C or 50°C. ePaper is still a relatively young technology, so there has been limited real-world data on its actual long-term durability.

After more than 20 years of use, it has been found that the displays perform better than originally specified. As a result, the datasheets for some black-and-white ePaper displays were updated. The operating temperature range was extended to -20°C to +60°C, which is now standard for industrial applications.

Cost

EP displays are currently relatively expensive and therefore only have limited appeal for low-end applications. New manufacturing processes such as roll-to-roll (R2R), increasing production volumes, and improved manufacturing yields are expected to reduce costs further. This could open up additional applications in the future.

Applications

Despite being a relatively new technology, electrophoretic displays already have a wide range of applications.

eReading

In 2007, Amazon launched the first »Kindle« (Figure 3). The first-generation eReader featured a 6-inch EP display with four levels of gray.



Figure 3

Today, eReaders with ePaper displays have become the standard. By 2023, more than 150 million devices had been shipped worldwide. The market is expected to grow to \$111.3 billion by 2033. The paper-like reading experience is particularly popular among book lovers. The low power consumption also allows for very long battery life. The latest devices already feature color displays, making the reading experience more vibrant.

Electronic Price Tags

This is probably the most obvious application. The size of the market reflects this: in 2025, the market was worth \$2.1 billion, and it is estimated to reach \$7.3 billion by 2033.

It feels like every supermarket is equipped with electronic price tags. Their use can increase the efficiency of price updates by 80% to 90%. The advantage is that prices can be changed in real time, eliminating manual work and minimizing sources of error.



Wearables

ePaper is increasingly being used in wearable devices. Smartwatches and fitness trackers benefit from low power consumption and excellent readability in direct sunlight. Battery life of 15–20 days on a single charge is possible.

Flexible ePaper displays, meaning displays with a plastic substrate, are also used in some cases. They conform to the shape of a wristband, are extremely lightweight, and, most importantly, are resistant to vibration and impact. This makes them ideal for sports activities.

Other Applications

The applications mentioned above are by far the largest in terms of revenue. However, there are many other areas where ePaper is at least equally interesting. The range of possibilities is broad, and we would like to highlight a few examples. One application is advertising boards and digital signage. ePaper displays are now available in sizes of up to 75 inches. Content can be updated remotely, replacing traditional paper posters both in public spaces and in stores. Full-color ePaper is particularly attractive for these applications

Bus, train, and tram stop displays can also benefit from the technology. Timetables, area maps, and arrival and departure times can be updated electronically and displayed in real time. In smart homes, compact black-and-white displays can be used to show the time and room temperature or to control devices.

ePaper can also replace paper in the medical field. Mobile displays can present patient data and vital signs with high contrast. Their low weight and low power consumption are additional advantages.

Options

For industrial applications, ePaper displays can be equipped with additional functions. Because they work by reflecting ambient light and do not have their own illumination, a frontlight can be integrated. The light guide is placed on top of the display and must be individually adapted to the respective display type.

Capacitive touchscreens can also be integrated, for example for room thermostats or other user interfaces. A combination of touch and frontlight is also possible. In addition, custom front glass can be used.

The Future

Compared with LCD technology, ePaper is still a relatively young technology. As a result, extensive research is being carried out to continuously improve both the technology and the materials used. This research focuses on three main areas:

1. Higher resolution
2. Improved color reproduction: Compared with LCD and OLED displays, color reproduction still lags behind. Significant research is therefore focused on improving color quality.
3. Faster display speeds

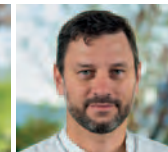
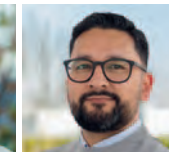
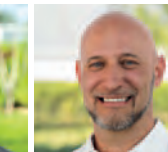
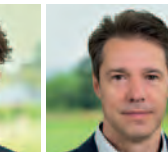
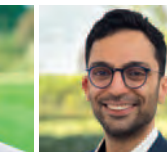
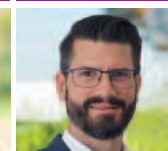
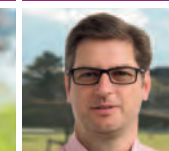
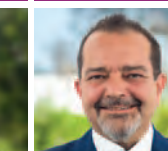
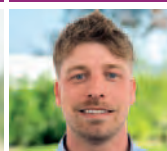
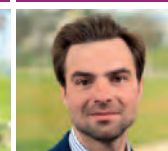
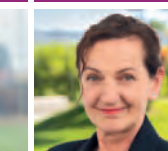
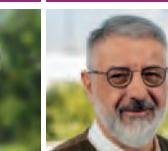
Very low power consumption, excellent readability, and low weight are the key advantages of electrophoretic displays. At present, however, they are still not suitable for displaying fast-moving video. Intensive research continues to further improve the performance of these displays.

A07

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CODICO Calendar

ACTIVE COMPONENTS

 Leonardo BAZZACO <table><tr><td>10.11.</td><td></td></tr><tr><td>11.11.</td><td></td></tr><tr><td>12.11.</td><td>●</td></tr><tr><td>13.11.</td><td>●</td></tr></table>	10.11.		11.11.		12.11.	●	13.11.	●	 Klaus BUCHENBERG <table><tr><td>10.11.</td><td></td></tr><tr><td>11.11.</td><td>●</td></tr><tr><td>12.11.</td><td>●</td></tr><tr><td>13.11.</td><td></td></tr></table>	10.11.		11.11.	●	12.11.	●	13.11.		 Vasily BUDKO <table><tr><td>10.11.</td><td>●</td></tr><tr><td>11.11.</td><td>●</td></tr><tr><td>12.11.</td><td></td></tr><tr><td>13.11.</td><td></td></tr></table>	10.11.	●	11.11.	●	12.11.		13.11.		 José-David CABEZAS <table><tr><td>10.11.</td><td></td></tr><tr><td>11.11.</td><td>●</td></tr><tr><td>12.11.</td><td>●</td></tr><tr><td>13.11.</td><td></td></tr></table>	10.11.		11.11.	●	12.11.	●	13.11.		 Thomas CARMODY <table><tr><td>10.11.</td><td>●</td></tr><tr><td>11.11.</td><td>●</td></tr><tr><td>12.11.</td><td>●</td></tr><tr><td>13.11.</td><td>●</td></tr></table>	10.11.	●	11.11.	●	12.11.	●	13.11.	●	 Peter DEGENHART <table><tr><td>10.11.</td><td>●</td></tr><tr><td>11.11.</td><td>●</td></tr><tr><td>12.11.</td><td>●</td></tr><tr><td>13.11.</td><td></td></tr></table>	10.11.	●	11.11.	●	12.11.	●	13.11.		 Andreas DIRSCHL <table><tr><td>10.11.</td><td></td></tr><tr><td>11.11.</td><td></td></tr><tr><td>12.11.</td><td>●</td></tr><tr><td>13.11.</td><td>●</td></tr></table>	10.11.		11.11.		12.11.	●	13.11.	●	 André EHLERT <table><tr><td>10.11.</td><td>●</td></tr><tr><td>11.11.</td><td>●</td></tr><tr><td>12.11.</td><td>●</td></tr><tr><td>13.11.</td><td></td></tr></table>	10.11.	●	11.11.	●	12.11.	●	13.11.	
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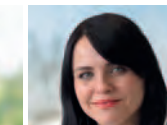
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Schedule Your
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electronica 2026
Messe München | November 10-13
MEET CODICO @ BOOTH C3.558

This year, electronica 2026 is all about »Empowering the All Electric Society«, showcasing the full spectrum of modern electronics. The trade fair offers plenty of opportunities for professional exchange, new impulses and personal networking. And, of course, CODICO will be there again – in Hall C3.558!

Here's what you can expect at our booth:

- Technical innovations and solutions for E-Mobility, Renewable Energy, Industrial Automation + Robotics, Power + Motion, Embedded AI and Industrial Edge AI
- Exciting demos from our leading manufacturers

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An additional highlight: As part of electronica, CODICO and our partner SYNAPTICS will host the conference on Tuesday afternoon »Edge AI in Action – From Concept to Deployment. Building the Next Generation of Physical AI & Robotics.« Would you like to learn more about the conference? Find all details and the programme here: <https://www.codico.com/en/current/events/conference-physical-ai>

Would you like personal advice and to arrange a meeting with your CODICO contact in advance? Get in touch with us – our team looks forward to meeting you in person at electronica!

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- Exciting demos from our leading manufacturers
- Design-in expertise at the highest level
- Austrian hospitality
- Our trade fair game – the unique »EXTREME BALANCER« by Martin Markeli

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NOISE-FREE

Clean the Power and Clock for Super-Accurate High-Speed Data Communication

Few technological trends have shaped our time as profoundly as the rise of artificial intelligence. In both private and professional environments, an increasing number of people are using LLMs and AI-based applications to efficiently search for, process, and utilize information.

The use of AI and Big Data to develop new business models and drive economic success has become firmly established worldwide. This new technological revolution, following the information revolution, is being propelled by ultra-fast data transmission and the continuously growing volume of data. Processing this data requires powerful electronic hardware, which in turn relies on advanced electronic components. For reliable communication, precise, stable, and noise-free electrical signals are essential.

Clock Jitter and Noise Suppression

As data transmission speeds increase, jitter – a fluctuation in timing – becomes a critical issue. This is because the SerDes technology required for high-speed communication transmits signals via serial communication, embedding the clock component directly into the transmitted data itself, which is then extracted and recovered at the receiving end (CDR = Clock Data Recovery). Consequently, if the clock within the transmitted data itself fluctuates too much, it cannot be recovered

at the receiving end, resulting in a flood of errors that renders the communication meaningless. While the accuracy of timing devices is critical on both the transmit and receive sides, the transmit side in particular requires jitter that is as low as possible.

The importance of the clock has also increased with the evolution of modulation schemes (from NRZ to PAM4). While NRZ (Non-Return-to-Zero) involved only a transition between 0 and 1, PAM4 (Pulse Amplitude Modulation 4) involves four types of transitions: 00, 01, 10, and 11. Due to these transitions – for example, a large voltage transition from 00 to 11 versus a small one from 01 to 10 – the rise and fall times of the waveform

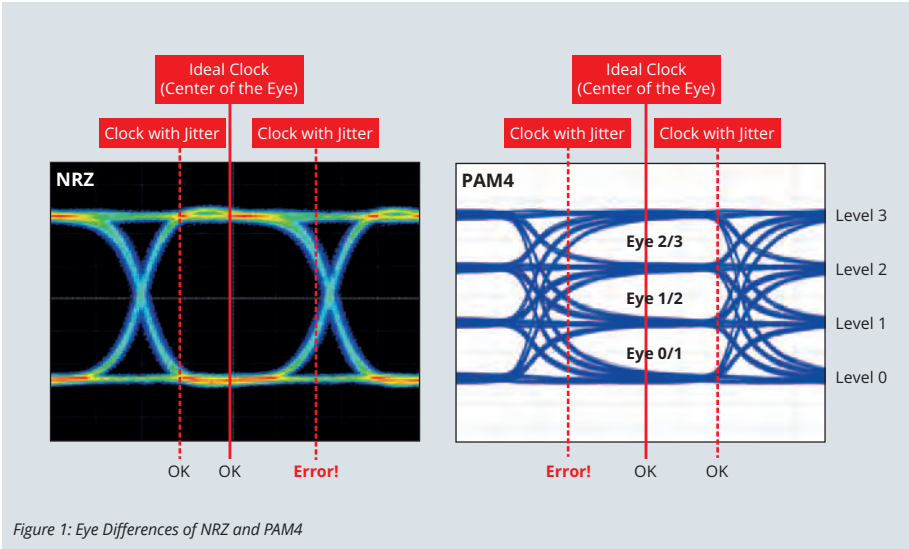


Figure 1: Eye Differences of NRZ and PAM4

differ, causing the timing of their intersections to vary slightly along the time axis. The »eyes« formed by this waveform are smaller than those in NRZ, and if the read clock arrives at the wrong time between the eyes, it will read the wrong signal (see Figure 1).

To suppress clock jitter, a low-jitter crystal oscillator is the ideal choice. Crystals have a high Q-factor, and their inherent jitter characteristics as a material are far superior to those of other timing components. Therefore, when it comes to

stable high-speed communication, the choice of crystal oscillator is critical.

Currently, the development teams at crystal oscillator suppliers are focusing most of their attention on differential-output oscillators. These oscillators output a phase-opposite signal on a separate line compared to the standard clock output signal; this allows any noise that may ride on both lines to be canceled out by the opposite phase. As a result, they can supply the IC with a clean clock signal that is consistently near-per-

fect – a critical requirement for high-speed communication (see Figure 2).

It is precisely the shift toward higher frequencies in these differential-output oscillators that is the area where crystal manufacturers are currently competing most fiercely. This is because the higher the clock frequency, the more effectively noise caused by frequency multiplication can be suppressed, thereby maximizing the efficiency of high-speed transmission. Mass production of both the 312.5MHz TXC and KDS models has already begun this year, and samples for the next generation – 625MHz – are already being accepted. Furthermore, the next step – 1.3GHz – is already on the horizon.

We must also not overlook frequency deviation. It may come as a surprise, but in high-speed communications, frequency deviation does not seem to be regarded as critically as jitter. This is because technologies such as CDR (Clock Data Recovery) can correct frequency deviations between the transmitter and receiver. However, there are limits to this correction; to maintain perfect synchronization between the transmitter and receiver over long periods – while transmitting and receiving massive amounts of data without loss and despite fluctuations in supply voltage – it is still necessary to minimize frequency deviation. For example, KDS's DE series is a product capable of limiting frequency deviation to ±20ppm (see Table 1).

Clock Characteristics Required for High-Speed Communication:

- High noise immunity
- Ultra-low jitter
- High frequency
- Narrow deviation

Suppressing Power Supply Noise

Furthermore, the shift to PAM4 modulation has heightened the importance of power supply noise suppression. As communication speeds

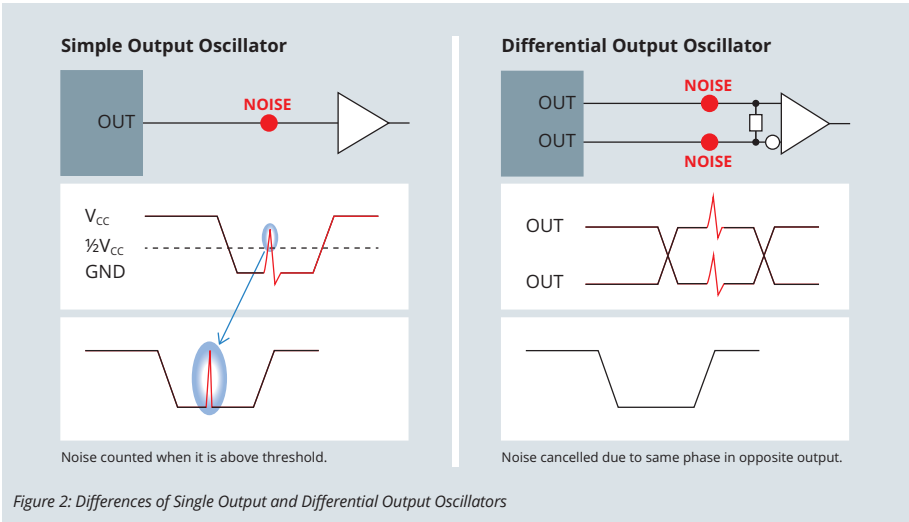


Figure 2: Differences of Single Output and Differential Output Oscillators

Table 1: Product Lineups from TXC and KDS							
SERIES	SUPPLIER	FREQUENCY	STABILITY	OUTPUT	PHASE JITTER	SIZE	AVAILABLE
EA Series	TXC	312.5MHz, 625MHz	±50ppm (-40 to +105°C)	LVDS, LV-PECL	30fs typ.	2520	312.5MHz in MP, 625MHz in Sample
DExxxxAx Series	KDS	312.5MHz, 625MHz	±20ppm (-40 to +105°C)	LVDS, LV-PECL	27–32fs typ.	2016, 2520, 3225	312.5MHz in MP, 625MHz in Sample
Ark.3G	KDS	156.25MHz	±50ppm (-40 to +105°C)	LVDS, LV-PECL	70–80fs typ.	1008	
Conventional Oscillators	Standard	156.25MHz	±50ppm (-40 to +105°C)	LVDS, LV-PECL, HCSL	70–150fs typ.	2016, 2520, 3225	

increase, frequencies rise, and the signal voltages required to process those speeds inevitably become smaller. Signal voltages are already as low as 0.8V, and PAM4 divides this voltage into three parts, each of which must rise and fall as a distinct signal. In this situation, where even the slightest power supply noise could be mistaken for a different signal, the importance of suppressing noise from the IC's power supply has grown.

As a capacitor for noise suppression, we would like to introduce RUBYCON's PMLCAP. Although this capacitor may not yet be widely known to the public, it offers outstanding characteristics that make it a high-quality solution for noise suppression. In fact, the PMLCAP has been used since the 2000s and has already proven its reliability in numerous applications, particularly in the fields of audio, sensor technology, and measurement equipment.

As the abbreviation PMLCAP stands for »Polymer Multi-Layer CAPacitor«, it is a capacitor that uses polymer; however, unlike capacitors that use conductive polymers – such as solid polymer capacitors and hybrid capacitors – it uses an insulating polymer as its dielectric. To put it simply, this capacitor is the same as an MLCC in terms of size, shape, and structure, and its internal structure is the same as that of a film capacitor. However, unlike multilayer chip film capacitors, the dielectric layers are deposited using vacuum evaporation, ensuring absolutely no unevenness in the dielectric. Furthermore, since its structure is the same multilayer type as an MLCC, it also possesses all the advantages of an MLCC. Although it is

said to be identical to an MLCC, the dielectric is, of course, a polymer (acrylic resin). Unlike MLCCs, which use ceramic with a crystalline structure as the dielectric, this capacitor exhibits absolutely no DC bias or piezoelectric effect, and therefore does not develop cracks (see Table 2).

The characteristics of PMLCAP are as follows:

- Compact, lightweight, and high-capacity
- Can be made 90% smaller than film capacitors with the same specifications (available in sizes down to 1608)
- Stable temperature characteristics (±5%/–55 to 125°C)
- Because it uses a thermosetting resin, the dielectric itself has high heat resistance and is compatible with reflow soldering.
- Virtually no noise caused by Coulombic forces compared to film capacitors
- No voltage derating or DC bias phenomenon
- No cracks, ignition, or flammability (The only failure mode is an open circuit.)
- No piezoelectric effect occurs during vibration, ensuring noise-free operation in all environments
- Very low ESL due to its multilayer structure, similar to MLCCs
- Very low dielectric absorption, ensuring clean electrical signals
- Very low leakage current due to insulating polymer layers deposited by vapor deposition
- Very low EMI due to the absence of magnetic materials
- Ultra-low distortion compared to MLCCs and any other polymer capacitors

Among these characteristics, the low dielectric absorption and extremely low ESL are particularly significant for high-speed data communication (see Figure 3).

Since PMLCAPs fall into the same category as film capacitors, they have extremely low dielectric absorption. In other words, they are unlikely to accumulate unwanted voltage again after being discharged. This enables extremely precise charging and discharging, preventing noise from being introduced into subsequent electrical waveforms. Of course, when considering dielectric absorption alone, film capacitors are slightly superior due to their material properties; however, this is where the low ESL of PMLCAPs comes into play. Film capacitors are generally large and leaded, resulting in a low resonant frequency; they are not effective at the frequencies used in high-speed data communication. However, since PMLCAPs use the same multilayer construction as MLCCs, they feature low ESR and low ESL, resulting in a high resonant frequency. In particular, their ESL is actually lower than that of small conductive polymer capacitors.

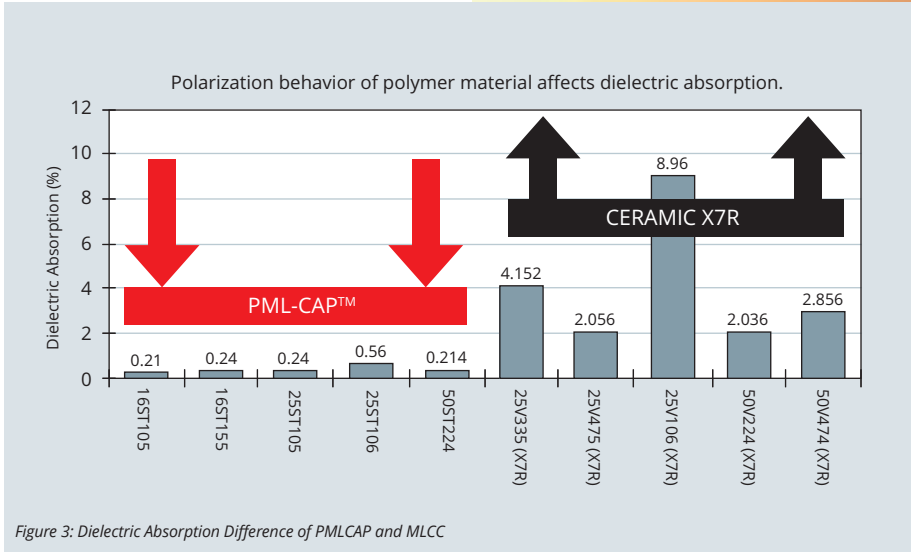
However, since its ESL is not as low as that of MLCCs, PMLCAPs cannot outperform MLCCs when it comes to GHz-band noise countermeasures in the signal stages of high-speed data communication. Nevertheless, PMLCAPs can be used very effectively as decoupling capacitors near the power supply of IC chips such as SerDes.

The challenge of high-speed data communication is not simply a matter of implementing noise

Table 2: Comparison between MLCC, PMLCAP and other Polymer-Stacked Capacitors

PARAMETER	MLCC (CLASS II)	PMLCAP	AL-POLYMER (STACKED)	TA-POLYMER
Polymer Type	–	Insulating	Conductive	Conductive
Voltage	4 to 100V+	10 to 200V	2 to 35V	2 to 75V
Capacitance	100nF to 100µF	25pF to 22µF	10 to 560µF	3.9 to 1500µF
ESL	Very low	Very low	Low	Low
Best Frequency Range	1MHz to 500MHz	100kHz to 10MHz	100kHz to 1MHz	100kHz to 1MHz
Size	0.4×0.2mm to 3.2×2.5mm	1.0×0.5mm to 5.7×5.0mm	7.3×4.3mm only	2.0×1.2mm to 7.3×4.3mm
DC Bias	Severe	None	None	None
Piezoelectric Noise	Yes	None	None	None
Shock Resistance	Poor	Excellent	Good	Good
EMI Resistance	Good	Excellent	Poor (metal structure)	Poor (metal structure)
Cracking Risk	Fire and smoke risk	None	None	None (no MnO ₂)
Failure Mode	Short circuit (fire risk)	Open circuit	Short circuit (low risk)	Short circuit

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countermeasures in the signal stage alone. Power supply noise fluctuations also generate switching noise jitter (SNJ) due to switching delays, and this jitter affects the signal stage. High-speed data communication is so sensitive to jitter that even jitter in the order of picoseconds in the clock signal is unacceptable. PMLCAP reliably suppresses this power supply noise.

Furthermore, it goes without saying that since PMLCAPs do not exhibit the piezoelectric effect found in MLCCs, they not only produce no buzzing but also generate no noise even when subjected to external impacts, making them capable of

withstanding harsh external environments. The fact that PMLCAPs have been used not only in automotive applications but also in Mars rovers proves this.

Electronic devices and components are the foundation supporting this society, which is evolving even further with the advent of AI. And the pace of that evolution is expected to accelerate even further. Both the Differential Output Oscillator and the PMLCAP discussed here are products that offer visibly tangible benefits in noise reduc-

tion. If you incorporate them into your PCB design from the early stages, the amount of noise mitigation work required after prototyping will be drastically reduced. Of course, in addition to these, our company also provides design support for inductors and other components.

If you are interested or have any questions, please feel free to contact us.

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PASSIVE KEY COMPONENTS

For Reliable, Demanding BLDC Applications

Since the brushless design reduces wear and friction losses, BLDC motors are a common solution in various applications where high efficiency, high torque and compact designs are key. Along with this, advantages like a high reliability, a precise control and the fact that they require less maintenance make BLDC motors a popular choice in many industries.

High-performance passives like capacitors, inductors and resistors play an essential role for a successful BLDC design. High-performance passives are key for efficiency, reliability, longevity and miniaturization. In this article we will have closer look at them.

Among the most important are the DC-link capacitors and filter inductor + capacitor, responsible for ensuring a clean and stable power supply, and the current shunt resistors, which provide the feedback required for precise motor control and system protection.

Every BLDC inverter behaves as a highly dynamic switching load. During PWM operation, the in-

verter continuously draws pulsed currents from the DC supply, generating rapid current changes (high di/dt) and voltage transitions (high dv/dt).

These switching events create conducted electromagnetic interference (EMI), voltage ripple and current harmonics that can propagate throughout the power distribution system. To suppress these disturbances, most inverter designs incorporate an input filter, consisting of a capacitor and inductor. Control electronics of a BLDC motor require capacitors, that perform a few important functions. Especially for the DC-link capacitor, low-ESR high-performance versions have to be selected. Since a certain capacity is also crucial, technologies such as Al-electrolyte

capacitors or – for miniaturization – Al-polymer hybrid capacitors are the perfect solution.

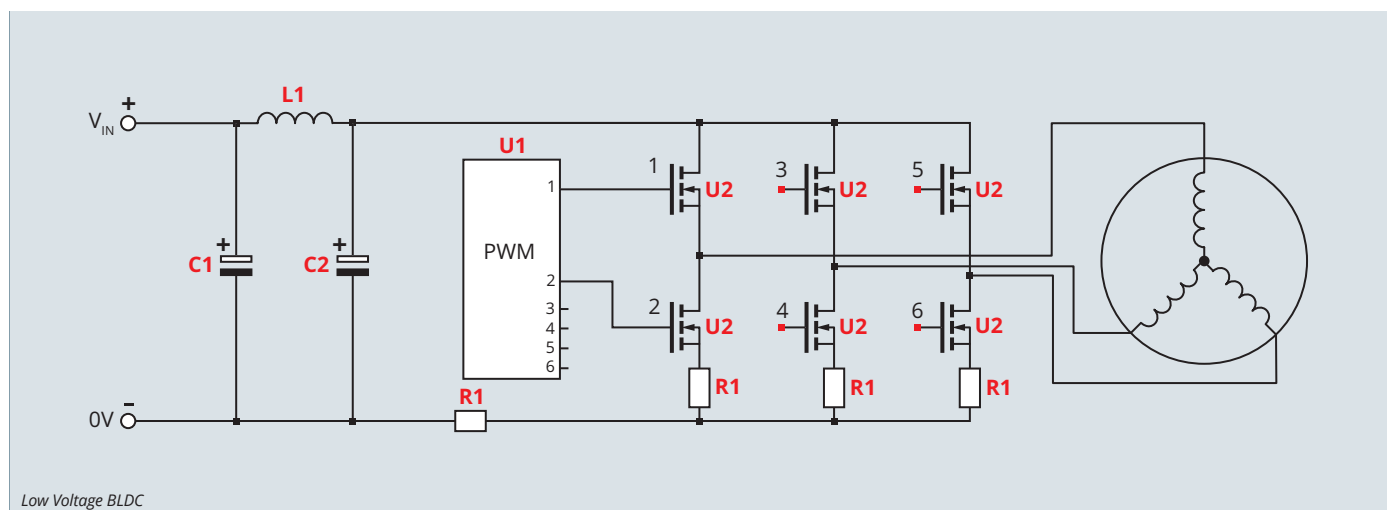
C1: Filter/Buffer Capacitor

Capacitors with low ESR smooth the residual ripple (ripple voltage) of the regulated voltage much more effectively than standard capacitors, which reduces electromagnetic interference (EMI) in the system. Depending on the inductor L1, a minimum capacitance might be required. Also depending on the inductor L1 is whether C1 has to take over a part of the voltage ripple described in the chapter above.

L1: Filter/Buffer Choke

The entire C1-L1-C2 network serves as the primary energy buffering component between the noisy inverter and the external power source. The component characteristics have a direct influence on conducted emissions, efficiency, thermal performance, and long-term system reliability.

As previously mentioned, under operation, the inverter draws pulsed currents from the power supply. For example, in power tools, the supply





is typically a battery that can be negatively impacted by these spikes, reducing its lifespan. The inductor (L1) presents very low impedance to DC while offering significantly higher impedance at the PWM switching frequency and its harmonics, thereby protecting the battery from these adverse effects.

So L1 reduces ripple currents by minimizing AC components in the current drawn from the power supply, thereby reducing stress on the battery and other system components. Additionally, it regulates current flow by smoothing out pulsed currents and providing a stable current supply to the inverter as a current buffer.

The larger the inductance, the more effectively rapid current changes are limited. However, selecting L1 inductor involves considerably more than choosing an inductance value.

DCR: based on the equation $P = I^2 \times R$, the DC losses can be calculated. The lower the DCR, the lower also the losses that are the main cause of the self-heating. The DCR can be lowered by using bigger wire gauge or even more significantly with flat wire.

I_{rms} (rated current): DC current that causes a certain self-heating due to the DCR of the winding. This value is not uniformly defined and therefore varies depending on the manufacturer and even between individual series. For the I_{rms} value, a value should be chosen, that reflects the nominal motor current.

I_{sat} (saturation current): is the defined current at a certain saturation level. The saturation behavior depends on the core material and even more on the air gap, thus the inductor construction. Ferrite inductors in general have smaller air gap, which leads to a hard saturation drop. While molded inductors provide a distributed air gap all over the whole core volume, leading to a higher saturation rating and softer behavior.

For the usage in automotive and industrial environments and heavy-duty power tools, vibration resistance and temperature stability are additional challenges. These can commonly be achieved by using AEC-Q200 qualified products, with a tendency to molded inductors that show a much narrower temperature drift. Less harsh applications tend to be more price-sensitive and less demanding, which opens the door for ferrite inductors.

C2: DC-Link Capacitor at PWM (Pulse Width Modulation)

Why low ESR and high ripple current capability is important:

BLDC motors are controlled via PWM (pulse width modulation). This generates high-frequency, rapidly alternating current pulses in the input circuit. A low ESR ensures that the capacitor can absorb and release these rapid load changes without significant power loss.

At the typical high currents during motor operation, a higher ESR causes the capacitor to heat up significantly internally, which drastically reduces its lifetime and leads to premature failure. Depending on the topology, 0.3 to 0.8 times the motor current flows from the DC-link capacitor C2 (the difference comes directly from the input). This is the ripple current that it must continuously supplied by the capacitor. Turning off the motor winding during a phase change also generates an induced voltage (commutation transients). The capacitor must be able to absorb this energy.

At low voltages like in the 12V to 48V range, percentage voltage fluctuations caused by higher internal resistance of standard capacitors during



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sudden load changes have a significant impact. Technologies with low ESR ensure a stable supply voltage, which prevents the controller's logic or microcontroller from failing due to undervoltage.

Furthermore, an extremely low ESL is even more important than the low ESR. For this reason, SMD components are advantageous and are placed directly next to the semiconductor (often distributed among three capacitors, one per half-bridge). That's where Al-polymer-hybrid capacitors really show their advantages. This technology achieves really low ESR values and very high ripple-current capabilities in SMD footprint and compact case sizes. Additionally, a long lifetime under high temperatures is provided.

Another factor is the maximum acceptable voltage ripple, which is caused by the current and the capacitive resistance (impedance). As the capacitance value has a direct influence on this ($\Delta U = I \times \Delta t / C$), selecting an adequate capacitance can help to stabilize the motor voltage and ensure that the motor remains within a safe operating range. C1 might take over a part of this task as well.

Al-Polymer-hybrid technology is moving forward quickly and offers various solutions. Latest technologies achieve more than 2Arms rated ripple current at 150°C with a guaranteed lifetime of 4,000hrs. At 125°C, this corresponds to 6Arms/4,000hrs. Of course, they are AEC-Q200 certified and commonly used in automotive water and oil pumps.

Small case sizes, like 5×6mm, 6.3×6mm and 6.3×7.7mm, provide higher design flexibility and

miniaturization in applications with limited space like handheld or battery-driven devices like power tools. Even such small dimensions have considerable ripple current capabilities of up to almost 3Arms@125°C/4,000hrs.

For vibration-resistant requirements, SMD capacitors with a vibration-proof socket are available for a diameter of 6.3mm or greater, as well as THT versions.

Related to PCB space, also new dimensions of 8×12.5mm and 8×16.5mm are currently under development, which are optimized for high ripple current capabilities at reduced PCB area or even much higher ripple current at the same PCB area.

Research and new developments in the field of Al-polymer-hybrid capacitors are moving in a clear direction: miniaturization. This means higher ripple current capability and higher capacitance while maintaining compact case sizes.

So, with focus on capacitance and lifetime at higher temperatures, in addition to ESR and ripple current, Al-polymer-hybrid capacitors are the perfect combination for a reliable, high-performance and space-optimized solution.

R1: Precision Current Sensing with Shunt Resistors

In low-voltage BLDC drives, accurate current feedback is essential for efficient commutation, torque control and reliable overload protection. A low-ohmic shunt resistor generates a voltage drop proportional to the current, which is amplified and evaluated by the motor controller. Depending on the control architecture, current can be measured

with a single shunt in the DC link or with two or three shunts in the inverter phases. A single-shunt approach reduces component count but requires more complex current reconstruction in the control software, whereas phase-shunt configurations provide more direct current information and can simplify field-oriented control.

The shunt must provide sufficient measurement resolution while keeping power losses and self-heating low. Low resistance values improve efficiency, but they also produce smaller measurement signals. Consequently, parameters such as resistance tolerance, temperature coefficient, thermal resistance, long-term stability and parasitic inductance directly influence the accuracy and dynamic response of the motor control system. Low-ohmic shunts for compact BLDC power stages, including designs with low inductance, high pulse-load capability and optimized heat transfer into the PCB are the preferred setup.

These characteristics are particularly relevant in applications such as power tools, drones, robotic actuators, light electric vehicles and compact industrial drives, where high currents, fast switching and limited PCB space occur simultaneously.

For support in finding the appropriate passive component solution for your requirements don't hesitate to contact us.

P02

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BE SAVE



Surge Protection for Industrial AC Networks

Industrial AC networks are rarely electrically »quiet«. Motors are switched, contactors open under load, transformers energize, inverters feed back into the grid, and outdoor cables may couple surge energy from lightning events into the installation. In many applications, the AC input is therefore not just a power connection. It is also a possible entry point for high-energy transients.

For equipment manufacturers, this creates a practical challenge: the protection circuit must be robust enough for the real installation environment, but still compact, cost-effective and suitable for series production. A single protection component is often not enough. In industrial AC applications, surge protection is typically built as a coordinated protection concept, using several components with different tasks. THINKING Electronic Industrial Co., Ltd. – TKS – offers a broad portfolio for this purpose, including metal oxide varistors, thermally protected varistors, gas discharge tubes and complementary protection components.

Why Protection Components Are Often Combined

A surge event is not defined by voltage alone. The waveform, source impedance, available energy, repetition rate and installation category all influence the stress on the protection circuit. One component may clamp quickly, another may handle high surge energy, and another may provide safe disconnection in a fault condition. This is why industrial surge protection is usually designed in stages.

A typical AC input protection architecture may use a gas discharge tube as a high-energy first protection element, combined with one or more metal oxide varistors for fast voltage limitation between line, neutral and protective earth. Downstream, additional protection may be used for the power supply, control electronics or communication interfaces. In this arrangement, the first stage absorbs or diverts the highest energy, while the following stages reduce the residual stress to a level the electronics can tolerate.

This approach is especially relevant in applications where the equipment is connected to long cables, external infrastructure or three-phase power networks. The protection target is not only to survive a single laboratory pulse, but to maintain reliable operation over the lifetime of the equipment.

Use Case: Industrial Power Supplies and UPS Systems

Industrial power supplies and UPS systems are often installed in control cabinets, machine rooms or decentralized field equipment. They

are exposed to grid disturbances, switching transients and possible surge coupling from the facility network. If the AC input stage fails, the effect is immediate: the controller, sensors, actuators or communication modules supplied by the unit may shut down.

In such systems, TKS metal oxide varistors can be used on the AC input to clamp line-to-line and line-to-earth overvoltages. For higher surge requirements, larger high-energy MOV types from the TVA family can be considered. In installations where the power supply is part of safety-relevant or difficult-to-access equipment, thermally protected varistors from the TVT series add another important function: if the MOV overheats due to abnormal overvoltage conditions, the integrated thermal protection disconnects it from the circuit. Three-terminal versions also allow monitoring of the protection status, which can be useful for predictive maintenance or service indication.

In UPS systems, the surge protection concept may be combined with inrush current limiting and thermal monitoring. This illustrates why TKS is not limited to one product family. The AC input must be protected against surge voltage, while large capacitors in the power stage require controlled charging during switch-on. A coordinated design can therefore combine MOVs or GDTs for surge protection with NTC or PTC elements for current and thermal management.

Use Case: Motor Drives, Pumps and HVAC Equipment

Motor-driven equipment is one of the classic sources of electrical stress in industrial AC networks. Pumps, fans, compressors, elevators, escalators and HVAC systems switch inductive loads and often operate in environments with long cable runs. When inductive current is interrupted, voltage peaks can occur. These peaks may stress relay contacts, semiconductors or the AC input of the control electronics.

MOVs are well suited for this type of application because they respond quickly when the voltage exceeds their threshold and conduct the transient energy away from the protected circuit. They can be used to reduce surge stress across supply lines or near switching elements, depending on the system architecture.

For engineers, the important point is the placement of the protection. A varistor at the mains input protects the equipment against incoming network transients. A varistor placed closer to an inductive load or switching contact can help reduce locally generated overvoltage. In larger systems, both positions may be needed. This is where CODICO can support the Design-In process: the component must match not only the nominal AC voltage, but also the expected transient energy, operating temperature, mechanical space and applicable safety requirements.

Use Case: Photovoltaic Inverters and Energy Storage Systems

PV inverters, energy storage systems and local



backup power systems are exposed to demanding electrical conditions. They are often connected to outdoor infrastructure, long cables and grid interfaces. Surge events may enter from the AC grid side, from external cabling or from nearby lightning activity. At the same time, these systems are usually expected to operate for many years with limited maintenance.

For such applications, the protection concept must be robust and serviceable. High-energy MOVs can be used for AC-side surge limitation, while GDTs may be added where high surge energy and high insulation resistance are required. A GDT can handle strong surge events by switching into a conductive plasma state when its spark-over voltage is reached. However, in power line applications, a GDT must be carefully coordinated, because the line can continue to supply current after the surge event. This is one reason why GDTs are often combined with MOVs, fuses or thermal protection elements rather than used as isolated components.

In practice, the MOV contributes fast voltage clamping, while the GDT supports high-energy surge diversion. The surrounding circuit ensures that the protection stage resets or disconnects safely after the event. This combination is particularly relevant for equipment connected to exposed AC lines or outdoor installations.

Use Case: Control Cabinets and Power Distribution Units

Control cabinets and power distribution units form the electrical backbone of many industrial installations. They supply PLCs, relays, drives, sensors, gateways and local power supplies. A surge entering at this level can affect several subsystems at once, so protection at the distribution point is often more effective than protecting only the final device.

In these applications, higher-energy TKS MOVs from the TVA range can be used as part of the main surge protection stage. For Class I SPD-related requirements, the TVA34 series is designed

COMPONENT	MAIN FUNCTION	TYPICAL USE IN INDUSTRIAL AC NETWORKS	KEY STRENGTH	WHY IT IS OFTEN COMBINED WITH OTHERS
MOV (Metal Oxide Varistor)	Clamps transient overvoltage	AC mains input, motor drives, HVAC, power supplies, control cabinets	Fast response and strong surge absorption	Good for voltage clamping, but repeated heavy surges can age the device
High-Energy MOV	Handles higher surge energy levels	Main AC input, distribution panels, heavy industrial equipment, outdoor-connected systems	Higher surge current and energy capability	Often used as the main clamping element, but still benefits from upstream/downstream coordination
Thermally Protected MOV (TVT series)	Clamps surges and disconnects safely in overload or end-of-life condition	Power supplies, UPS, control cabinets, building systems	Improved fail-safe behaviour	Adds safety and monitoring capability where a standard MOV alone may not be sufficient
GDT (Gas Discharge Tube)	Diverts high-energy surge current after spark-over	Lightning-related protection, exposed AC lines, infrastructure, PV and outdoor systems	Very high surge capability, high insulation resistance, very low capacitance	Works well with MOVs because it handles heavy surge energy, while the MOV provides faster voltage clamping
SMD Varistor	Board-level surge protection in compact designs	Control boards, compact AC/DC modules, automation electronics	Low profile, SMT assembly, space-saving	Usually not the only protection stage; often supported by stronger input-side protection
NTC Inrush Current Limiter	Limits switch-on inrush current	Power supplies, UPS, converters, industrial equipment with large input capacitors	Protects against startup current stress	Not a surge clamp itself, but complements the protection design by reducing current stress during power-up



TVA22 & TVA25 Series



TVR Series



TVT Series

for impulse current capability with the 10/350 μ s waveform, making it relevant for applications where lightning-related surge energy must be considered. Depending on the mechanical design, screw-fastened terminal versions can support stable integration into power assemblies.

Compact Board-Level Protection

Decentralized I/O modules, compact power supplies, controllers and building automation devices often have limited PCB area and restricted component height.

TKS addresses this with SMD varistors such as the TVBDS and TVBES series. These components allow automated assembly and reduce the height above the PCB compared with leaded MOVs. They are useful for board-level surge protection where the expected energy level is compatible with the component rating. Typical examples include compact AC input stages, control

boards, small industrial power modules or auxiliary power circuits.

The benefit is not only mechanical. SMD protection also allows the designer to place the protection element closer to the circuit section that needs protection. However, layout remains critical. Creepage and clearance distances, surge current paths, thermal dissipation and coordination with upstream protection must be considered from the beginning of the design.

Practical Design Assessment

Surge protection is always a compromise between protection level, component size, thermal behaviour, lifetime, cost and available space. A larger MOV may offer higher surge current capability, but requires more installation volume. A compact SMD varistor can simplify assembly, but cannot replace a high-energy protection stage at the mains entry. A GDT can handle high-

energy pulses with very low capacitance and high insulation resistance, but it must be coordinated to avoid unwanted follow current. A thermally protected varistor improves fault behaviour, but requires the designer to consider monitoring and replacement strategy.

This is why the selection should start from the application, not from the component. Relevant questions include: Is the equipment connected to indoor or outdoor AC lines? Is it single-phase or three-phase? Are long cables involved? Are inductive loads switched? Is the device installed in a control cabinet, machine, PV system, railway system or building infrastructure? Is protection monitoring required? What surge waveform and current level must be considered?

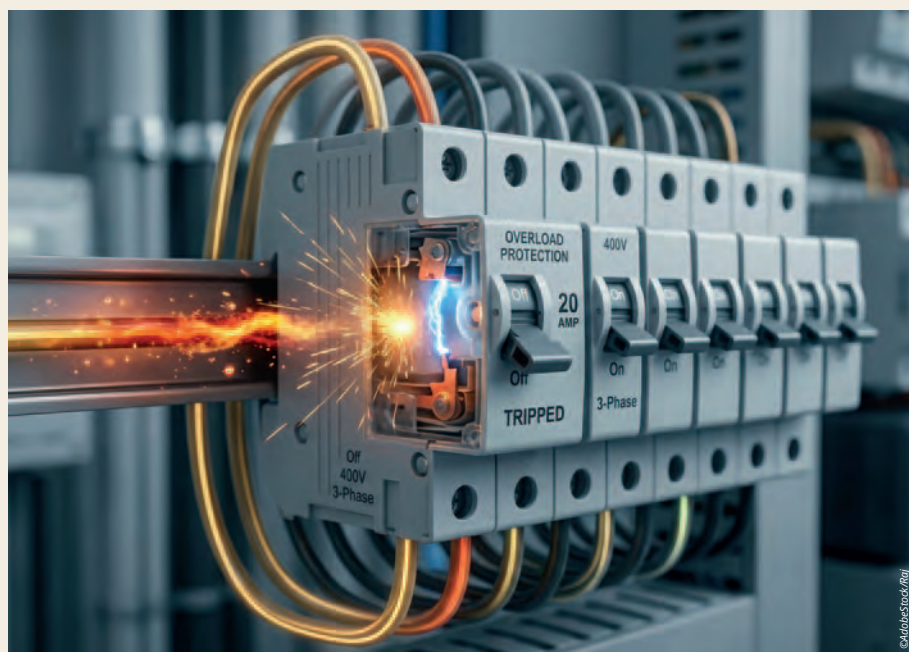
CODICO and TKS: From Component Selection to Protection Concept

With TKS, CODICO offers a wide range of components for industrial AC surge protection, from compact SMD varistors to high-energy MOVs, thermally protected varistors and gas discharge tubes. As supplier and design-in partner, CODICO supports customers not only in selecting a product series, but in defining a suitable protection concept for the application.

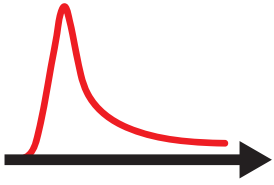
For engineers developing industrial power supplies, motor drives, HVAC controllers, PV inverters, energy storage systems, control cabinets or infrastructure equipment, TKS provides a practical portfolio for building robust AC surge protection. The result is a protection design that helps reduce field failures, improve system availability and protect the investment behind the electronics.

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INRUSH CURRENTS

When Milliseconds Determine Relay Endurance

Why the rated current alone is not enough: A relay can easily carry and switch 16A – and still fail with a 2A load. The crucial factor, when inrush currents occur, is: What happens in the first microseconds and milliseconds after contact closing? The high inrush current is hitting bouncing contacts and small contact areas.

The term »inrush« current refers to the increased current immediately after a load is switched on. While with ideal resistive loads the current simply jumps to its steady-state value, in many real-world applications, empty capacitors, cold filaments, motors, etc., can cause massive current spikes.

Rated Current Can Be Misleading

- When switched on, LED lamps and switched-mode power supplies charge their input capacitors. In extreme cases, the resulting current peak can reach up to 300 times the rated current. Particularly in lighting applications, the importance of inrush currents has increased dramatically in recent years due to the widespread adoption of LED lamps.
- Motors require time to start up and draw significantly higher currents during this phase than under rated operating conditions. The same may also apply to solenoid valves.



- Particularly in smart home and factory automation applications, electronic designers often do not know the specific loads that will ultimately be connected. In such cases inrush currents should be carefully considered as well.

GOODSKY

SANYOU

THINKING

This often explains a typical field failure: Although the relay is correctly selected for the continuous current, its contacts are welding together after significantly fewer switching cycles than expected.

What Happens on the Relay Contact?

The closing of an electromechanical contact is not an ideal, instantaneous process. At the moment of initial contact, the actual contact area is small and the contact resistance is still high. The moving contact may then rebound several times, a phenomenon known as contact bounce. Each brief reopening of the contact under load can produce an electric arc. This may locally melt the contact material, causing the two contact surfaces to weld together or transferring material from one contact surface to the other.

Contact material, contact mass, movement dynamics, and contact force therefore are influencing the relay's ability to withstand inrush currents



GOODSKY GQ-16A Series

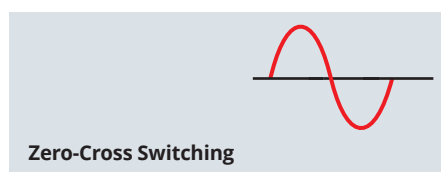


SANYOU SM-SC & SJ-SC Series

GOODSKY, for example, offers the GQ-16A series for this purpose, which also provides a TV-8 rating in a very compact form factor.

Additional Solutions

In some cases, additional measures are required to make an application more resistant to high inrush currents:



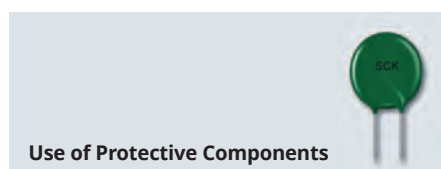
Zero-Cross Switching

- The relay is switched on precisely at the zero crossing of the AC supply voltage.
- This can significantly reduce the current peak.



Hybrid Switching

- The switching operation is performed by a semiconductor device, such as a thyristor, triac, or MOSFET, so that the relay contacts are not subjected to the inrush current during turn-on.
- The electromechanical relay then carries the current with minimal power loss.



Use of Protective Components

- Inrush-current-limiting protective components can also provide an effective means of reducing current peaks.
- For this purpose, the manufacturer THINKING offers, among other products, a broad portfolio of NTC and PTC components.

just as much as its nominal contact-current rating. Consequently, at the same continuous current, a relay with a contact system specifically designed for high inrush currents can be significantly more robust than a standard relay.

Relays Optimized for Inrush Currents

A relay's ability to handle inrush currents is often expressed by UL »TV« and/or »Electronic Ballast« ratings. For example, during its endurance test, a relay with a »TV-8« rating is tested with a continuous current of 8A and an inrush-current peak of 117A.

SANYOU offers high-inrush-current versions in many relay categories. For example, both the SANYOU SM-SC, featuring the conventional 16A form factor, and the SANYOU SJ-SC, featuring a new compact 16A design, are available in inrush-current versions. Both relays have already a UL TV-8 rating.

These applications require a close coordination with relay parameters to achieve a robust and reliable solution.

Working Together to Find the Optimum Relay Solution

As a European relay specialist, we support our customers far beyond product distribution alone. With in-depth expertise at manufacturer level and comprehensive application consulting, CODICO actively assists customers with applications involving complex loads.

Don't hesitate to get in touch!

P04

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CONCLUSION

The complexity of loads switched by electromechanical relays continues to increase due to LED lamps, switched-mode power supplies, motors, and building automation applications. As a result, the traditional, purely resistive load is becoming more and more uncommon in practice, making the selection of the appropriate relay more complex.

The rated current determines whether a relay can carry the current of a particular load. However, the inrush current often determines whether the relay can switch on that load reliably. Giving the first few milliseconds the same attention as continuous operation helps to prevent welded contacts, unexplained failures, and unnecessarily oversized relays.

POWER CONVERTERS

Based on SiC Raise the Requirements for Passive Key Components

More power in less space is creating new challenges for power electronics. Wide-bandgap semiconductors such as SiC and GaN enable more compact and efficient designs, but at the same time place greater demands on passive components. The right selection and dimensioning of these components are therefore becoming key factors in achieving performance and reliability.

The growing demand for higher power density in power electronics increasingly justifies the use of wide-bandgap semiconductors. SiC-MOSFETs and GaN-HEMTs enable significantly higher switching frequencies than conventional silicon IGBTs, while simultaneously reducing switching losses. Combined with higher permissible blocking voltages and operating temperatures, this allows for more compact and efficient inverters than would be economically feasible with silicon devices.

INVENTCHIP owns its own 6-inch SiC wafer fabrication plant and continuously expands its portfolio of SiC switches, SiC diodes, and drivers up to 3.3kV blocking voltage. With excellent technical support, we can bring new designs from concept to production readiness.

However, the resulting demands on passive circuitry rapidly push the limits of passive components. To combine the benefits of compactness with the required reliability, the correct selection and sizing of passive parts is indispensable.

Power Conversion or Inverter – a Typical Application Domain

SiC semiconductors truly shine in power converters and drive in the higher-kW range. This necessitates a closer look at the associated passive components.

Figure 1 shows the block diagram of a typical power inverter with its relevant sections. The core of this topology consists of an input filter, a rectifier, an active PFC, followed by the DC link and the semiconductor bridge. In this issue we focus on the EMC filter.

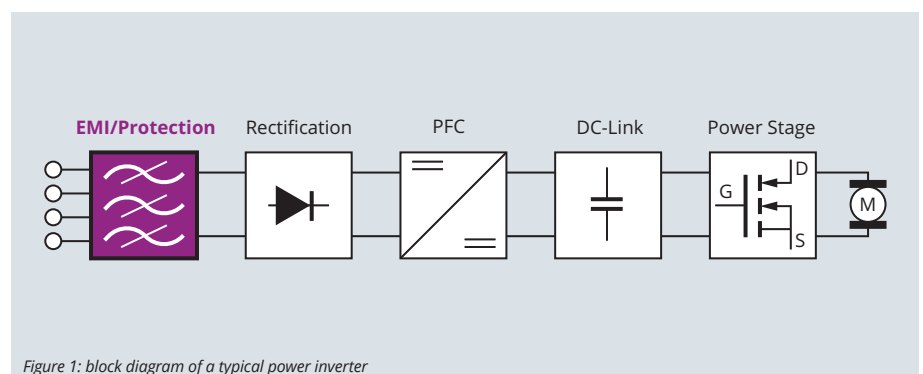


Figure 1: block diagram of a typical power inverter

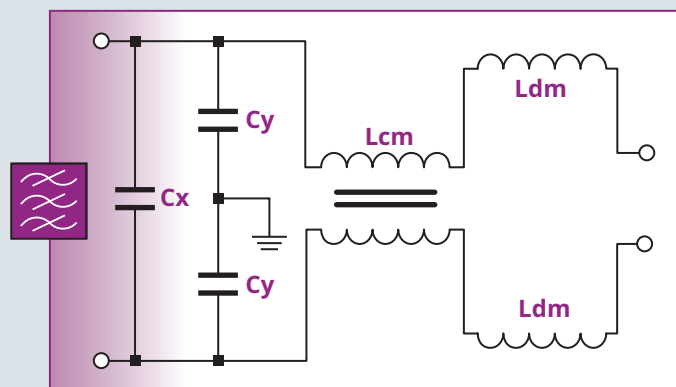
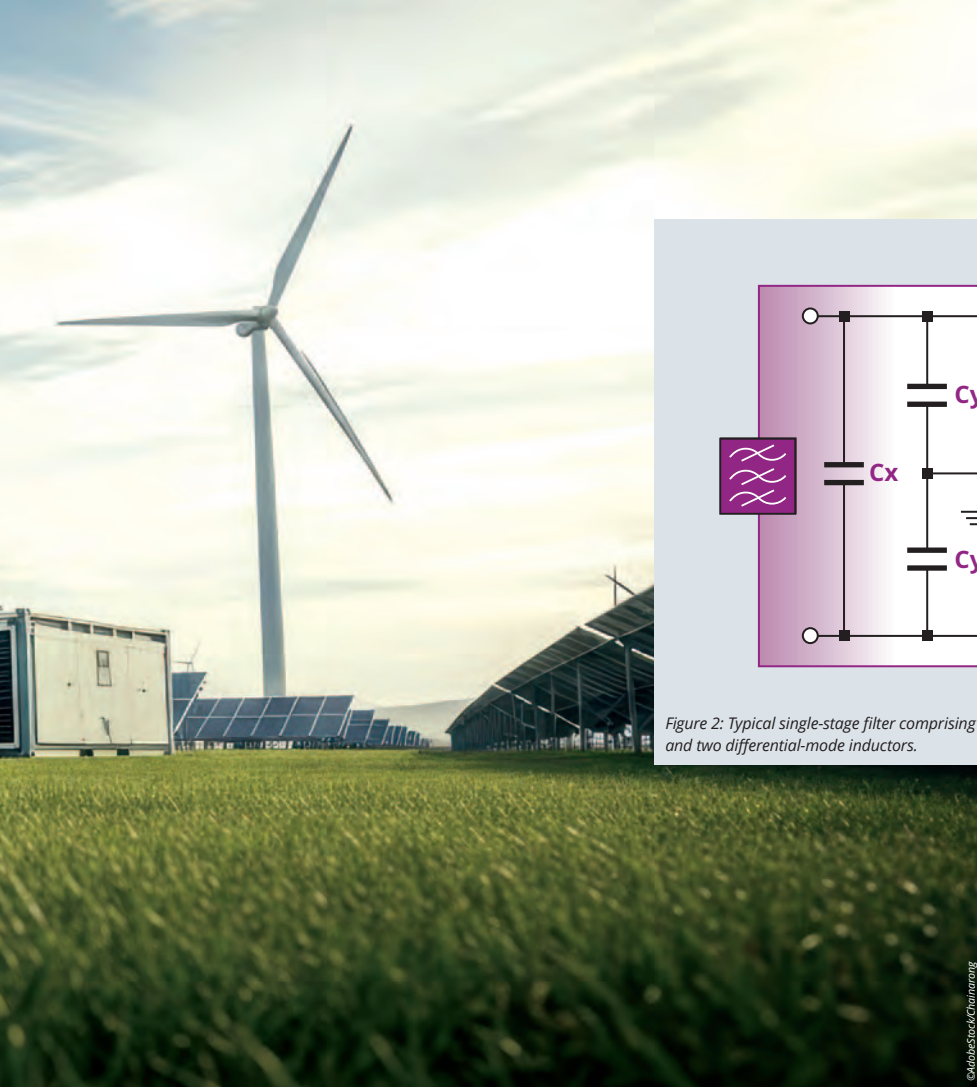


Figure 2: Typical single-stage filter comprising X- and Y-capacitors as well as a common-mode and two differential-mode inductors.

dressed in the section on Y-capacitors. Consequently, the primary burden of common-mode damping must be borne by the CM-inductor.

For EMC inductors, the following features are particularly important:

- High impedance profile over a wide frequency range
- High self-resonant frequency
- Low parasitic capacitance and coupling
- Suitable core material for the relevant frequency range
- Stable properties over temperature and ageing

Nominal inductance alone is insufficient. The decisive factor is the frequency-dependent behavior up to the two-digit MHz range, primarily determined by parasitic effects, winding layout, and the chosen core material. EMC inductors are therefore optimized in winding geometry, segmentation, and core material for the expected disturbance spectrum.

Nanocrystalline and amorphous core materials provide high common-mode inductance with few turns due to their high permeability, reducing parasitic effects while achieving high self-resonant frequencies. They also exhibit lower temperature dependence of magnetic properties compared to many ferrites.

In demanding SiC applications, multi-stage EMC filters are frequently employed, combining several common-mode and differential-mode inductors of different design. This maintains effective impedance over a wider frequency range.

EMC Inductor Requirements

SiC-MOSFET characteristics affect both the type of disturbances generated and the requirements on the inductors used. From an EMC perspective, the essential difference is the markedly higher switching speeds.

Typical Values

PARAMETER	SI-MOSFET	SiC-MOSFET
du/dt	5–20kV/μs	20–100kV/μs
di/dt	A few 100A/μs	Typically a few kA/μs
Switching Time	20–100ns	5–30ns

Because of limited di/dt in the actual commutation loops and the absence of pronounced reverse-recovery effects, the differential-mode disturbances of SiC systems are often comparable to or lower than those of silicon systems. Common-mode disturbances, however, increase substantially.

High du/dt values generate displacement currents through parasitic capacitances such as:

- Trace and cable capacitances to ground
- Motor windings to chassis
- Power semiconductor to heatsink

The common-mode current is given by

$$I_{cm} = C_{par} \times du/dt$$

Since SiC-MOSFETs frequently reach du/dt values exceeding 50kV/μs, the common-mode disturbances can be several times higher than with equivalent silicon solutions.

For assessing conductor-borne disturbance emissions, the frequency range from 150kHz to 30MHz is typically relevant, as examined in the corresponding CISPR emission standards. In classic Si-MOSFET applications, dominant disturbance components often lie in the lower part of this band and fade with increasing frequency. SiC-MOSFETs generate significant disturbance components up to the upper MHz region.

While Y-capacitors can dampen common-mode disturbances, their capacitance is often limited in grid-coupled systems by the permissible leakage current at line frequency (distinct from the switching-frequency common-mode current). The relationship between Y-capacitance, common-mode current, and leakage current is ad-

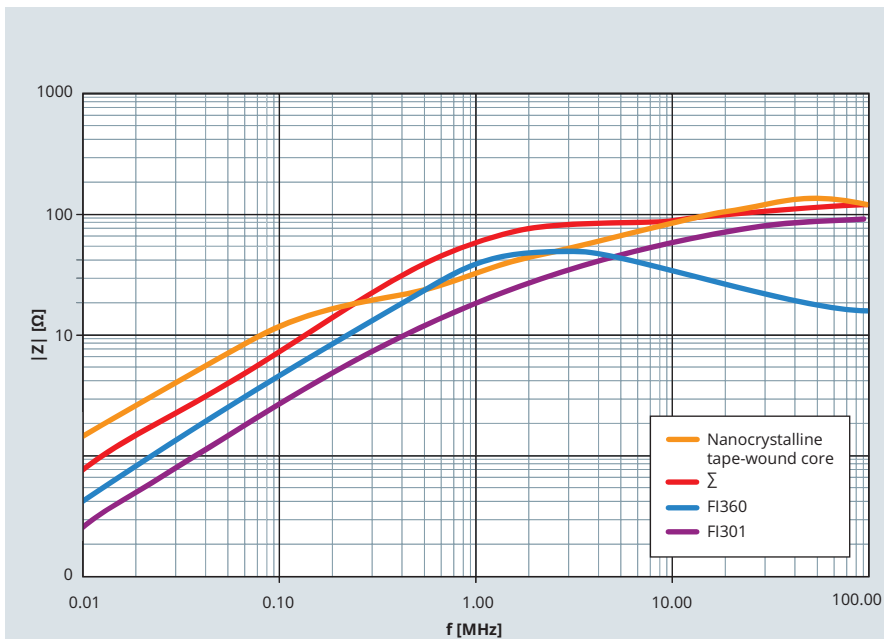


Figure 3: The targeted use of different ferrite materials enables inductor design adapted to the disturbance spectrum. In the shown example, the combination of FI301 and FI360 achieves at least equivalent attenuation above 250kHz compared to a nanocrystalline solution.

To make informed optimizations, our partner SUMIDA can simulate the real disturbance spectrum and match it with the frequency-dependent material properties of the core materials used. With proprietary ferrite development, detailed data on performance in the relevant frequency range are available. On this basis, filter stages can be precisely designed and optimized for EMC effectiveness, size, and cost. In practice, for instance, individual nanocrystalline filter stages can be replaced by suitable ferrite solutions (see Figure 3).

Beyond electromagnetic optimization, mechanical constraints are increasingly important in modern SiC systems. High power densities impose special demands on the integration of EMC components. With its own ferrite production, SUMIDA can develop ferrite cores in customer-specific geometries and mechanically tailor them to each application, for example, to match busbar shapes or tight installation spaces. This allows simultaneous optimization of both mechanical integration and electromagnetic performance.

SUMIDA brings extensive expertise in material development, simulation-based filter design, and customer-specific mechanical optimization. ELYTONE complements this portfolio as an automotive-certified manufacturer with high manufacturing quality.

X- and Y-Capacitors in the EMC Filter

Designing EMC filters requires a shifted weighting of the requirements on safety capacitors. While X-capacitors mainly focus on high-frequency behavior and long-term stability, Y-capacitors must additionally withstand significantly higher common-mode currents and dynamic loads.

X-Capacitors – Focus on High-Frequency Behavior and Stability

X-capacitors primarily damp differential-mode disturbances between conductors. Since these disturbances do not scale proportionally with higher switching speeds in SiC systems, required capacitance values often remain largely unchanged. Design is based on the desired differential-mode attenuation and the resonant behavior of the overall system.

With SiC semiconductors, part of the disturbance spectrum shifts to higher frequencies, raising the importance of the following characteristics:

- Low parasitic inductance (ESL)
- High self-resonant frequency and favourable impedance profile
- Low-inductance integration into the layout
- Stable electrical properties over the entire life cycle

Higher du/dt values affect X-capacitors less directly. The key is that the capacitors must retain

their filtering performance under demanding environmental conditions over the long term. Major stress factors include humidity, elevated temperatures, temperature cycling, and repeated grid transients.

The high power density of compact SiC systems often leads to increased component temperatures and more demanding thermal constraints. Combined with humidity effects, these factors accelerate the ageing of safety capacitors. THB-qualified X-capacitors ensure high stability of electrical properties and help maintain the EMC filter characteristics consistently over the life cycle.

KEMET offers miniaturized, THB-qualified solutions with 85°C/85% relative humidity for 1,000–2,000h. Besides improved humidity and temperature tolerance, optimized winding structures enable compact footprints and favourable high-frequency behavior.

Y-Capacitors – Primary Load-Carriers of Common-Mode Filtering

Y-capacitors are much more strongly affected by the characteristics of modern SiC circuits. Their role is to shunt common-mode disturbances to the protective earth or chassis.

The principle described for EMC inductors applies directly to the Y-capacitor: the common-mode current component is approximately $I_{cm,Y} = C_Y \times du/dt$, where C_Y is the capacitance of the used Y-capacitor.

For Y-capacitors this implies:

- Higher pulse-current loads
- Higher RMS currents
- Greater thermal stress
- Increased electrode and dielectric stress
- Higher long-term stability requirements

In addition to the classic safety requirements (Y1/Y2 certification, voltage endurance, creepage and clearance), extra parameters become critical:

- High permissible du/dt endurance and thus pulse-current endurance
- Low dielectric losses/high RMS current endurance
- Stable behavior under high-frequency continuous loading
- High THB endurance
- Long-term stable capacitance values

At the same time, a classic trade-off emerges in design: higher Y-capacitance improves common-mode attenuation but also increases the regulation-limited leakage current at line frequency. A suitable compromise between EMC performance and permissible leakage current must be found.

As with X-capacitors, temperature and humidity effects play a vital role in long-term reliability, intensified by the continuous high-frequency pulse loading of Y-capacitors. The corresponding THB tests per IEC 60384 serve as important indicators.

KEMET also offers miniaturized safety capacitors that secure EMC performance over extended operating periods. For applications with particularly high loads, KEMET's R41D series provides a specifically optimized Y2 capacitor. While conventional safety capacitors are typically specified for voltage rises of around 500V/ μ s, the R41D series reaches specified values up to 6,000V/ μ s, offering a considerably larger safety margin against dynamic loads.

Key characteristics of the R41D series include:

- High RMS and pulse-current endurance
- Optimized electrode structures for repeated high-frequency impulses
- Robust performance at high switching frequencies
- Compact form factors with high reliability

Thus, the R41D series directly addresses the challenges of modern SiC topologies.

P05

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CONCLUSION

The use of SiC power semiconductors not only alters the requirements for EMC inductors but also for the safety capacitors employed. Selecting suitable X- and Y-capacitors increasingly goes beyond capacity and safety certification to include du/dt endurance, current handling, THB behavior, and high-frequency characteristics.

With KEMET we provide a supplier that offers miniaturized, THB-optimized safety capacitors as well as series specifically developed for demanding high-du/dt applications. Together with our technology partners, we support our customers in selecting and designing the optimal EMC filter solution.

CODICO, in partnership with its suppliers, offers the optimal solution for SiC-based inverters. In this issue we intentionally focused on the EMC filter. Topics such as the DC link, gate drive, PFC, power transformers, and other passive components in SiC applications will be covered in upcoming editions.



SOLID STATE RELAYS



SILD Series



SOD Series



ESUC Series



SOI Series

With Advanced Features



Take manufacturing processes to the next level with innovative SSR solutions from CELDUC® relais

Solid State Relays (SSRs) switch electrical loads using semiconductor devices such as TRIACs, thyristors or MOSFETs instead of mechanical contacts. This results in silent operation, high switching speeds, long service life and precise power control. As mechanical wear is eliminated, maintenance requirements are reduced while consistent switching performance is maintained.

Solid State Relays have therefore become an indispensable component of modern manufacturing systems, helping companies sustainably increase efficiency, reliability and safety.

However, modern SSR technology can do much more than simply switch. Integrated intelligent functions provide valuable insights into ongoing

processes, enhance equipment protection and optimize production performance. Four of these functions are presented below.

1. Integrated Diagnostic and Monitoring Functions

CELDUC® relais Solid State Relays continuously monitor key parameters such as load status, relay output condition and network performance, making this information available in real time. Potential problems such as overheating, overcurrent or short-circuit faults can therefore be detected at an early stage, helping to prevent unplanned downtime and protect critical equipment. Integrated diagnostic messages also shorten troubleshooting times, as maintenance teams can specifically locate and resolve faults.

These advanced functions are designed to increase the reliability, availability and efficiency of industrial processes while providing operators with valuable real-time information. Troubleshooting times are significantly reduced, while the impact of unexpected process interruptions is minimized.

Benefits for Manufacturing Processes

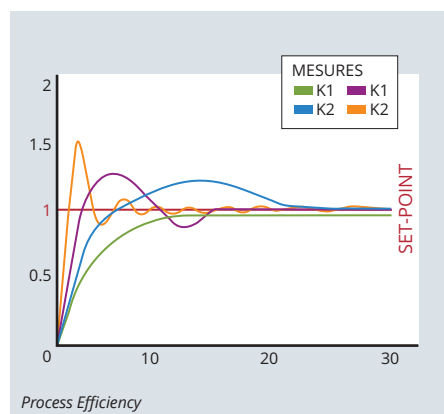
- Early detection of faults and abnormal operating conditions
- Continuous real-time monitoring of critical system parameters
- Reduced downtime and maintenance costs through predictive fault management

Applications: Plastic injection molding machines, PET blow-molding machines, packaging machines, semiconductor manufacturing equipment and glass tempering furnaces – in other words, wherever high equipment availability is critical.

2. PID Temperature Controller

Precise temperature control is a key requirement for numerous industrial manufacturing processes. Combining a PID controller with a Solid State Relay enables highly accurate, stable and energy-efficient temperature regulation. In heating applications such as industrial ovens, melting furnaces, plastic processing machines or heat treatment systems, temperature sensors measure the process temperature and transmit the measured values to the PID controller.

The controller compares the actual value with the setpoint and continuously calculates the required control output. The Solid State Relay then regulates the power supplied to the heating element quickly and precisely, compensating for deviations immediately and minimizing process fluctuations.



PID-controlled SSR solutions are suitable wherever precise temperature control is critical to the process, for example in plastics processing and extrusion, food and beverage production, packaging systems, chemical processes, and industrial and firing furnaces. Manufacturers can increase process efficiency, reduce scrap and ensure consistently high production quality.

The CELDUC® relais Solution: ECOM PID Temperature Controller

The ECOM module, compatible with the SU, SUL and SUM series, features a galvanically isolated thermocouple input for the most common thermocouple types (J, K, T and E). Two independently configurable logic outputs (OUT1 and OUT2) enable separate heating and cooling control.

The integrated PID controller provides automatic tuning, with the PID parameters being adjusted automatically once the control deviation exceeds the »Max Gap Tune« threshold, as well as manual

tuning for individual process requirements. The combination of integrated temperature measurement, flexible control outputs and advanced tuning functions provides precise, reliable and energy-efficient temperature control for demanding industrial applications.

Application Examples

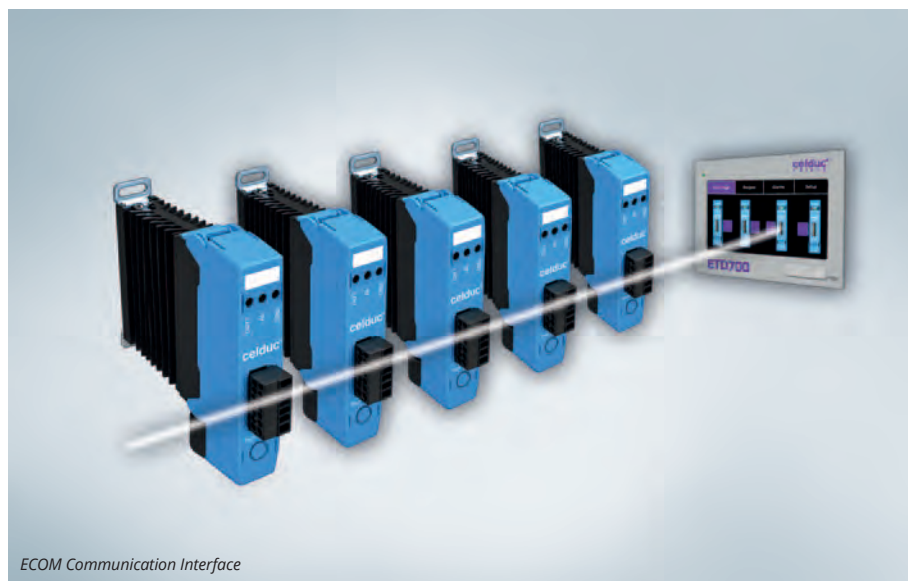
A plastics manufacturer uses Solid State Relays from the SUL series in combination with the plug-in ECOM module to control the temperature of its extrusion systems, achieving stable process temperatures, consistently high product quality and reduced energy consumption.

In a chemical production facility, the same combination ensures optimum reaction conditions throughout the entire production cycle, improving process stability, yield and product quality. Other typical applications include food and beverage production, packaging systems, and industrial and firing furnaces.



Key Benefits

- Highly precise temperature control with improved process stability and repeatability
- Reduced temperature overshoot and undershoot
- Higher product quality and consistent manufacturing results
- Optimized energy consumption
- Reduced maintenance requirements through wear-free switching
- Increased equipment reliability and availability



3. Communication Interfaces

Communication interfaces enable Solid State Relays to exchange data with PLCs, HMIs, SCADA systems and remote monitoring platforms. This gives users greater transparency, improved control capabilities and higher operational efficiency.

Seamless Integration into Automation Systems

Communication-enabled SSRs can be easily integrated into centralized control architectures. Through continuous data exchange with PLC systems and higher-level control systems, operators can monitor equipment status, retrieve process information and adjust operating parameters remotely. This optimizes machine performance and reduces the need for manual intervention.

Real-Time Monitoring and Remote Diagnostics

Modern communication functions provide access to load status, relay condition, electrical measurements and process parameters. Abnormal operating conditions are detected and immediate warnings are issued in the event of faults. Remote access to detailed diagnostic information significantly reduces troubleshooting time, enabling corrective measures to be initiated more quickly and minimizing production downtime.

Ready for Industry 4.0 and Smart Factories

Connected SSRs are becoming an integral part of Industry 4.0 and IoT ecosystems. They provide real-time data to higher-level control and analysis systems, supporting predictive maintenance,

data-driven decision-making and continuous process optimization.

The CELDUC® relais Solution: Communication Module

The ECOM module enables real-time monitoring and control via an RS485 interface using the widely adopted Modbus RTU protocol (other protocols available on request). As an established industrial standard in Building Management Systems (BMS) and Industrial Automation Systems (IAS), Modbus RTU enables seamless integration into existing control architectures, thereby protecting existing investments.

Through this interface, users can remotely retrieve operating data, configure parameters and directly control devices via a PLC or HMI.

Benefits for Manufacturing Processes

- Seamless integration into Industry 4.0 and IoT environments
- Real-time monitoring, remote diagnostics and remote control
- Simplified communication with PLCs, HMIs and higher-level control systems
- Faster fault analysis and increased equipment availability
- Reduced wiring effort and smaller control cabinet dimensions
- Compact all-in-one solution for monitoring, measurement, control and communication

Typical applications: Energy management systems, HVAC systems (heating, ventilation and air conditioning), water and wastewater treatment,

industrial process automation, building management systems and smart manufacturing facilities.

4. Analog Power Control

Where simply switching a load on and off is not sufficient, SSRs with analog control continuously adjust the output power to meet process requirements. Unlike conventional SSRs, which operate in a binary manner, they modulate the output power smoothly and precisely.

Advanced control methods such as phase-angle control, burst firing or full-wave pulse control are used. This ensures that the load receives exactly the amount of energy required, improving process efficiency, reducing energy consumption and minimizing equipment stress.

CELDUC® relais Solutions

CELDUC® relais offers a comprehensive portfolio of power controllers with input signals of 0–10VDC, 4–20mA, potentiometer and PWM (pulse-width modulation). Available control methods include:

- **Burst-firing control (SO3 series):** ideal for resistive loads with low thermal inertia, such as short-wave infrared emitters and infrared heating lamps



- **Full-wave pulse control (SG5 series):** for applications with high thermal inertia, such as industrial ovens and large heating systems, providing smooth power control with reduced mains disturbances
 - **Phase-angle control (SG4, SO4, SIL4, SIM4, three-phase SGTA and SVTA):** for loads that respond immediately to voltage changes, such as lamps, motors, transformer-coupled loads, heating wires and DC loads downstream of rectifier bridges (e.g. Peltier modules)
- Benefits**
- **Precise control:** Proportional control enables
 - **significantly finer regulation of temperature, pressure or flow** than simple on/off operation, ensuring consistently high product quality in food processing, pharmaceutical production and the plastics industry.
 - **Energy efficiency:** Output power follows actual demand in real time, ensuring that only the required amount of energy is supplied.
 - **Extended equipment lifetime:** Heating elements and motors are subjected to lower thermal and mechanical loads, reducing failures, downtime and maintenance costs.
 - **Prevention of overshoot and undershoot:** Significant temperature deviations that could

damage products or impair quality are minimized.

- **Improved process stability:** Operating conditions remain stable even in the event of rapid load changes or external influences.

SSRs with analog control are therefore indispensable for all applications requiring precise, consistent and efficient power regulation.

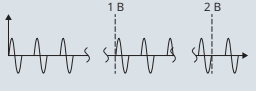
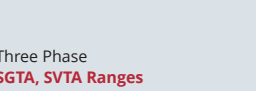
With its extended SSR portfolio, CELDUC® relays goes beyond conventional switching technology, combining real-time diagnostics, PID temperature control, industrial communication and analog power control in compact solutions. Manufacturers can achieve greater process stability, higher product quality, better equipment protection and lower maintenance costs.

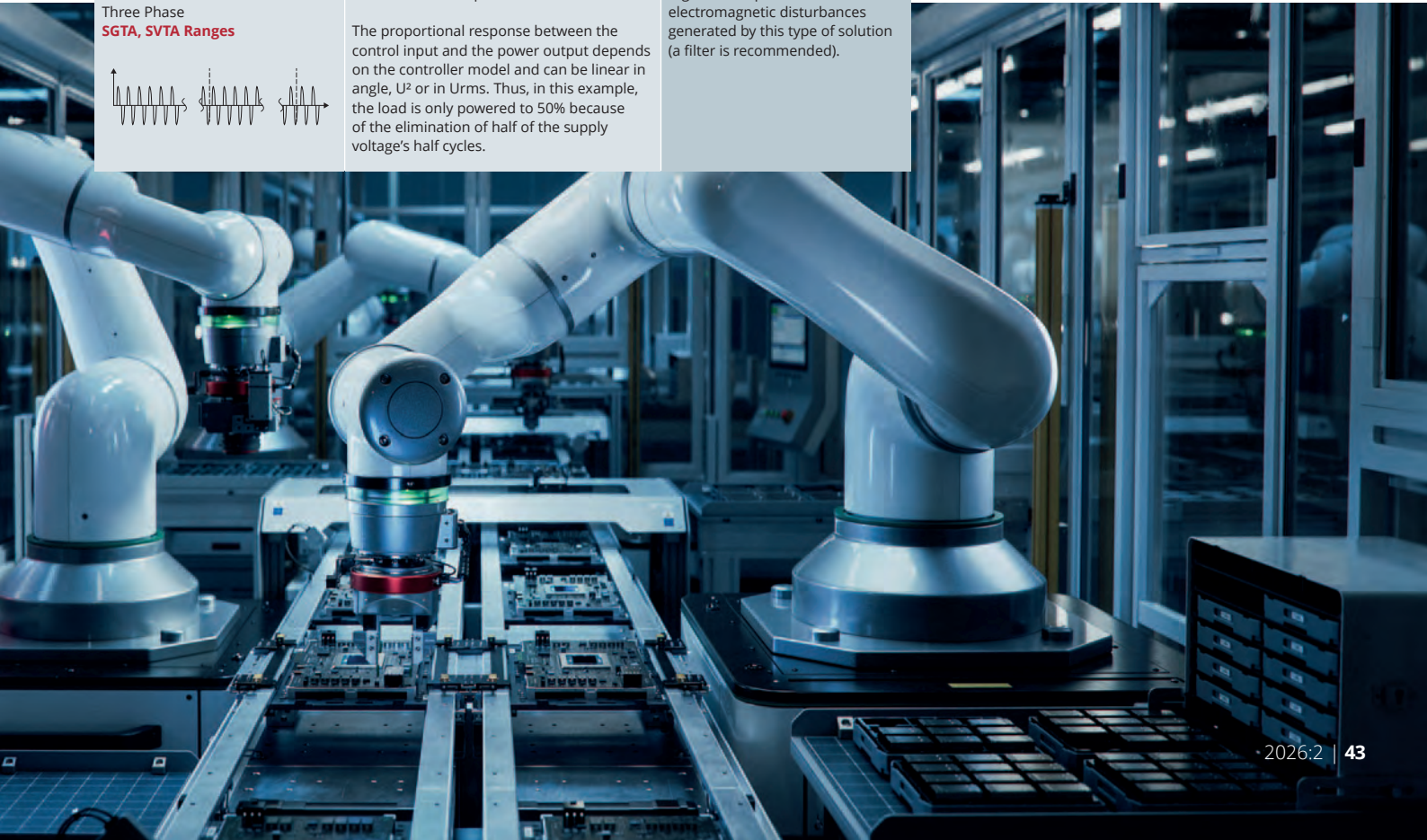
Modern manufacturing processes require more than reliable switching. They need intelligent solutions that increase efficiency, reduce downtime, optimize energy consumption and drive digital transformation.

CODICO will be happy to advise you on the right solution for your application.

P06

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	WORKING PRINCIPLES	ADVANTAGES
Burst Control Mode SO3 Range 	In a given cycle time (in this case, 1 or 2 seconds), the variation of the load power is achieved by eliminating whole alternations. Eliminations are distributed in accordance with a complex rule. Thus, in this example, the load is only powered to 50% because of the elimination of one alternation out of two.	This type of control makes it possible for the power to be finely modulated in accordance with the analog control, while limiting disturbances.
Full Wave Pulse Controllers SG5 Range 	In a given cycle time (variable depending on the models), the variation of the load power is achieved by eliminating whole alternations. The elimination is performed linearly in accordance with the Ton/Tcycle duty cycle requested by the control input. Thus, in this example, the load is only powered for 50% of the cycle time (Ton/Tcycle=0.5).	This type of control has the advantage of not generating interference since triggering takes place at around 0 voltage.
Phase Angle Controllers SG4, SO4, SIL4, SIM4 Ranges 	In terms of the principle of the light dimmer, this control mode makes it possible to finely vary the load power by removing a part of the supply voltage sinusoid in accordance with the control input.	This control mode makes it possible to finely adjust the load power, for example, when the accuracy of the temperature regulation is prioritized over the electromagnetic disturbances generated by this type of solution (a filter is recommended).
Three Phase SGTA, SVTA Ranges 	The proportional response between the control input and the power output depends on the controller model and can be linear in angle, U² or in Urms. Thus, in this example, the load is only powered to 50% because of the elimination of half of the supply voltage's half cycles.	



GXT® PLATING

High-Performance Contact Surfaces with Significantly Reduced Gold Content

Amphenol
COMMUNICATIONS SOLUTIONS

How AMPHENOL GXT® plating ensures reliable electrical connector performance while reducing dependence on gold prices.

The contact surface of a connector has a major impact on contact resistance, corrosion resistance, performance and long-term reliability. Gold has been the established standard for this use. Despite this, it is one of the biggest cost drivers in a connector.

AMPHENOL's GXT® Plating system significantly reduces the gold content while maintaining the high performance of precious-metal contact surfaces. Instead of using a continuous hard gold layer, GXT® combines a palladium-nickel layer with a very thin gold flash finish. This creates a technically robust and cost-effective alternative to traditional 30µ" gold plating.

Layer Structure

A conventional 30µ" gold system consists of a

0.76µm hard gold layer on top of a nickel barrier layer with a minimum thickness of 1.27µm. This nickel barrier layer acts as a diffusion barrier between the base material and the contact surface and contributes significantly to resistance, thermal stability and corrosion protection.

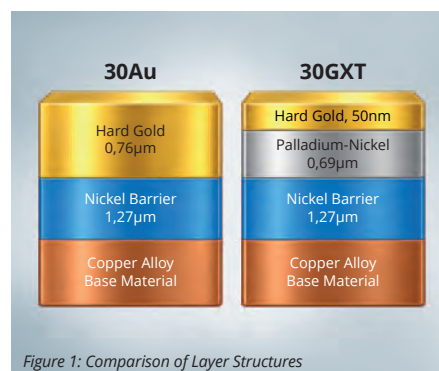


Figure 1: Comparison of Layer Structures

With 30GXT, the total thickness of the functional layer remains comparable, but the layer structure changes significantly. Approximately 0.69µm of palladium-nickel is combined with a hard gold flash of around 50nm.

Each layer (Figure 1) performs a specific function:

- **Copper alloy base material:** Mechanically and electrically conductive material
- **Nanocrystalline nickel layer:** Diffusion barrier and corrosion protection
- **Palladium-nickel layer:** Resistance, thermal stability and reduced porosity
- **Hard gold flash:** Defined precious-metal contact surface

The most important advantage lies in the efficient use of materials. The gold surface essential for the contact function is preserved, while most of the gold layer that would otherwise be used is replaced by palladium-nickel.



Figure 2: Comparison of Coatings

high thermal stability. The final gold layer is crucial for electrical contact.

Material Efficiency Without Compromising on Contact Quality

In addition to the 30GXT variant, there are other options available with a reduced palladium-nickel thickness, such as the 15GXT, 10GXT and 6GXT. These options allow greater customization in terms of the required number of mating cycles and respective corrosion and resistance classifications.

Cost-Effectiveness Through Efficient Use of Materials

Conventional gold platings often use standardized layer thicknesses. In many applications, these designs are more conservative than technically required. GXT® enables a more application-specific design of the plating system.

This becomes particularly relevant when precious-metal prices are high. By substantially reducing

gold content, material costs can be lowered without broadly replacing the contact zone with a lower-performance system.

Additionally, the gold plating can be limited specifically to the active contact zone. For example, solder or press-fit pins may use tin plating, while only the actual contact area is finished with GXT®. This selective plating further reduces the use of precious metals.

Selection Criteria for the Right Plating System

The appropriate contact finish results from the interaction of several requirements:

- Operating temperature range and thermal ageing
- Vibration and mechanical shock exposure
- Corrosion conditions, such as humidity or corrosive gases
- Number of mating cycles
- Contact force and contact geometry
- Contact resistance over the full service life

Gold remains the preferred choice when particularly high requirements for corrosion resistance, long-term durability or contact stability are necessary. GXT® offers a cost-effective alternative for many high-performance signal and data connectors.

For high-current and power applications, additional plating systems are available. AGT® is based on hard silver and is designed for low contact resistance, high current-carrying capability and low power loss. This makes it suitable for power and busbar connectors, including electrified vehicles and other applications with large contact areas and high current loads.

GCS® (Gold Capped Silver) combines a hard silver layer with a gold flash and a high-performance lubricant. This multilayer system was developed to overcome typical limitations of conventional silver surfaces. The gold flash provides long-lasting protection against tarnishing, while the lubricant reduces friction and corrosion during mating. GCS® therefore offers a cost-effective solution with high corrosion resistance, low contact resistance and good durability for both signal and power contacts.

S01

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Amphenol
Industrial

DURABLE

ePower-Lite Mini X – Compact High-Voltage Connectivity

With the introduction of Mini X, AMPHENOL expands its proven ePower-Lite connector family with an ultra-compact high-voltage solution designed for applications where installation space is limited. The two-position connector combines high electrical performance with outstanding reliability, making it an ideal choice for the growing number of electrified automotive and industrial systems.

Despite its compact footprint, the ePower-Lite Mini X supports operating voltages of up to 1,000VDC and current ratings of up to 35A when using a 4mm² cable. This makes it perfectly suited for a wide range of auxiliary high-voltage applications in electric and hybrid vehicles, as well as industrial power distribution systems.

Designed for demanding environments, the connector provides IP67 and IP6K9K sealing when mated, while its IP2XB touch-safe design en-

hances user safety during installation and operation. A wide operating temperature range from -40°C to +125°C ensures reliable performance under harsh environmental conditions.

To meet the safety and EMC requirements of modern high-voltage systems, the ePower-Lite Mini X is available with an optional High Voltage Interlock Loop (HVIL) for continuous connection monitoring, as well as optional EMI shielding to reduce electromagnetic interference. Multiple

- Compact two-position high-voltage connector for space-constrained applications
- Rated for up to 1,000VDC and 35A
- IP67 and IP6K9K sealing in the mated condition
- IP2XB touch-safe design for enhanced user protection
- Operating temperature from -40°C to +125°C
- Optional HVIL and EMI shielding
- Multiple keying options to prevent mismatching
- Ideal for automotive, industrial and energy storage applications

mechanical keying options help prevent mismatching and simplify integration into complex vehicle and industrial architectures.

Typical applications include DC/DC converters, electric air-conditioning compressors, PTC heaters, battery systems, fuel cells, energy storage solutions and industrial automation equipment. Wherever compact dimensions, high reliability and robust high-voltage performance are required, the ePower-Lite Mini X provides an efficient and future-proof connectivity solution.

As an authorized AMPHENOL distributor, CODICO supports customers throughout the entire design cycle from component selection and technical consultation to volume production.



Mini X Series

S02

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FLEXIBLE

CVILUX CBF1 Series

Floating Board-to-Board Connector with Tolerance Compensation in the X/Y/Z Axis.

The CBF1 series from CVILUX is a floating Board-to-Board connector specifically designed to address mating errors. In industrial automation and automotive electronics, uneven pin stress or even damage can result from assembly tolerances when multiple connectors are mounted on the same PCB. The CBF1 series was developed to address the issues of »blind mating« and »mechanical deviations«.

The system has a pitch of 0.8mm and is designed to be a high-density connection solution. The floating range can compensate for movement of up to $\pm 0.5\text{mm}$ in the X, Y and Z directions. It supports high-speed signal transmission with selected models compatible with PCIe Gen3 or SATA 3.0 protocols. Thanks to its high mating cycle durability, the CBF1 series is well suited to devices that require frequent maintenance.

Additionally, the system offers high-temperature resistance using high-performance engineering plastics such as PA9T, ensuring compliance with SMT reflow soldering processes. Basic electrical ratings include a maximum rated voltage of 50V AC/DC, a maximum rated current of 0.5A and an operating temperature range of -40°C to $+105^{\circ}\text{C}$.

Key Technical Feature: Floating Mechanism

- **Three-dimensional displacement compensation:** Provides a certain amount of movement space in the X, Y and Z axes (typically 0.5mm or more, depending on the specification).
- **Stress absorption:** When displacement occurs due to housing assembly or machine vibration, the internal position of the connector automatically fine-tunes to prevent solder joints from cracking due to stress concentration.
- **High-reliability contact:** With a dual-contact design, it maintains a stable electrical connection even during movement.

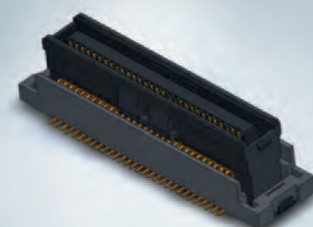
The connector is designed to withstand vibration and shock conditions. During the vibration test, the connector is exposed to an amplitude of 1.5mm and a frequency range of 10–55Hz, with transient interruption required to remain below 1 μs . During the shock test, the connector is subjected to an acceleration of 490m/s² (50g) for 11ms. Transient interruption is also required to remain below 1 μs .

S03

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CBF1 Series



CBF1 Series

APPLICATIONS

- Industrial control: PLC control modules, industrial computers (IPCs), robot control arms
- Automotive electronics: In-vehicle navigation systems, audiovisual head units and ADAS sensor modules
- Networking equipment: Server blade modules and daughter card connections within switches
- Consumer electronics: Mainframe computers, internal Board-to-Board connections in photocopiers

DEPENDABLE

PPAC Terminal Blocks – Reliable Power and Signal Transmission Through Panel Walls



Panel feed-through terminal blocks are indispensable components wherever electrical energy, signals, or data need to be safely routed through cabinet and device walls. They ensure a permanently reliable connection, reduce installation effort, and facilitate clear wiring.

Due to various sizes, the modern panel feed-through terminal blocks of the PPAC series with traditional screw connection are suitable for numerous conductor cross-sections and enable fast, safe, and maintenance-free installation. Depending on the version, they can transmit high currents of up to 230A/UL and 232A/IEC and volt-

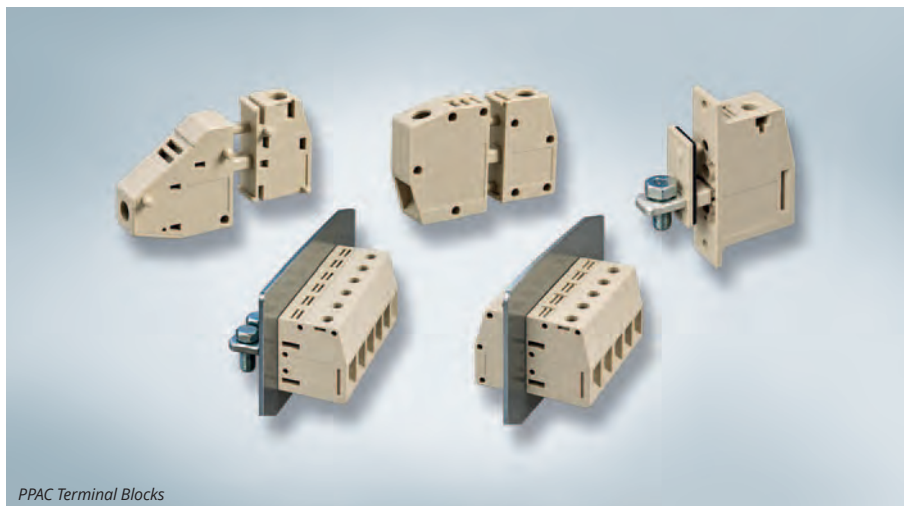
ages of up to 600V/UL and 1000V/IEC, meeting the requirements of industrial installations, machine building, electrical engineering, and building automation.

In addition to their electrical performance capabilities, the terminal blocks are characterized by

their simple installation. Many systems can be installed without tools in wall panels and can be mechanically secured if necessary. The precise latching mechanism ensures a secure fit for panel thicknesses of 1mm to 6mm.

The outer and inner sides of the panel feed-through terminal blocks can be configured differently, offering maximum flexibility for various installation requirements. For applications with higher pole numbers, versions with attachment clips are available, allowing easy cascading of multiple connectors. Furthermore, custom labeling using plastic labels as well as special executions in different colors – e.g., green-yellow variants for earthing applications – are available upon request.

The PPAC series is particularly well suited for telecommunications and power distribution applications. The product range also supports manufacturers of electrical equipment such as filters, transformers, rectifiers, transformers, power supplies, and industrial batteries.



PPAC Terminal Blocks

S04

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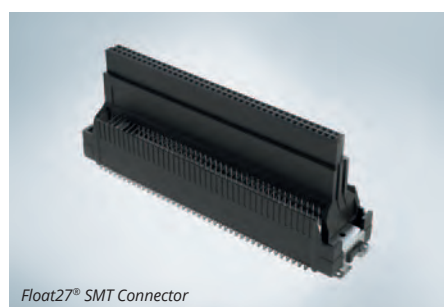
FLOAT27®

Highly Flexible and Reliable

ept

ept is a German manufacturer of high-quality Board-to-Board connectors and customized connection solutions. With innovative technologies, extensive manufacturing expertise, and decades of experience, ept develops reliable connection solutions for demanding applications in the industrial, automotive, and electronics sectors.

The Float27® SMT connectors from ept expand the proven and reliable One27® product family with a floating solution for demanding Board-to-Board applications.

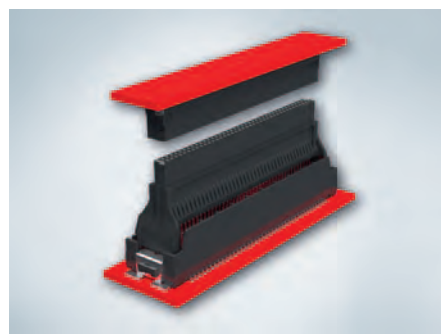


Float27® SMT Connector

The connector is based on a 1.27mm pitch and enables a tolerance compensation in the X and Y directions of $\pm 0.8\text{mm}$ during the mating process as well as in the mated condition. This allows mechanical deviations to be reliably compensated. In addition, it offers a contact overlap of up to 2.4mm in the Z direction as well as a PCB spacing range from 26.1mm to 30.7mm.



Thanks to the proven mating system, the Float27® female connector is compatible with various designs of the One27® male connectors and can be flexibly integrated into existing designs. The high vibration and shock resistance, reduced stress on the mating area and solder joints, as well as the low displacement forces ensure a reliable and durable connection even under demanding operating conditions.



Technical Features

- Proven and reliable One27® Knife Block
- Anti-twist protection to ensure proper connection between the blade and the terminal strip
- Lead-in chamfers to compensate for axial and angular misalignment during assembly
- Boardlock to provide a secure connection to the circuit board
- Positioning pin to ensure precise placement during assembly
- Coplanarity for reliable soldering during processing
- Meniscus formation for high mechanical strength and durability of the solder joint
- Float27® Connector Strip
- Double-arm spring contact for secure and reliable connections
- Smooth surface for reliable contact through Contact closure on a rolled, smooth surface
- Overlap area for high reliability due to high tolerance compensation
- Meander to achieve high tolerance compensation

S05

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Float27®	
Technical Specifications	1.27mm Board-to-Board Connectors
Tolerance Compensation in X and Y Directions	$\pm 0.8\text{mm}$
Operating Temperature Range	-55°C to +125°C
Insulator Material	LCP
Contact Material	Copper Alloy
Contact Resistance	<95mΩ
Clearance and Creepage	min. 0.45mm
Insulation Resistance	>10GΩ
Test Voltage	500VDC
Compliance	RoHS Compliant

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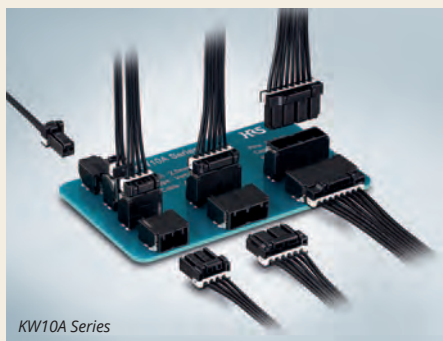
KW10A

2.5mm Pitch Wire-to-Board Connector with Center Lock

HRS HIROSE ELECTRIC EUROPE BV

The KW10A series has been designed with a central locking mechanism that enables high-density mounting and simple, one-handed insertion and removal. Unlike side-lock connectors, which require additional clearance for the unlocking operation, the central locking mechanism of the KW10A allows connectors to be mounted close together, significantly reducing the space required on the PCB.

The KW10A series has been designed with a central locking mechanism that enables high-density mounting and simple, one-handed insertion and removal. Unlike side-lock connectors, which require additional clearance for the unlocking operation, the central locking mechanism of the KW10A allows connectors to be mounted close together, significantly reducing the space required on the PCB.



The connector is available in a wide range of variations to meet a variety of customer requirements and is available in 2, 4, 6 and 8 positions, with straight and right-angled orientations. The connector is compatible with 20–22 AWG cable and has an SMT contact lead section and a THT retention tab that is through-hole reflow compatible, supporting efficient mounting processes.

The KW10A series features a dual-spring, three-point contact design that enhances contact force and maintains stable connections, improving contact reliability under severe vibration. The connectors also incorporate a safety-focused design, including a finger-protection wall to prevent accidental contact with the male contacts and a resin-enclosed housing with a retainer to prevent contact with the female contacts during assembly. Keying prevents misinsertion when using multiple connectors and an inner lock design pre-

vents cables from catching or tangling during installation. The housing is available in black and gray versions. It is RoHS-compliant, halogen-free, and UL/C-UL-listed.

Suitable applications include office equipment, medical devices, factory automation (FA) machinery, drones, delivery robots, AGV/AMR systems, and electric tools.

S06

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KEY FEATURES

- Contact pitch: 2.5mm
- Number of contacts: 2, 4, 6, 8
- Rated current: 5A (2, 4 contacts) / 3A (6, 8 contacts) per pin
- Rated voltage: AC/DC 250V
- Operating temperature range: -40°C to +125°C
- Mating cycles: 30
- Termination: 20–22 AWG
- Contact resistance: max. 25mΩ

HIROSE
ELECTRIC
EUROPE B.V.

IT18

INNOVATIVE

The IT18 from HIROSE

HIROSE releases COM-HPC®-compliant BGA mezzanine connector IT18 – delivering high speed, high density, and high reliability for the AI era.

The industrial equipment sector is undergoing a major transformation due to the rapid advancement of AI technologies, including a shift from cloud-based processing to edge computing. As the importance of AI inference at the edge continues to grow, the demand for COM-HPC® modules is increasing rapidly. To meet this market demand, HIROSE ELECTRIC has developed and released the IT18 series, which delivers high reliability and high-speed performance for next-generation embedded systems.

COM-HPC® is one of the latest standards promoted by PICMG (PCI Industrial Computer Manufacturers Group). PICMG is a consortium with over 25 years' experience in embedded computing and has published more than 50 industry standards.

Examples of Expected Applications

Industrial PCs, industrial robots, humanoid robots, automated guided vehicles (AGVs) and autonomous mobile robots (AMRs), medical equipment, measuring instruments, semiconductor manufacturing equipment, broadcasting

equipment, gaming devices, and other advanced embedded systems.

Supporting Next-Generation Equipment with High Speed and Reliability

In recent years, rapid advances in AI technology, including the spread of generative AI and improvements in inference accuracy, have driven a major transformation in industrial equipment. Growing interest in edge processing, as well as cloud processing, reflects the increasing importance of edge AI inference for real-time performance and security. Consequently, there is a rapidly expanding demand for COM-HPC® modules that support higher-performance edge computing.

In response to these technological shifts, HIROSE ELECTRIC has developed and released the IT18 series: a COM-HPC®-compliant BGA mezzanine connector that offers high reliability and high-speed performance. Featuring a 0.635mm narrow pitch and small-diameter BGA design, the IT18 series supports excellent high-speed trans-

mission, high-density signal placement and reliable soldering using the pin-in-ball method. In addition, the line spacing has been optimized to provide sufficient routing space, and the footprint design incorporates GND vias to suppress crosstalk. Weld tabs (also known as retention tabs) are incorporated to strengthen solder ball retention and prevent damage. Furthermore, the connector comes with a metal cap to prevent deformation during reflow and protect against foreign material during handling and assembly.

The IT18 series uses COM-HPC® modules to support performance improvements across a wide range of industrial equipment.

Key Features

- **COM-HPC® Standard Compatible Connector** (Version with weld tabs)
- **High-Speed Transmission**
PCIe Gen5 (32GT/s), Gen6 (64GT/s PAM4), 100Gbps Ethernet (4×25Gbps)
- **Low-Profile Design**
Available in 5mm and 10mm stacking heights
- **High Pin Count and Density**
400 positions (0.635mm Pitch)
- **Open Pin-Field Layout**
Flexible pin mapping for various system architectures
- **Reliable BGA Termination**
Pin-in-ball structure ensures high mounting reliability
- **Officially Licensed COM-HPC® Connector by Samtec**

Future Product Development

HIROSE ELECTRIC is currently developing a new COM-HPC®-standard-compliant version with a solder-ball-free design.

S07

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LIGHTWEIGHT

Secure AF60 and AF90 Connectors for Power Transmission in UAV Systems



Unmanned aerial vehicles (UAVs) continue to expand in the fields of logistics, agricultural monitoring, military surveillance and urban inspection. They place high demands on all components used. In addition to reliability and operational safety, low weight, high-temperature resistance and a secure electrical connection are important criteria.

To meet these requirements, NEXTRON has specifically developed the AF60 and AF90 series to sustainably improve the performance and power transmission of UAVs.

This is achieved through:

Design: The 2-pole design ensures spark-free contact when connecting and disconnecting. At the same time, the connector design prevents incorrect insertion in the mating process itself, as well as during installation and maintenance.

Low Weight: Another key advantage is the low weight of both series. Every gram saved enables a higher payload, longer flight times or improved energy efficiency in UAVs.

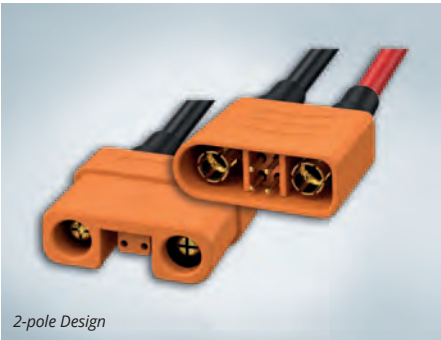
Material: The material is durable and heat-resistant and meets the criteria of fire safety class UL94 V-0.

Operating Temperature: The operating temperature range extends from -20°C to +120°C and enables usage in a wide variety of climatic con-

ditions – from cold outdoor applications to thermally demanding environments.

IP Rating: The advantages of the AF60 and AF90 are complemented by an IP66 rating in the mated condition.

Both series are available as pre-assembled or fully assembled units!



2-pole Design



S08

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SERIES	AF60	AF90
Rated Current	30A	45A
Number of Pins	2	2
Variants	Wire-to-Wire	Wire-to-Wire, Wire-to-Board
Wire	Up to 12AWG	Up to 2AWG
Mating Cycles	100	100
Material	Nylon, UL94 V-0	Nylon, UL94 V-0
IP Rating	IP66 (mated)	IP66 (mated)

LOCKING EXPERT

M12: Screw, Bayonet & Push-Pull Locking



Flexibility Without Compromise

No single system replaces the others. Instead, the three locking technologies complement each other to provide the ideal solution for your application. Whether the priority is fast installation, robust vibration resistance, or tool-free handling, the Y-Circ M12 portfolio provides the right connection solution for every requirement.

Advantages

- Standardized product ensuring worldwide compatibility with other M12 connectors
- Designed and manufactured in Germany
- Protection rating IP65/IP67
- Available with A-, B-, D-, X- and L-codings
- Continuous expansion of the series – now also featuring M12 bayonet locking

Compare and Choose

The comparison table provides a clear overview of the key differences, making it easier to select the most suitable locking technology and optimize connectivity.

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S09

One Connector Platform. Three Locking Technologies.

The launch of the new M12 bayonet-locking variant completes the YAMAICHI Y-Circ M12 product family. Together with the established screw and push-pull solutions, YAMAICHI now offers three powerful locking technologies, providing the right solution for every application.

	SCREW	BAYONET	PUSH-PULL
			
Standard	IEC 61076-2-101	IEC 61076-2-011	IEC 61076-2-012
Additional Qualification	No	No	Yes (Additional testing for locking mechanism)
System Compatibility	Basic standard	Backward compatible with screw-type versions	Backward compatible with screw-type versions
Installation Time	Slow (manual screwing)	Medium (plug + ¼ turn)	Fast (plug in only)
IP Assurance	Requires a torque tool	By locking + turning	By locking
Space Efficiency	Low (needs wrench access)	Medium (manual access required)	High (plug directly)
Mechanical Robustness	Standard	Standard	High (additional mechanical tests)
Effort For Direct Integration Into Customer Device	Low (only screw contour needs to be integrated)	High (screw and complex bayonet contour need to be integrated)	Medium (screw and push-pull contour need to be integrated)

The CODICO TEAM says hello!

Heike Streckfuß

I had a dream...

My dream was to »dress« people. I began my professional career with this dream in mind. After graduating from high school in a small town in the Odenwald region of Hesse, I began my apprenticeship as a women's tailor at the Frankfurt School of Fashion – with the clear goal of going on to study fashion design. I successfully completed the apprenticeship.

My name is Heike Streckfuß. I've been working at CODICO since May 2022 as the Field Sales Engineer responsible for the Berlin region and surrounding areas. My age? I suppose I'll have to reveal that. I recently turned 61!

But sometimes life has its own plans.

After the fall of the Berlin Wall in 1989, I moved to Berlin in 1992. Once there, I had to change my plans pretty quickly: The fashion industry was in shambles, career prospects were correspondingly bleak – and then I had my first child. My planned fashion design studies initially gave way to becoming a »family manager«.

That marked the beginning of a rather long professional journey that was, above all, anything but straightforward. I didn't finish the business administration degree I'd started in the meantime, choosing instead to focus on my two children. I raised my son and daughter on my own after my divorce. My motto in life has always been: Seize opportunities when they arise. And that's exactly how I've navigated my professional life. By the way, one thing you learn »for free« as a family manager is that success is based above all on teamwork: empathy, passion, loyalty, strong communication skills, appreciation, respect – and a huge dose of love.

I'm convinced that these very factors are also crucial for success in professional life – no matter what industry you're in. I've always tried to live by these principles in my various professional roles while continuing to develop them. My career in electronics distribution began in 2007 – back then, also at a family-run company, initially in internal sales.

In 2013, completely out of the blue and rather unprepared, I was given the opportunity to switch to the field sales team. True to my motto, I seized this opportunity – and over the years, I've successfully established myself in this new role.



portunity – and over the years, I've successfully established myself in this new role.

But life can sometimes bring you to a screeching halt completely out of the blue. For me, that sudden halt came at the end of 2018. Diagnosis: leukemia.

My only real chance of survival was through a stem cell transplant. Giving up was never an option for me. I survived. And I'm very aware that not everyone with this diagnosis is so fortunate. What remains, above all, is one thing: gratitude.

And a great deal of humility toward life and the opportunities we have. We've – if you will – hit the jackpot in nature's lottery. The mere good fortune of being born here is not something to be taken for granted. For me, this gratitude and humility are therefore also among the factors that make up true and lasting success – both personally and professionally.

And yes: I'm grateful to have the opportunity to do a great job at CODICO and to be part of a team with wonderful and amazing colleagues. Because in the end, it's not just skill and performance that make the difference, but above all the people with whom you make a difference together. For that, I feel immense gratitude and humility.

And what else?

I love life!

I love my children and my partner, my family, and our friends.

I love good food, good wine, and above all, good conversations.

And then there are Carlo and Carlotta: Carlo is our campervan, and Carlotta is our 125cc scooter. With them, we go on incredibly beautiful and unforgettable trips.

I once had a dream.

I still have a dream.

Only today, it's a different one.

And that's a good thing.

D02

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Nicole Rott

Between Relays, Horse Stables and Book Pages

I've now been part of CODICO for ten years. It all started in Inside Sales and Project Management.

After my parental leave, it was time for a new chapter, so I moved into Product Management. Today, I'm responsible for relays from various suppliers.

What does that actually mean? I work with our products, communicate with manufacturers, support our sales team with technical questions, and try to find the right solution for all kinds of requirements. In other words: whenever questions arise about relays, I'm one of the people you can turn to. There is, however, one important exception: please ask your questions only after my first coffee. Before that, I probably wouldn't know what a relay is myself.

Anyone can go in a straight line

My career path within the company wasn't necessarily planned this way from the beginning – and that's a good thing. From Inside Sales to maternity leave and then into Product Management. The past ten years have shown me that changing direction can sometimes take you exactly where you're meant to be.

My experience in sales is particularly valuable to me today. I don't just know the product side; I also know that there can sometimes be a gap between technical specifications, customer requirements and real-world needs – and having someone to translate between them can be pretty useful. That connection is what I particularly enjoy about my work: listening, understanding, asking the right questions and, ultimately, finding a solution that someone can actually put to use. And if something doesn't work right away? *Then we keep thinking. Problems can be complicated – solutions shouldn't be, if possible.*

Switching off after work

When I'm not busy with relays, you'll find me pretty reliably in one of three worlds: around horses, between the pages of a book, or somewhere out in nature. The stable is where I clear my head. Horses reflect people and force you to slow down. Something we tend to forget far too often in everyday life. Books also play a major role in my life. I don't just love reading them – I also write. I'm fascinated by the process of turning a first idea into characters, stories and entire worlds. And when neither a horse nor a book is within reach, I head outdoors. The main thing is to get out, breathe, and think about something other than technical details and an inbox that looks like it might explode any minute.

Short & Sweet

Mornings: Coffee. Then we can talk about relays.

To switch off: Horse instead of screen.

Books: Reading isn't enough – apparently, I also have to write them myself.

Nature: Always a good idea!

Plan A doesn't work: Then we move on to Plan B. Or C. Luckily, the alphabet gives us plenty of options.

After ten years at CODICO: Still curious about what comes next. If the past ten years have taught me anything, it's that you don't always have to know exactly where the road is going to take you. Sometimes it's enough to stay curious and seize the opportunities that come your way. And for everything else, there's coffee.

Until then: Work smart, not hard!

D03

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Adriano Gasparoni

Dear Impulse readers!

My name is Adriano Gasparoni, and I have the pleasure of representing CODICO in Spain and Portugal as a Field Sales Engineer for passive components. I have been part of CODICO for the last four years and I am based in Barcelona, where I work closely with customers across the Iberian market.

My professional journey started after graduating in Electronic Engineering. I began my career in sales within the telecommunications industry and later completed a Master's degree in Management.

Over the years, I built up more than 20 years of experience in selling technology and electronics across different markets. My engineering background has always given me a strong connection to technology, while sales, business development and, above all, working with people have become my real passion.

I joined CODICO because I enjoy combining technology with business development. My background in Electronic Engineering helps me understand the technical challenges our customers face, while my experience in sales allows me to focus on finding the right solutions and building long-term relationships.

One of the things I appreciate most about CODICO is its international environment. Working with colleagues, customers and suppliers from different countries, cultures and perspectives means that I learn something new almost every day. The electronics industry is constantly evolving, and I enjoy being close to new technologies and understanding how they can contribute to the products of tomorrow.

When I am not working, family comes first. I am married and have two wonderful children: Luca, 10, and Sara, 6. They remind me that there is much more to life than work and that sometimes the best moments are the simplest ones. I also love travelling and discovering new places and cultures. Whenever I have the opportunity, I enjoy exploring a new city, discovering nature, trying local food or simply experiencing how people live somewhere different. For me, travelling is one of the best ways to broaden your perspective – and there is always something new to discover.

And, like many people in Europe, I am also a football fan. I enjoy following both international competitions and local leagues. A good football match, a nice meal and a few friends around the table is, in my opinion, a pretty good way to spend an evening!

After four years at CODICO, I am very happy to be part of the CODICO family. I look forward to continuing this journey, meeting more colleagues from around the company and, hopefully, having the opportunity to welcome some of you to Spain for a good conversation – and perhaps a coffee, a meal or even a football match!

D04

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