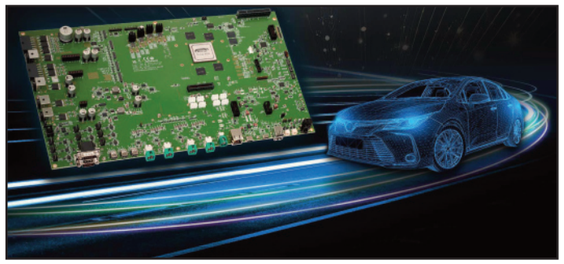
VEHICLE electronics

The monthly magazine for automotive electronics engineers

Renesas to show at CES how AI can power SDVs



At CES in Las Vegas, Renesas will show how AI can power multi-domains in software-defined vehicles (SDVs) using its fifth-generation R-Car family.

The latest Gen 5 device is the X5H multi-domain automotive SoC manufactured with 3nm process technology. It can simultaneously run vehicle functions across adas, in-vehicle infotainment and gateway systems.

The firm has begun sampling Gen 5 silicon and now offers full evaluation boards and the R-Car Open Access (RoX) Whitebox software development kit (SDK) as part of the next phase of development.

At CES, Renesas will show AI-powered multi-domain demonstrations of the X5H in action.

As AI becomes integral to SDVs, the SoC delivers central compute for multiple automotive domains, with the flexibility to scale AI performance using chiplet extensions.

It delivers up to 400Tops of AI performance, with chiplets boosting acceleration by four times or more. It also features 4Tflops equivalent of GPU power for high-end graphics and over 1000k DMips powered by 32 Arm Cortex-A720AE CPU cores and six Cortex-R52 lockstep cores with Asil-D support.

Leveraging mixed criticality technology, the SoC executes features in multiple domains without compromising safety.

RoX simplifies development by combining all essential hardware, operating systems, software and tools required to develop vehicles with seamless software updates.

The RoX Whitebox SDK is an open platform built on Linux, Android and Xen hypervisor. Additional support for partner OSes is available, including Autosar, EB Corbos Linux, QNX, Red Hat and SafeRtos.

Renesas will show the capabilities of the X5H for the first time in invitation-only demos at CES.

Renesas is shipping X5H silicon samples and evaluation boards, along with the RoX Whitebox SDK, to select customers and partners.

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Holon picks PTC for PLM SaaS on L4 EV

Holon is using PTC's Windchill+ product lifecycle management (PLM) software-as-a-service (SaaS) to help develop and bring to market an autonomous level-four electric vehicle.

Benteler subsidiary Holon wants to reshape public transport with inclusive, autonomous and sustainable mobility.

Its first vehicle, the Holon Urban, will offer fully barrier-free access and space for up to 15 passengers and is designed for scheduled routes, on-demand service, ride-pooling and goods transport.

To support development, Holon has introduced a flexible production concept that allows multiple vehicle variants to be built on the same assembly line, improving efficiency while advancing the company's sustainability goals.

It implemented Windchill+ in six months, creating a digital product development environment that replaces paper-based processes with modern workflows. With real-time access to accurate product data through cloud PLM, teams can collaborate more efficiently across the development centre and future manufacturing sites in Germany and the USA.

This digital foundation lets Holon move from design to production of the Urban with the speed and agility needed to achieve its five-year vision of sustainable, inclusive mobility at scale.

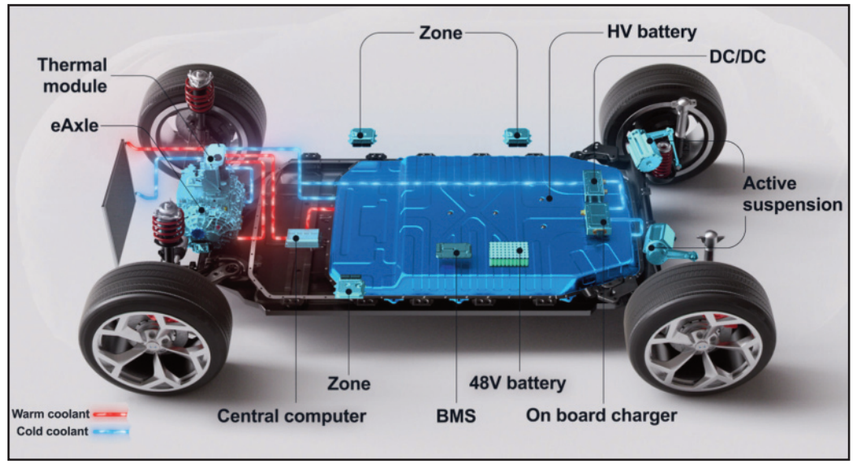
"Building on nearly 150 years of Benteler's automotive expertise, Holon is evolving into a next-generation OEM with a clear focus on people and the planet," said Sven Herzig, chief sales officer at Holon. "The go-live of Windchill+ is a key milestone in the development of the Urban and reflects our commitment to delivering EV vehicles that redefine mobility for communities around the world."

Robert Dahdah, chief revenue officer at PTC, added: "Automakers are navigating a pivotal moment as vehicles become increasingly electric, connected, autonomous and software defined."



Holon Urban vehicle





Intelligent energy management technology handles thermal flows

Marelli manages energy for hybrid and electric vehicles

Marelli unveiled its intelligent energy management for hybrid and electric vehicles at December's CTI Europe event in Berlin.

The system is modular and based on proprietary software that can be integrated with vehicle and zonal control units, and thermal components.

This enables seamless coordination across the vehicle's three main energy domains of thermal, propulsion and electronics.

This holistic approach to vehicle energy optimisation increases efficiency across all vehicle systems, delivering enhanced battery range, optimised fast charging and improved longevity, all while maintaining cabin comfort and operational reliability.

The system is aimed at advancing hybrid and electric propulsion, and software-defined vehicle (SDV) technologies.

It was developed by integrating digital-twin methodologies and software. These approaches reduce development time and costs, while enabling flexible collaboration with customers.

In the thermal domain, the system manages and optimises thermal flows, ensuring precise control of heating and cooling processes within the vehicle. Decoupled software algorithms intelligently manage complex thermal systems, regulating temperatures to optimise overall performance and extend battery life.

These reduce energy losses and promote effective reuse of excess thermal energy, resulting in lower operational costs and more sustainability.

For electric and hybrid propulsion, the system continuously monitors and adjusts power delivery to optimise energy distribution. This increases battery efficiency and vehicle performance.

By effectively recovering energy and balancing its distribution, it extends driving range and enhances overall resilience.

Regarding the electronics domain, it enhances the intelligence and integration of vehicle systems by facilitating seamless communication between all components and systems. Data exchanges occur over communication protocols from Can to Ethernet, enabling direct management of sensors and actuators.

Development of a digital-twin application allows for precise virtual modelling of every vehicle subsystem, including electronics, electromechanics, thermodynamics and hydraulics. By creating virtualised car models, automakers can iterate faster, test more efficiently and bring vehicles to market sooner and more confidently.

AB adas tester meets NCap 2026 protocols

AB Dynamics has developed an adas target platform that can achieve the higher test speeds required by Euro NCap's 2026 protocols.

Capable of reaching 130km/h, the GST 120 Plus lets manufacturers test their vehicles against the highest speed rear-collision scenarios in Euro NCap's latest requirements.

Externally, the Plus is identical to the Euro NCap-approved GST 120 platform, retaining the same chassis and dimensions. Upgrades include a 13% increase in battery capacity to support the energy-intensive higher-speed tests and an updated drivetrain using the latest brushless motor technology and optimised gearing.

TUM researchers develop centralised architecture

Researchers at the Technical University of Munich (TUM) have teamed up with partners from the automotive industry to develop a centralised architecture for software-controlled vehicles.

The software is largely self-generating and allows the simulation of any scenario involving autonomous vehicles on a test bench.

To ensure future cars can travel safely and reliably on roads regardless of environmental conditions, vast amounts of data must be processed. The data are collected in real time from sensors in the vehicle while driving and from databases or simulations on test benches during vehicle development.

Over the past three years, researchers at TUM and partners from the automotive and chip industries have developed an architecture that evaluates and uses the data on an ad-hoc basis. A central and entirely software-based architecture of this kind will be required for vehicle generations from 2033 onwards.

Researchers have created a simulation environment in which a wide range of scenarios can be generated with the aid of graphics chips. After training, the vehicle has the knowledge to cope with the given situation on board.

The scenarios can also be made available to users from the automotive industry and research via open-source access.

The TUM test bench allows vehicles to be securely clamped in place with all axles and wheels for testing. This means driver assistance, anti-lock braking and emergency braking systems can be tested.

In addition, scenarios from real-world accidents involving autonomous or semi-autonomous vehicles can be imported and used for training, without anyone being harmed in the process.

The researchers have shown that language models can process specifications as long as they are consistent, complete and free of contradictions, which in turn can be checked by AI.



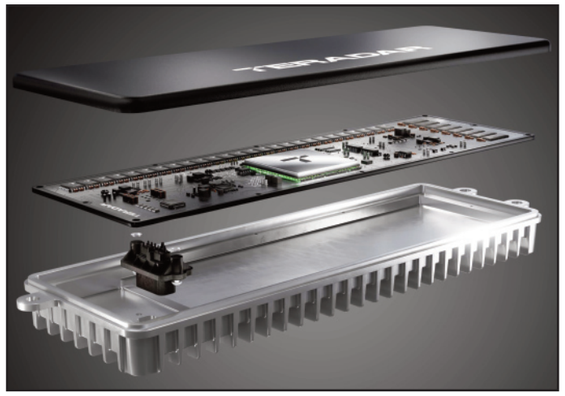
Teradar terahertz sensing boosts radar resolution

Teradar has emerged from stealth to unveil commercial sensing technology that can see in the terahertz band of the electromagnetic spectrum.

The chip technology is said to provide up to 20 times the resolution of today's automotive radar. This could signal an era of high-definition, all-weather vision and awareness for vehicles, and additional growth applications in military, healthcare and manufacturing.

As scrutiny of camera-only sensors grows and the limits of radar and lidar become increasingly clear as automakers pursue higher levels of autonomous driving, Teradar is in collaborations with five automotive OEMs in the USA and Europe, as well as three tier-one suppliers, and expects to win a vehicle production programme by 2028.

"Terahertz sensors represent a transformative leap for automotive perception" said Tom Lee, professor of electrical engineering at Stanford University. "Their ability to deliver exceptional resolution in all weather conditions and at long range enables intelligent vehicles to detect hazards with unprecedented accuracy. This technology brings reliable, real-time environmental awareness to autonomous systems, promising dramatically safer roads and redefining what's possible for advanced driver assistance and fully autonomous driving worldwide."



Solid-state customisable chip architecture

Teradar's proprietary MTE modular terahertz engine is an all solid-state, customisable chip architecture that can be tailored to meet the range and resolution requirements of adas or autonomous driving systems. The MTE consists of a series of proprietary chips that safely transmit, receive and process terahertz waves.

The firm has completed a series B round totalling $150m.

"Teradar has made terahertz vision a reality by bringing unprecedented resolution and awareness at long range in any weather," said Matt Carey, CEO of Teradar. "This breakthrough provides vehicles the perception needed to anticipate danger, avoid accidents and, ultimately, save lives."

VEHICLE electronics

The monthly magazine for automotive electronics engineers has a vacancy for an

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Mercedes leads UAE robotaxi service

Mercedes-Benz, Chinese autonomous driving company Momenta and UAE taxi operator Lumo have jointly launched a robotaxi service in Abu Dhabi.

The fleet, based on the Mercedes S-Class, is planned to start formal operations in Abu Dhabi in 2026, with future expansion to additional global markets.

The S-Class robotaxi fuses the brand's signature experience with SAE-L4 technology and Lumo's local ecosystem.

Mercedes-Benz invested in Momenta in 2017. The two companies have already launched an intelligent driving assistance system in China.

OnSemi signs GaN MoU with Innoscience

OnSemi and Innoscience have signed a memorandum of understanding (MoU) to accelerate the deployment of GaN power devices, starting with 40 to 200V, and broaden adoption.

The collaboration outlined in the MoU brings together OnSemi's integrated systems and packaging with Innoscience's GaN technology and high-volume manufacturing to enable delivery of cost-effective, efficient GaN products for automotive and other uses.

GaN semiconductor devices offer higher switching speeds, smaller form factors and lower energy losses to deliver more power in less space. Until now, limited offerings and manufacturing capacity have slowed GaN adoption in the low and medium-voltage segment.

This collaboration seeks to overcome these barriers to bring high-volume, worldwide deployment of optimised GaN products for mainstream markets such as automotive DC-DC converters and synchronous rectification.

The collaboration should enable rapid prototyping, accelerated design-in and swift entry into mainstream markets.

Mass-market scalability should be able to handle large-volume ramps, leveraging OnSemi's global integration and packaging experience and Innoscience's established GaN capacity.

"Through a collaboration with Innoscience, we expect to be able to access the industry's largest GaN production footprint and quickly scale our GaN offerings for customers worldwide to enable broader adoption in mainstream power applications," said Antoine Jalabert, OnSemi vice president.

OnSemi expects to begin sampling in the first half of 2026.

Mazda adopts EEA+ architecture



The CX-5 is the first model to adopt Mazda's EEA+ electrical and electronic architecture. At its heart is a human-machine interface (HMI) with Google Assistant built-in; Gemini AI will follow.

The EEA+ brings together the vehicle's ECUs, software, communications and external servers. This forms the basis of the reimagined HMI and connectivity and enables over-the-air updates as well as adas, laying the foundation for future software-defined vehicles.

The HMI is designed to keep drivers in control while reducing visual, manual and cognitive distraction.

At the centre of the horizontal layout sits an integrated touch display with customisable smartphone-style interaction. Physical buttons remain for essential functions with frequently used features positioned higher and permanently visible. All models come with a digital instrument cluster and a larger head-up display.

Capacitive haptic steering wheel switches consolidate key functions such as the 360° view camera and Mi-Drive. Voice recognition enables control without removing hands from the wheel.

Apple CarPlay, Android Auto, MyMazda app and a 12-speaker Bose premium audio system elevate the in-car digital experience.

Infineon partners Lenovo to integrate AI in SDVs

Infineon and Lenovo are intensifying their collaboration to accelerate the next level of autonomous driving.

Lenovo's AD1 and AH1 flagship autonomous driving domain controller units will take advantage of Infineon's Aurix microcontrollers to support adas, energy efficiency and high-speed data exchange across in-vehicle networks.

The collaboration aims at enabling intelligent, high-performance automotive computing platforms that power AI integration in software-defined vehicles (SDVs). The joint offering builds a scalable foundation for OEMs to develop connected, safe and smart vehicles, supporting autonomy levels L2, L3 and L4.

"As the world number one in automotive microcontrollers, the Aurix product family plays a crucial role in enabling safe and secured computing in the era of SDVs," said Thomas Böhm, senior vice president at Infineon. "By working closely with partners such as Lenovo, we combine robust, safety-critical computing with scalable software architectures, empowering OEMs to accelerate their SDV strategies and advance smart mobility."

The aim is to accelerate the transition towards SDV architectures by enabling faster development cycles, flexibility and dependability. Infineon and Lenovo will work closely with more partners across the automotive value chain in areas such as system integration, services, software and tools.



Infineon and Lenovo speed autonomous driving

Both companies want to expand the collaboration in the future by combining hardware platforms with intelligent software integration to enable a new era of connected, automated and sustainable mobility.

"Our collaboration with Infineon is a key embodiment of Lenovo's smarter-technology-for-all strategy deeply integrated into the realm of intelligent vehicles," said Tang Xinyue, vice president at Lenovo. "Infineon's leading semiconductors provide a solid and reliable foundation for our computing platforms. Built on years of trusted collaborations and synergies, we are committed to deepening the integration of AI with real-world driving scenarios, jointly creating more dependable experiences for our customers."

Bitsensing in adas pilot for South Korean buses

Radar company Bitsensing is collaborating with transportation firm Korea Wide to launch a large-scale pilot adas project for commercial vehicles in South Korea.

Working with Gyeongbuk Express and Jinan Express, the initiative will begin by installing Bitsensing's adas kit in Korea Wide's express, intercity and city buses to verify performance in real road environments, with plans to expand the system gradually to more than 500 buses.

The pilot will take place in downtown Daegu, with a population of 120,000.

Data will be collected to evaluate detection accuracy, response speed and driver usability.

Bitsensing plans to use these data to refine algorithms for commercial vehicles and expand the application of its technology to other vehicle types, including lorries and heavy-duty models.

This partnership is expected to serve as a step towards the commercialisation of adas for commercial fleets. Both companies plan to use the data collected from the pilot to support digital transformation in the bus industry and further enhance traffic safety initiatives.

The adas kit combines radar, camera and adas functionalities in one package. The system integrates safety features to help large buses navigate.



Vector integrates software stack with Quintauris Risc-V platform

Risc-V expert Quintauris has announced a technical collaboration with Vector to develop software-defined systems.

The partnership integrates Vector's Microsar Classic software stack with Quintauris' RT-Europa, a platform designed to accelerate the development and secure software interoperability of automotive Risc-V real-time processors.

RT-Europa provides a Risc-V platform tailored for real-time processors, targeting automotive applications. It integrates compilers, real-time operating systems, toolchains, microarchitecture IPs and validation frameworks from multiple ecosystem partners into a unified reference architecture.

Through the integration of the Microsar Classic stack, Quintauris secures this software as part of its reference architecture, accelerating the deployment for OEMs and tier-one suppliers.

This helps developers secure access to the automotive real-time software component as part of Quintauris' reference architecture. It accelerates Autosar Classic integration on RT-Europa reference architecture. and validates platform performance, timing and reliability using Quintauris' benchmark framework.

"By integrating Vector's Microsar Classic with RT-Europa, we are bridging the gap between open, modular Risc-V architectures and the standardised automotive software environment," said Pedro Lopez, market strategy officer at Quintauris. "This collaboration provides the foundation for developing and validating next-generation real-time automotive systems with the robustness and predictability required for production."

Jochen Rein, senior vice president at Vector, added: "Through our collaboration with Quintauris, we are actively supporting the creation of a serial approved software ecosystem around the Risc-V technology. Microsar Classic is proven to be reliable and compliant with automotive standards. Combined with RT-Europa's flexibility, we enable developers to explore new architectures while maintaining familiar Microsar methodologies and toolchains."

The joint offering will be shown at CES in Las Vegas, where Quintauris will unveil its real-time platform and demonstrate the integration with key ecosystem partners.

AGL SoDeV enables software-first development

Automotive Grade Linux (AGL) has announced SoDeV, an open-source software-defined vehicle (SDV) reference implementation that enables software-first development decoupled from hardware constraints.

Led by Panasonic, Honda and AGL's SDV expert group, SoDeV combines the AGL UCB unified code base with multiple open-source projects hosted by the Linux Foundation to support consolidation of ECUs, hardware abstraction using virtualisation, and cloud integration.

Additional contributors include Toyota, Mazda, Aisin and Renesas.

"SoDeV combines AGL's proven UCB with Linux containers, VirtIO, Xen hypervisor and Zephyr rtos, all in a single pre-integrated downloadable package that can run on real hardware SoCs or cloud-based processors," said Dan Cauchy, AGL executive director. "Until now, developers had to do all this complex integration themselves. SoDeV serves as a catalyst for the community to build and deploy SDV technologies much faster."

SoDeV provides an SDV reference architecture and environment to build multiple components in a single downloadable package.

Anritsu and Head develop way to evaluate NG e-Call

Anritsu and Head Acoustics have developed a way to evaluate acoustics for NG eCall automotive emergency call systems.

Compliant with ITU-T Recommendation P.1140, it enables precise assessment of voice communication quality between vehicle occupants and public safety answering points (PSAPs), supporting faster and more effective emergency response.

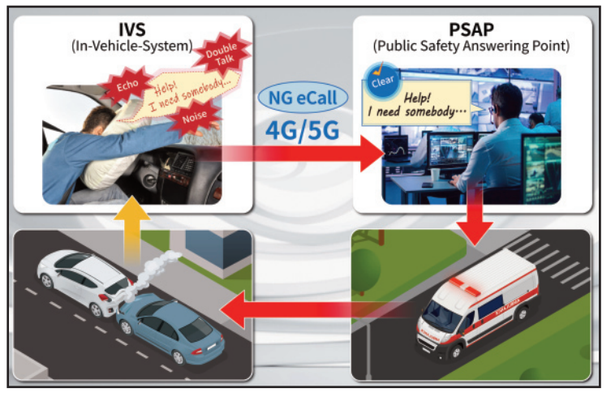
With NG eCall over 4G (LTE) and 5G (NR) now mandatory in Europe as of January 2026, ensuring high-quality, low-latency voice communication during vehicle emergencies has become essential.

After a collision, calls are conducted hands-free inside the vehicle cabin, where high noise levels, echoes and other acoustic hurdles can significantly degrade speech clarity. Reliable voice performance is therefore critical to conveying the situation accurately and enabling rapid rescue operations.

The development integrates Anritsu's MD-8475B for 4G LTE basestation simulation or MT8000A for both 4G LTE and 5G NR simulation with Head's Acqua voice quality analysis platform. This combination enables evaluation of transmitted (microphone) and received (speaker) audio under a wide range of realistic operating conditions.

Example evaluation scenarios include: echo and double-talk situations where speaker output re-enters the microphone or simultaneous speech may affect intelligibility; and cabin noise simulations representing real driving environments, including road, wind and engine noise.

Head is from Herzogenrath in Germany.



How NG eCall works



Delphi cloud assists workshop diagnostics

Delphi has launched a cloud-based platform to help garages and workshops securely store diagnostics reports, access vehicle history and gain insights that support faster and smarter repairs.

Integrated through the Delphi DS-Hub, the DS-Cloud automatically uploads and stores diagnostics sessions from Delphi's current and previous DS tools. Every workshop using Delphi Diagnostics can create a DS-Cloud account and link it to their PC or tablet, making it quick and simple to build a complete picture of the vehicles they service.

With DS-Cloud, workshops can securely save all diagnostics reports, then search, filter and view them anytime, from any device. Reports can also be downloaded or printed as PDFs for customer communication or record-keeping.

It builds a detailed vehicle history, making it faster to identify recurring issues and improving the accuracy of future diagnostics.

For distributors, it can link to a network's workshop management platform, giving managers visibility of most common fault codes, popular brands and models, plus trends across the network. These insights help inform stocking decisions, targeted promotions and training programmes.

Reports remain stored even if a licence has expired. If a workshop uses multiple tablets or laptops, all can be linked to the same account for unified reporting.

Features include search reports by VIN or registration number, automatic syncing of past sessions, dashboard insights on brands, models and systems diagnosed, GDPR-compliant data handling, compatible with classic and new DS software interfaces, and no action required if a VCI is replaced as DS-Cloud continues seamlessly.

Drako builds single-ECU hard real-time OS

Drako Tech has built what it claims is the first single-ECU hard real-time automotive operating system.

DriveOS with HyperSafety is based on DriveOS launched in 2015, which has been battle-tested in Drako GTE and Dragon vehicles.

It consolidates all vehicle subsystems, including control systems, adas and digital cockpit, into a single standard PC. DriveOS supports all propulsion systems – ICE, EV and hybrid.

HyperSafety defines a multi-layered standard for automotive safety performance, delivering predictable real-time performance under all operating conditions.

The single-ECU architecture provides nanosecond-level control processing.

The control and networking backbone is said to deliver four times faster communications than multi-ECU TSN Automotive Ethernet.

The architecture deploys strict hardware isolation as well as hardware and software redundancy.

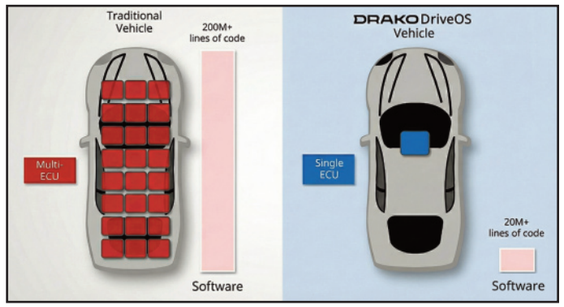
An order-of-magnitude smaller code footprint, secure hardware partitioning and on-chip memory communications between virtual ECUs reduce attack surfaces and streamline safety validation and OTA updates.

The entire communication flow is continuously analysed to detect and prevent erroneous operation.

Drako provides systems, development environments and reference designs that run natively on DriveOS.

The design environment helps control engineers build high-performance vehicle control systems directly from Simulink models, preserving their existing tools and workflows.

A separation kernel provides safety isolation and a unified electronics system enables reliable, low latency connectivity across all vehicle domains.



Comparing DriveOS with a traditional vehicle

Daimler and Torc pick Innoviz lidar for L4 trucks

Daimler Truck and its Torc Robotics subsidiary have selected Innoviz as their lidar partner for the series production of level-four autonomous lorries.

Innoviz will supply its short-range lidar for the SAE level-four autonomous Class 8 semi-trucks.



Innoviz sensors deliver consistency for commercial operation

As part of a joint development effort, the companies will collaborate to advance the sensors for commercial trucking applications.

Daimler and Torc plan to integrate Innoviz's lidar technology into the autonomous Freightliner Cascadia with Torc's virtual driver as one of several components enabling level-four autonomous trucking.

Deployment is planned across highway and regional routes in North America to help fleet operators improve operational efficiency and enhance road safety.

"The trucking industry demands lidar sensors that can perform reliably in the most challenging conditions while delivering the precision and range needed for safe autonomous operation," said Omer Keilaf, CEO of Innoviz. "Our InnovizTwo sensors have demonstrated compliance with these stringent requirements, and we're excited to support Daimler Truck and Torc in bringing this transformative technology to market."

Mike Avitabile, head of engineering at Torc, added: "Integrating Innoviz's technology into our self-driving vehicle software enhances our system's ability to detect, classify and track objects in real time across diverse road and weather conditions. Innoviz's sensors deliver the consistency and durability required for commercial operation, while supporting the redundancy needed for safe level-four autonomy."

Aumovio uses AI to boost automotive cameras

At the Consumer Electronics Show (CES) in Las Vegas, Aumovio will present an automotive camera system that uses AI to extract usable image information in difficult light conditions.

Whether driving at night, navigating through spray on wet roads or reversing in a downpour, the all-weather camera is said to ensure particularly sharp images and provides the vehicle's onboard system with detailed data, helping drivers manoeuvre safely.

Demand for high-performance cameras is growing. These depend on sensors such as cameras and radar to detect and interpret traffic situations accurately.

Aumovio's camera delivers crystal-clear images even in rain or darkness, displaying the entire area around the vehicle on the display.

"Reliable, high-resolution image data are a prerequisite for safe mobility, especially as assisted and automated driving functions become more prevalent," said Thomas Petzold from Aumovio, formerly Continental's automotive division. "Our innovative AI-supported camera represents a true technological leap in detecting and visualising traffic situations under adverse weather conditions."

Developers leveraged the company's expertise in custom sensor systems, incorporating hardware components known for durability and reliability.

The proven and modular camera portfolio, which allows easy integration of components such as lenses, image sensors, connectors, data transmission and chips, has been enhanced with AI software. The AI is used on a central control unit for image processing.

The camera algorithm optimises contrast and provides more accurate data based on the images than is the case with conventional systems.

Due to road traffic regulations, the area to the right and left of the vehicle must not be illuminated with visible light but, thanks to the algorithm-based integrated contrast enhancement, this area can now be captured a lot better.

The camera only illuminates the critical zones virtually for data acquisition by the central control unit, not in the real vehicle environment. This allows early detection of pedestrians or wildlife at the edge of dark roads, for example.

To ensure clear vision in difficult weather conditions such as thick fog, heavy rain, spray or snow, Aumovio is working on an effective all-weather camera variant. Equipped with an infra-red filter, it can accurately detect objects and traffic situations up to 160m ahead.

In principle, all cameras in a vehicle have infra-red filters because light waves in the infra-red spectrum could interfere with the colour representation of a camera. This innovation involves selectively opening a small section of the filter to allow a defined infra-red wavelength range, improving image clarity.

The aim is to enable better visibility and thus greater safety, even in foggy conditions. This is achieved by means of high-resolution images from the camera.

However, the more pixels there are, the greater the amount of data.

For most applications, Aumovio relies on camera systems with a maximum of 8Mpixel, and for special applications up to 18Mpixel, so as not to overload the onboard computing capacity.



Night vision cameras improve visibility in low light



SciChart visualises data for Formula One

SciChart has strengthened its role in Formula One data visualisation as the sport's software-driven engineering demands intensify.

The data visualisation technology is seeing record use across F1, where it supports most of the sport's telemetry, simulation and engineering workflows, either directly or indirectly.

With F1 increasingly driven by a software-first engineering philosophy, GPU-accelerated visualisation has become essential for applications across the grid. Deployments include pit-wall telemetry, remote operations, simulation-to-track correlation, power-unit development, ECU analysis, tyre performance modelling and wind-tunnel data interpretation.

These workflows rely on high-frequency datasets where engineers must extract precise insights in real time.

F1's financial regulations have shifted competitive advantage towards computational capability: simulation efficiency, rapid interpretation of high-frequency sensor data and the ability to correlate disparate datasets with precision.

With physical development restricted, performance gains increasingly come from stronger software pipelines rather than additional hardware.

This shift has driven demand for visualisation engines capable of extremely low latency, stable rendering under high data load and full numerical precision, capabilities essential for engineers making split-second decisions during live race sessions.

Teams are increasingly replacing older visual layers with modern GPU-accelerated engines built for high frequency engineering applications.

"Under the cost cap, performance is no longer only mechanical, it's computational," said Andrew Burnett Thompson, CEO of SciChart. "F1 teams need to extract maximum insight from every sensor, every lap and every simulation."

Contemporary F1 environments involve hundreds of sensor channels sampled at high rates, strict timing constraints and multi-disciplinary data that must be interpreted instantly.

Real-time correlation across aero, chassis, power-unit and driver-input data has become fundamental to trackside operations and remote engineering rooms.

Modern rendering engines are designed to process large, fast-moving datasets without down sampling, frame drops or numerical artefacts. This enables engineers to examine transient behaviour, often lasting only milliseconds, without loss of signal integrity. In production systems, single visualisations may involve tens of millions of data points displayed without lag.

The technology is now used across live telemetry dashboards, simulation-to-track correlation workflows, wind-tunnel analysis, power-unit test environments and various commercial toolchains. As teams blend internal development with proven external components, the visual layer has become a key part of their software ecosystems.

Growth in motorsport has been fuelled by the rising reliance on software-driven engineering. Other contributing factors include the need to visualise increasingly complex telemetry environments, and long-term programmes from existing teams and new manufacturers. Broader engineering trends, including heavier reliance on simulation, correlation loops and sophisticated sensor fusion, continue to expand the need for high precision, real-time visualisation.

"Teams are building more of their own software and relying on visualisation that is instantaneous, reliable and exact," said Sheldon Vestey, chief commercial officer at SciChart. "Our momentum reflects that shift, and the fact that our technology is now used across the grid, whether through internal systems or external platforms, shows how central real-time visualisation has become to modern race engineering."

SAFETY & SECURITY

ENSURING TRUST

Caroline Guillaume looks at the evolving automotive cyber-security landscape



Vehicle Electronics January 2026, 14



Systems integrate infotainment, adas and V2X communications

Software-defined vehicles (SDVs) fundamentally alter automotive engineering architectures. Modern EE architectures shift from distributed setups to zonal controllers and high-performance computing clusters.

These systems integrate infotainment, adas and vehicle-to-everything (V2X) communications into centralised platforms. Codebases now exceed 100 million lines of code across heterogeneous environments using C, C++ and, increasingly, Rust.

Interconnectivity expands the attack surface significantly. Malicious actors target these entry points to manipulate safety-critical functions such as braking and steering. Relying on legacy security validation methods for systems of this magnitude proves negligent. The industry requires a shift from probabilistic detection to deterministic proof.

Limitations

Standard verification and validation methodologies rely on statistical probability. Penetration testing and fuzzing operate on the premise of finding defects through stochastic exploration or heuristic attack patterns. These methods demonstrate the presence of defects yet fail to prove their absence.

Fuzzing engines generate random or mutation-based inputs to trigger crash states or unexpected behaviour. While effective for discovering shallow bugs and handling edge cases in input parsing, fuzzing suffers from the path explosion problem.

Complex automotive software contains virtually infinite execution paths. A fuzzer cannot explore the entire state space within a feasible timeframe. It achieves code coverage saturation where deeper logic paths remain untested. Critical vulnerabilities often reside in these deep states reachable only through precise sequences of inputs that random mutation rarely achieves.

Penetration testing faces similar constraints regarding scope and time. Human testers and automated scripts target known vulnerabilities and common weak points. This approach mimics known attacker behaviour but leaves the system exposed to zero-day exploits and novel attack vectors.

The window of opportunity for a pen tester is finite. A sophisticated attacker operates without time constraints. Relying on pen testing implies acceptable risk rather than assured security. It validates the security posture at a specific point in time against known threats. It offers no guarantee against future exploit techniques or dormant vulnerabilities.

Deficiencies

Static application security testing (SAST) attempts to analyse source code without execution. Traditional SAST tools use pattern matching and heuristic algorithms to identify potential flaws. These tools prioritise finding bugs over guaranteeing correctness.

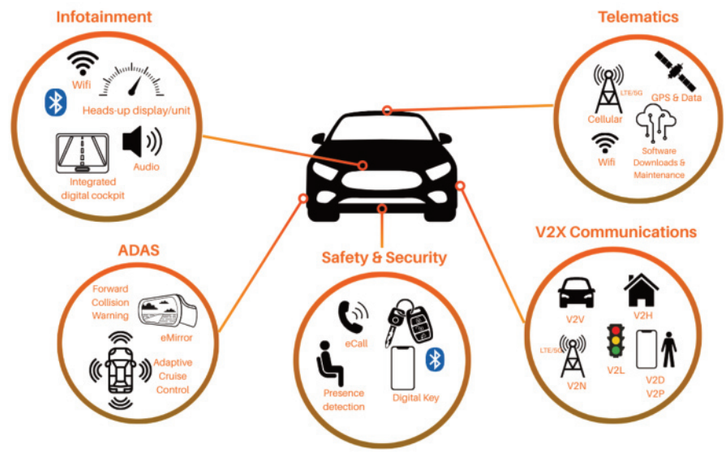
Consequently, they generate significant volumes of false positives. Developers waste cycles triaging non-issues leading to alert fatigue and the eventual disabling of checks. Furthermore, traditional SAST struggles with the semantic complexity of C and C++. It often fails to reason accurately about pointers, memory aliasing and concurrency.

The tools lack the mathematical rigour to verify global properties of the programme. They identify local syntax errors or simple logic flaws while missing complex defects arising from component interactions.

Verification

Formal verification (FV) establishes a paradigm distinct from testing. It employs mathematical logic to prove a software model satisfies a defined specification. The process uses techniques such as abstract interpretation and model checking to analyse the entire state space of the programme. FV provides a mathematical guarantee of correctness regarding specific properties.

The core advantage lies in soundness. A sound verification tool guarantees that if it reports no vulnerabilities of a certain class then none exist in the code. This eliminates the uncertainty inherent in testing.



Evolving automotive landscape

FV analyses all possible execution paths and input combinations simultaneously through symbolic reasoning. It does not run the code with specific data. It solves the logic of the code against the constraints of the language and the hardware. This approach proves the absence of runtime errors definitively.

Memory

Automotive firmware predominantly relies on C and C++ due to performance requirements and legacy code reuse. These languages grant developers direct memory access and manual resource management capabilities.

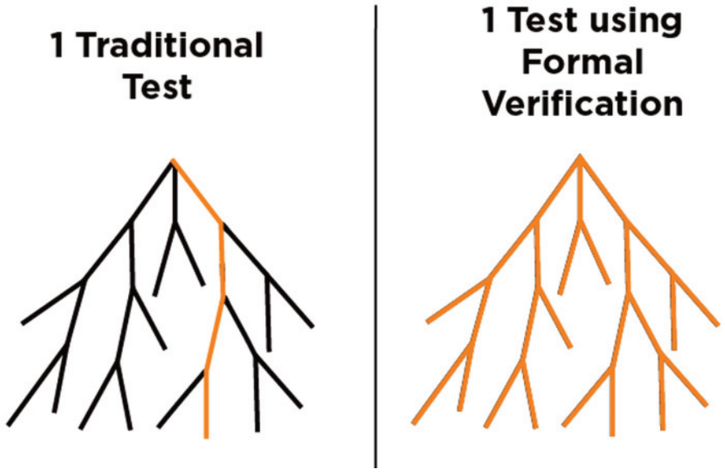
This power introduces the risk of undefined behaviour. Common vulnerabilities include buffer overflows, use-after-free, null pointer dereferencing and uninitialised memory usage. These memory safety violations constitute the majority of critical common vulnerabilities and exposures in systems software.

Formal methods specifically target these classes of errors. Through formal proofs, the analyser verifies that memory access pointers always remain within valid bounds for every possible execution state. It tracks the lifecycle of memory objects to ensure access occurs only on allocated and initialised memory. This prevents the classic stack smashing and heap exploitation techniques used by attackers to gain arbitrary code execution.

While languages such as Rust introduce memory safety guarantees at the compiler level, the automotive ecosystem will rely on C and C++ for the foreseeable future. Moreover, Rust integration often involves unsafe blocks and foreign function interfaces to communicate with C libraries. FV remains essential to verify these boundary layers where the compiler's safety guarantees do not apply.

ISO 26262

ISO 26262 defines functional safety standards for road vehicles.



Traditional test trees versus formal verification

It mandates rigorous verification and validation activities proportional to the required automotive safety integrity level (Asil). For Asil C and D components, the standard recommends methods that provide high confidence in correctness.

Part six of ISO 26262 explicitly references formal methods as a technique for software unit verification.

Traditional testing requires defining test cases for every scenario. FV covers the input space exhaustively without manual test case generation.

This capability significantly reduces the verification effort while increasing the assurance level. It provides the objective evidence required for the safety case. The mathematical proof serves as an artefact demonstrating that safety goals are met with the highest degree of certainty.

ISO/SAE 21434

ISO/SAE 21434 establishes the standard for automotive cyber-security engineering. It requires a risk-based approach throughout the product lifecycle. OEMs and suppliers must perform threat analysis and risk assessment (tara) to identify potential assets and threats. The standard mandates verifying that implemented security controls effectively mitigate identified risks.

Formal verification directly supports the concept of cyber-security assurance levels (CALs). By proving the absence of common vulnerabilities such as buffer overflows, FV mitigates the technical impact of threats identified in the tara. It ensures



Vehicles now have more than 100 million lines of code

the software component is robust against exploitation attempts targeting memory corruption.

This moves the security argument from "we tested and found nothing" to "we proved nothing exists". This distinction is vital for liability and compliance. It demonstrates due diligence beyond the state-of-the-art in testing.

Integration

Effectuating formal verification requires shifting left in the software development lifecycle. Waiting until the validation phase to apply formal methods results in costly rework.

FV tools must integrate into the CI and CD pipeline. Automated analysis should occur at the code commit stage. This provides immediate feedback to developers regarding safety violations.

Modern FV tools have evolved to become usable by software engineers rather than requiring PhD-level mathematicians. They integrate with standard build systems and IDEs. The analysis runs in the background. Violations appear as errors similar to compiler warnings.

This democratisation of formal methods allows for continuous verification. The codebase remains permanently in a verified state. This approach aligns with the V-model used in automotive engineering while accelerating the feedback loop. It reduces the burden on downstream QA teams who can focus on functional logic rather than hunting for crashes and memory leaks.

Imperative

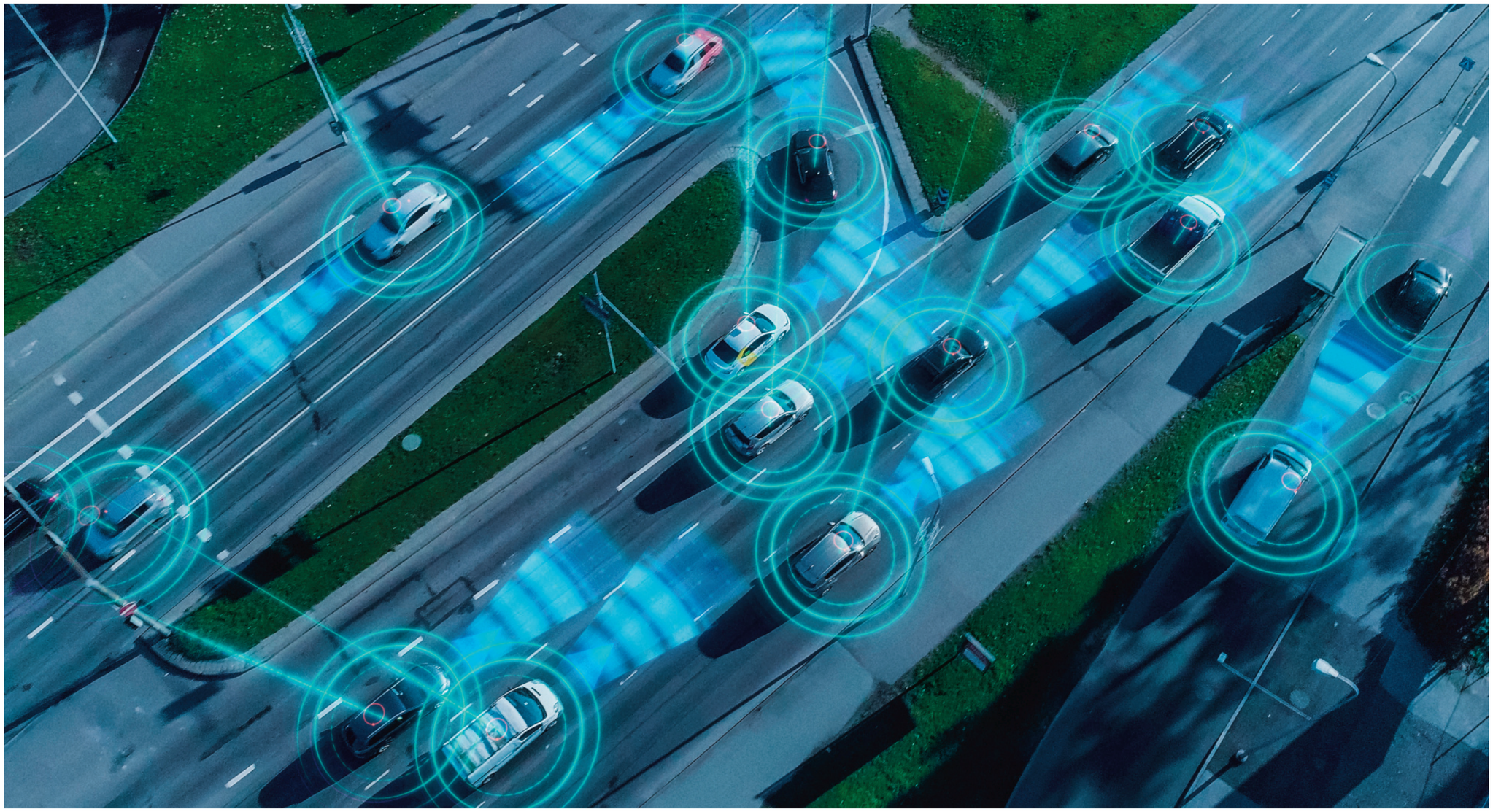
The trajectory of automotive technology points towards increasing autonomy and connectivity. The liability associated with software failure grows exponentially. Traditional methods such as fuzzing and pen testing remain useful for validating the final system integration and finding logic flaws.

However, they are insufficient for certifying the low-level correctness of safety-critical code. Formal verification provides the foundational bedrock of trust. It ensures that the millions of lines of C, C++ and Rust code driving future vehicles function as intended without undefined behaviour. Adopting FV is not merely a technical upgrade. It represents a necessary evolution in engineering rigour for the SDV era.



Caroline Guillaume is CEO of TrustInSoft

MEMORY



IN THE DRIVING SEAT

Lancelot Hu asks how automotive standards are shaping in-vehicle memory design

Automotive systems have relied on rigorous safety and reliability requirements long before the arrival of automated driving features or centralised compute platforms. The steady introduction of digital control, electrified subsystems and interconnected vehicle functions has intensified scrutiny on memory components that store safety-critical information and support time-sensitive processing.

Across modern architectures, memory and storage underpin essential operations. Everything from propulsion control to driver assistance algorithms depends on correct, timely access to data.

If a memory subsystem behaves unpredictably during braking, steering or power management, vehicle operation may be compromised. This puts memory at the centre of discussions about functional safety, diagnostics and long-term reliability.

Shifts

New vehicle designs are moving towards zonal and centralised compute structures, replacing the distributed networks of traditional ECUs. This change does not reduce the workload placed on memory; instead, it concentrates larger volumes of data into fewer high-performance processing domains.

Over-the-air updates, connected services, V2X communication and richer infotainment systems depend on storage devices that can support demanding workloads while still operating within strict power and thermal envelopes. In zonal architectures, memory components must also remain dependable across extended cable lengths, fluctuating voltages and a wider variety of electromagnetic environments.

In addition to data throughput, environmental robustness remains a non-negotiable requirement. Memory devices must tolerate vibration, broad temperature ranges, humidity and electrical noise. As compute elements consolidate, the consequences of a single storage fault increase, elevating the importance of redundancy, partitioning, diagnostics and predictable behaviour under stress.

Safety

Functional safety and cyber security are increasingly interdependent in vehicle design. As vehicles connect to external networks, every memory component becomes part of the broader attack surface. Manipulated or corrupted data stored in memory can undermine safety mechanisms, misreport sensor information or interfere with update processes.

Hardware-based security is

therefore essential, offering tamper detection, secure boot support, authentication and controlled key storage. Secure memory subsystems help ensure safety functions operate using unaltered and trusted information. This connection between safety and security has encouraged designers to evaluate memory not only for endurance and retention but also for its contribution to overall system integrity.

Standards

Relevant automotive standards continue to shape expectations for storage performance and testing.

ISO 26262 defines processes for assessing the safety performance of automotive components. It categorises risk using automotive safety integrity levels (Asils), from A to D. Memory used within a braking system, steering controller or central compute platform supporting adas would typically be required to meet the highest levels of assurance.

To reach those levels, memory devices must undergo extensive analysis to quantify potential failure modes and evaluate diagnostic coverage. Techniques such as FMEDA (failure modes, effects and diagnostic analysis) allow designers to understand the contribution of storage components to overall system reliability.

AEC-Q100 qualification ensures memory devices can survive automotive-grade environmental stress. It verifies robustness under temperature extremes, mechanical shock, thermal cycling and electrical disturbance. This qualification is foundational for any semiconductor targeting long-term deployment in vehicles.

ASpice provides a framework for assessing process maturity in software development for automotive systems. While originally focused on software, its influence extends to hardware components that must integrate within well-defined design flows. Storage subsystems must behave predictably within these frameworks to support traceability, reliability testing and functional verification.

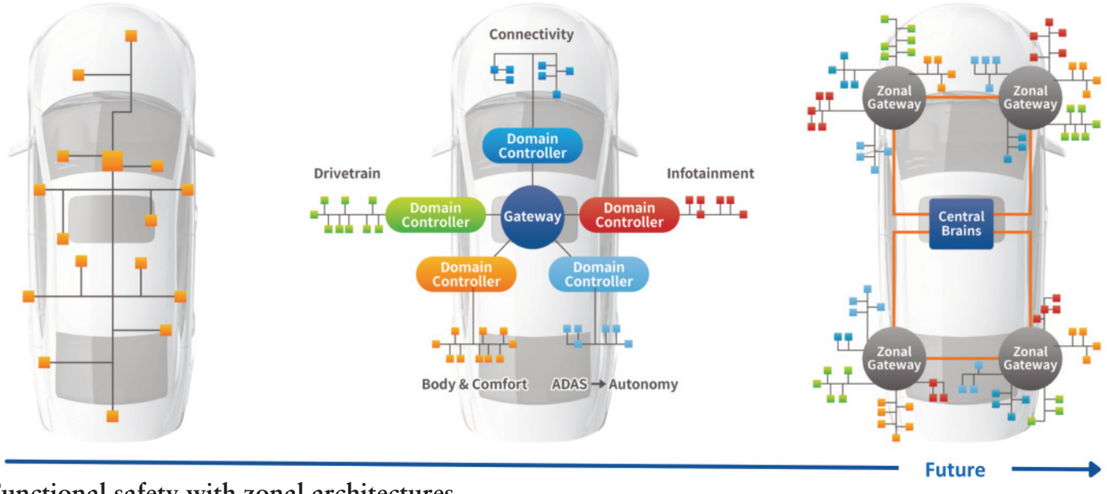
ISO/SAE 21434 complements these standards by addressing cyber security. Memory components supporting secure storage must comply with this framework to ensure encryption, key management and update processes meet industry expectations.

Requirements

Memory for automotive environments must meet several demanding requirements simultaneously:

- High endurance and retention: Applications such as infotainment, navigation, adas data capture and diagnostic logging generate constant write activity. Storage must support sustained workloads without premature wear.
- Predictable response under power events: Sudden power loss can occur during collisions, disconnections or system faults. Storage components must manage data safely and protect against corruption.
- Thermal and mechanical resilience: Flash memory is particularly sensitive to temperature. Automotive-grade designs ensure stable operation across extended ranges and resist degradation caused by vibration or shock.
- Diagnostics: Error correction, lifetime monitoring, wear-level indicators and self-test capabilities help system designers predict behaviour and plan redundancy strategies.
- Support for virtualised architectures: As central compute domains expand, virtual machine environments may require memory controllers capable of partitioning resources while preserving isolation and low latency.

These requirements influence everything from controller firmware to physical packaging. Designers must balance workload demands with consistent performance across a vehicle's lifetime, often spanning well over a decade.



Functional safety with zonal architectures

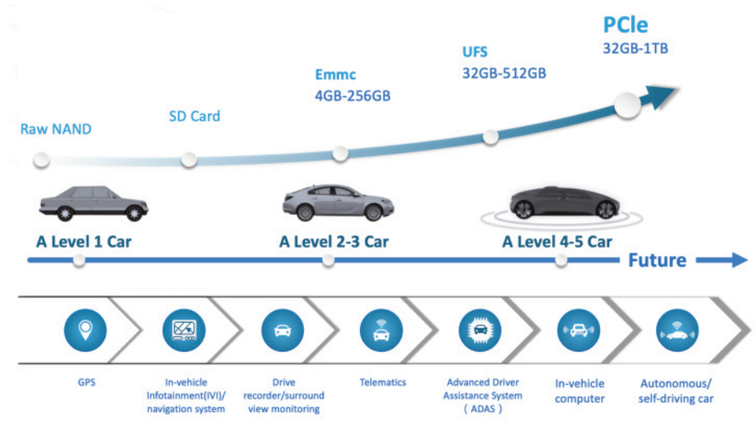
Virtualisation

Centralised compute platforms are introducing virtualisation as a foundational concept. Multiple domains – infotainment, adas, instrument clusters, telematics and safety-related applications – may share the same storage infrastructure while operating independently.

Virtualisation demands storage controllers that maintain performance even as multiple virtual machines access memory concurrently. Isolation ensures faults or heavy workloads in one domain cannot interfere with the operation of others.

Latency control, bandwidth management and predictable quality-of-service behaviour become essential attributes.

These capabilities support scalable system design, enabling engineers to consolidate ECUs without sacrificing determinism or safety.



Progression of storage requirements with functional safety

Reliability

Memory design for automotive platforms extends beyond raw performance metrics. Engineers must consider:

- Failure propagation: How a storage fault influences the wider system.
- Data criticality: Whether information stored in memory affects real-time decision-making, user experience or long-term logging.
- Redundancy schemes: Techniques such as mirroring, partitioning or dual-channel storage that improve resilience.
- Diagnostic intervals: How frequently a system must check the health of its memory devices to maintain compliance with Asil requirements.
- Integration with safety mechanisms: How storage interacts with watchdog timers, secure boot flows and ECU power management.

This holistic approach ensures memory subsystems strengthen, rather than limit, vehicle safety.

Conclusion

Vehicle architectures built around zonal control and central compute demand storage that remains dependable under harsh conditions while handling large volumes of data. Functional safety standards, cyber-security frameworks and stringent environmental requirements shape how memory is designed, tested and qualified.

As virtualisation, connectivity and software-centric features advance, engineers continue to rely on robust, well-validated storage components that deliver stable performance throughout a vehicle's lifetime.



Lancelot Hu is director of automotive and embedded at Silicon Motion

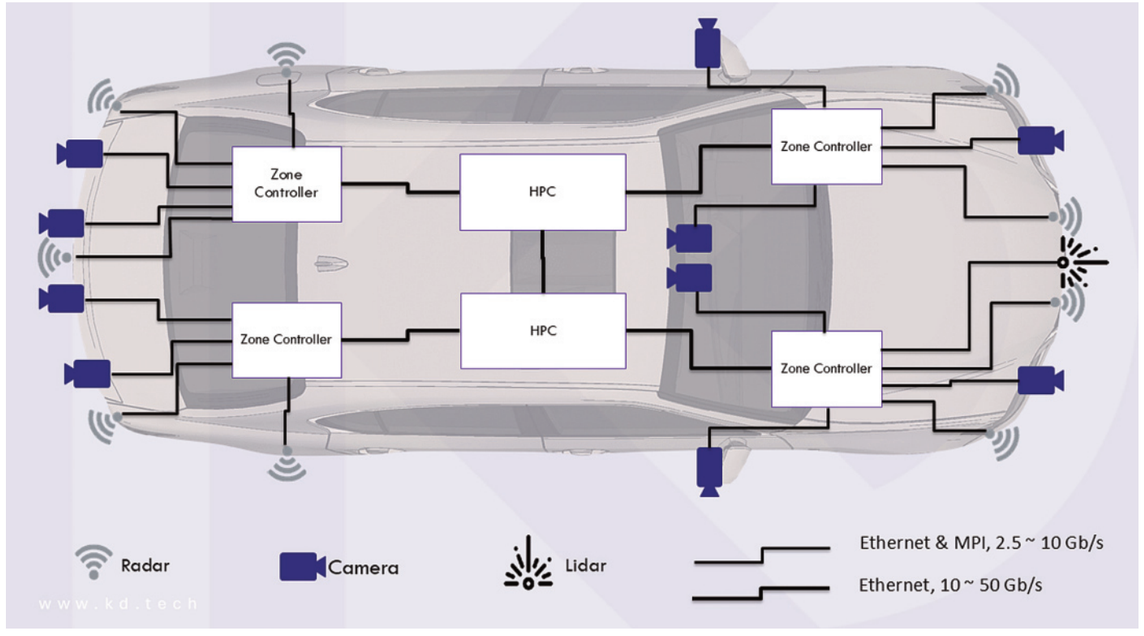
VEHICLE NETWORKS

FIBRE DIET

Pablo Blázquez discusses whether optical communications can be the backbone for software-defined vehicles

Image: Lucent_Designs _dinoson20 via Pixabay

Vehicle Electronics



Automotive zonal architecture with optical links

The automotive industry stands at a defining moment. Vehicles are no longer isolated mechanical systems but interconnected data centres on wheels. The convergence of cameras, radars, lidars and high-resolution displays is generating unprecedented data rates, now exceeding 10Gbit/s.

The rise in data rates is creating new challenges for in-vehicle communication. Modern vehicles must connect dozens of high-speed links that carry information from sensors to centralised high-performance computers, while reducing weight, electromagnetic interference and cost.

Traditional copper networks, once sufficient for infotainment and basic driver assistance, are now reaching their physical and economic limits.

The question is no longer whether vehicles need more data. They do!

But, how to move it efficiently, reliably and at scale. The answer increasingly points towards optical communication.

Bandwidth

Each generation of automotive sensors captures richer information at faster rates. A typical automotive adas camera can easily reach 4Gbit/s of uncompressed data, and multiple such cameras operate simultaneously in modern driver assistance systems. Lidar and radar modules add complexity to the challenge by generating large amounts of high-speed data. Their point clouds and velocity information must be synchronised and sent to the vehicle's central computers with precise and predictable timing.

Historically, automakers have tried to manage this data explosion through distributed processing, where local ECUs or zone controllers pre-process sensor data before sending them upstream. While this approach reduces bandwidth requirements on the backbone, it introduces new problems: increased power consumption in each node due to local compute capability; thermal management issues, especially in constrained spaces such as mirrors, bumpers or pillars; and scalability limitations, since adding more sensors means duplicating compute resources across the vehicle.

As sensor resolution and redundancy grow, a necessity for level 3+ autonomy, the model becomes unsustainable. The industry is now shifting towards centralised HPC-based architectures, which demand transport networks capable of aggregating multi-gigabit data streams with zero compromise in latency or reliability.

Architectures

To address both the bandwidth and scalability problems, OEMs are migrating to zonal architectures. Instead of hundreds of discrete ECUs connected through point-to-point links, zonal designs group functions by physical location (front, rear, left, right, cabin) and connect them through a high-speed optical or hybrid (optical and electrical) backbone to one or more HPCs. The high-speed links remain optical, while lower-speed communication continues to use copper.

This architectural shift brings multiple advantages:

- Cabling simplification: Optical fibres replace bundles of shielded twisted pairs, reducing weight and complexity. A single fibre can carry the equivalent of dozens of copper lines.
- Connection consolidation: Each zone aggregates traffic locally, reducing the number of long-distance cables going through the vehicle.
- Enhanced reliability: Simplified routing reduces potential failure points and improves manufacturing robustness.
- Centralised computing: HPCs act as the brain of the vehicle, concentrating processing power where it can be better cooled, monitored and upgraded via software.

Within this topology, the backbone network becomes the nervous system of the vehicle. This is now a mission-critical layer where latency, synchronisation and electromagnetic immunity are key. And it is precisely in this layer where optical communication demonstrates its full potential.

Optical

Copper-based Ethernet, even with the evolution from 100baseT1 to 10GbaseT1, faces intrinsic physical limitations. Signal attenuation, EMI susceptibility and power consumption rise sharply as bandwidth increases. Cable shielding adds weight and cost, reducing the gains from new data rates.

The nGbaseAU multigigabit optical Ethernet standard, on the other hand, relies on a mature, flat frequency-response multimode OM3 glass optical fibre, enabling the use of low-complexity, power-efficient transceivers. This technology offers a fundamental leap in performance and scalability.

Automotive-grade optical nGbaseAU already supports 10 to 50Gbit/s per lane, with clear upgrade paths towards 100Gbit/s.

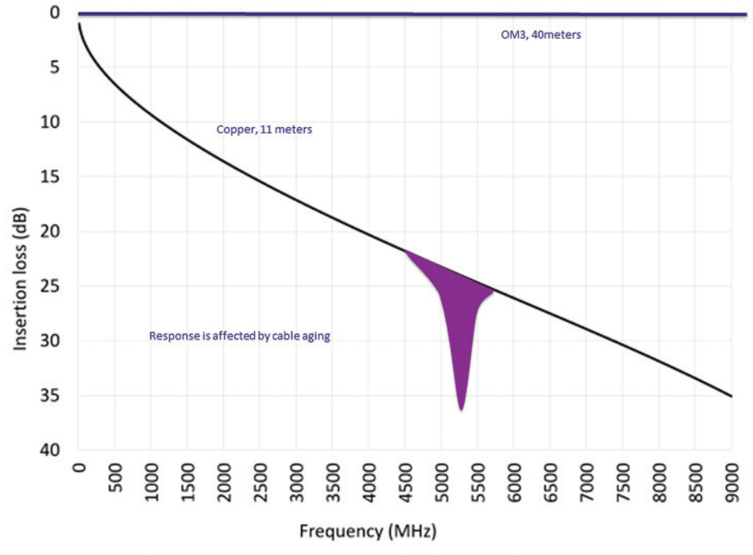
Simpler transceivers contribute to lower network latencies and facilitate deterministic response times. These are key features for safety-critical applications such as sensor fusion and real-time decision making.

Unlike copper, optical fibres are immune to electromagnetic interference and are inherently galvanically isolated, ensuring stable operation even in electrically noisy environments, such as those created by electric powertrains and onboard chargers.

Glass optical fibre (GOF) can reduce cable weight by 30 to 40%, contributing directly to efficiency and CO_2 reduction goals.

The reduced need for complex digital signal processing in the transceivers, combined with efficient light sources, results in significantly lower power consumption per transmitted bit.

With increasing adoption and simplified connector designs, the



Ageing and frequency response on high-speed transmission: Copper cables vs OM3 fibre

total system cost of optical links is on par with high-speed copper, especially when factoring in weight savings and assembly simplification.

These attributes make optical communication not merely an alternative, but an enabler for future automotive architectures.

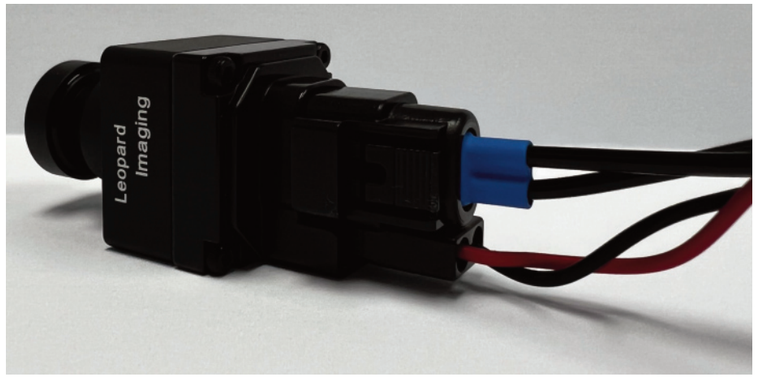
Implementation

Transitioning from copper to optical requires coordinated standardisation and ecosystem maturity, both of which are advancing rapidly. The IEEE has introduced the baseAU standard to define automotive-grade optical Ethernet, ensuring interoperability and reliability under the harsh temperature and vibration conditions of vehicle environments from 2.5 to 50Gbit/s.

Additionally, several trends accelerate adoption. For example, the same connectors and cable harnesses can be used for 2.5, 10, 25 and 50Gbit/s, simplifying the validation cycle on future system upgrades.

The OM3 multimode fibre optic cables offer longer operating link distances and support tighter bending radius (18mm), enabling flexible and space-efficient integration within automotive platforms.

Small footprint transceivers are optimised for automotive assembly and cost targets.



Leopard Imaging implemented an optical transceiver in an automotive camera with automotive grade hybrid connector and harness

Operating temperature ranges from -40 to +105°C, and they are mechanically robust.

Hybrid cable and connectors integrate optical and power lines, simplifying system design. Integrated diagnostics and link monitoring enable predictive maintenance.

The convergence of these innovations makes it feasible for OEMs and tier-one suppliers to deploy optical links not only in the backbone but also within zonal networks and sensor domains.

Impact

The transition to optical networking aligns perfectly with the automotive industry's evolution towards the software-defined vehicle (SDV). Centralised computing, high-speed data transport and cloud connectivity form the foundation of vehicles that can evolve through software updates, new feature deployment and data-driven services.

In this paradigm, sensors become data producers, continuously streaming raw information. HPCs act as intelligent aggregators, performing real-time fusion and AI-based interpretation. Optical backbones ensure the flow of data between zones and compute nodes.

The result is an architecture that supports autonomous driving, immersive infotainment, AI-based diagnostics and future features that have yet to be imagined.

From an engineering standpoint, this transformation demands collaboration across multiple disciplines: optical physics, network engineering, embedded systems and software architecture, all converging around optical communication as the fundamental enabler. Optical technology makes high-speed and low-latency data transfer possible, unlocking the full potential of autonomous systems and SDVs.

From a business perspective, it represents a shift from hardware differentiation to software-defined value creation, enabled by a high-speed, low-latency optical infrastructure.

Conclusion

As vehicles evolve into intelligent, connected platforms, the communication backbone becomes their defining component. The growing need to process and transport terabytes of sensor data per hour cannot be sustained by legacy copper networks.

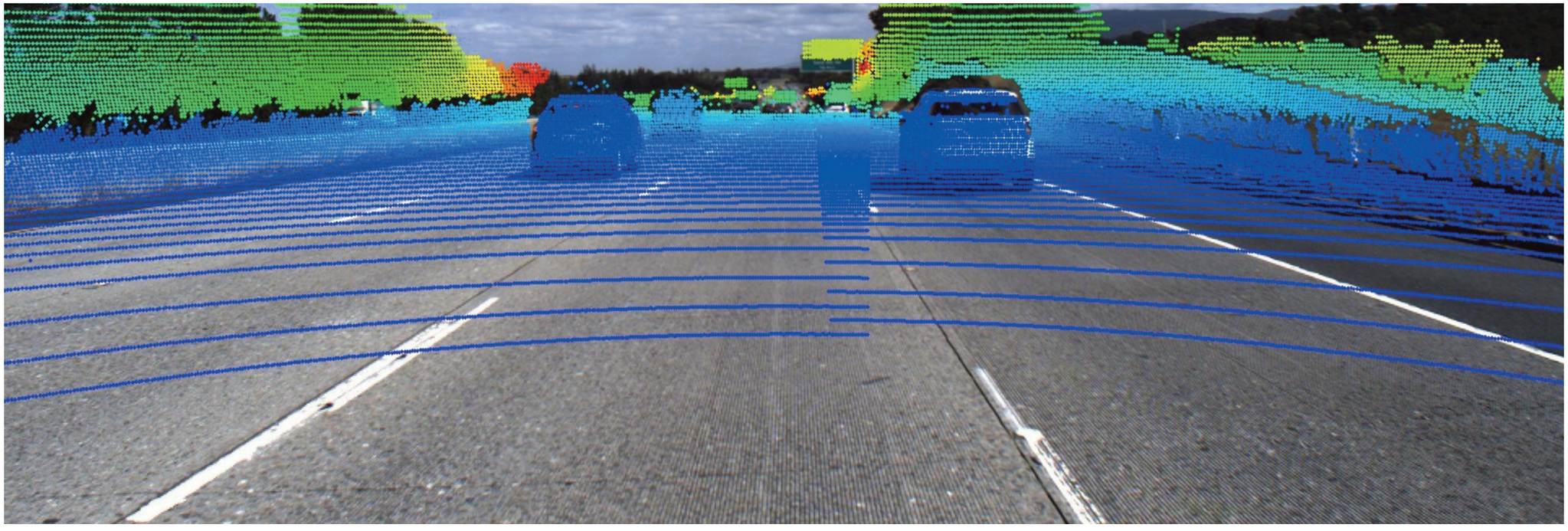
Optical communication delivers what modern mobility demands: massive bandwidth, low latency, immunity to interference and efficiency at scale. Its adoption marks a natural and necessary step in the evolution of vehicle electronics, one that bridges today's adas with tomorrow's fully autonomous, software-defined cars.

In the new era of hyperconnectivity, light is not just a metaphor for innovation, it is the medium itself.



Pablo Blázquez is business development manager at KD

VEHICLE NETWORKS

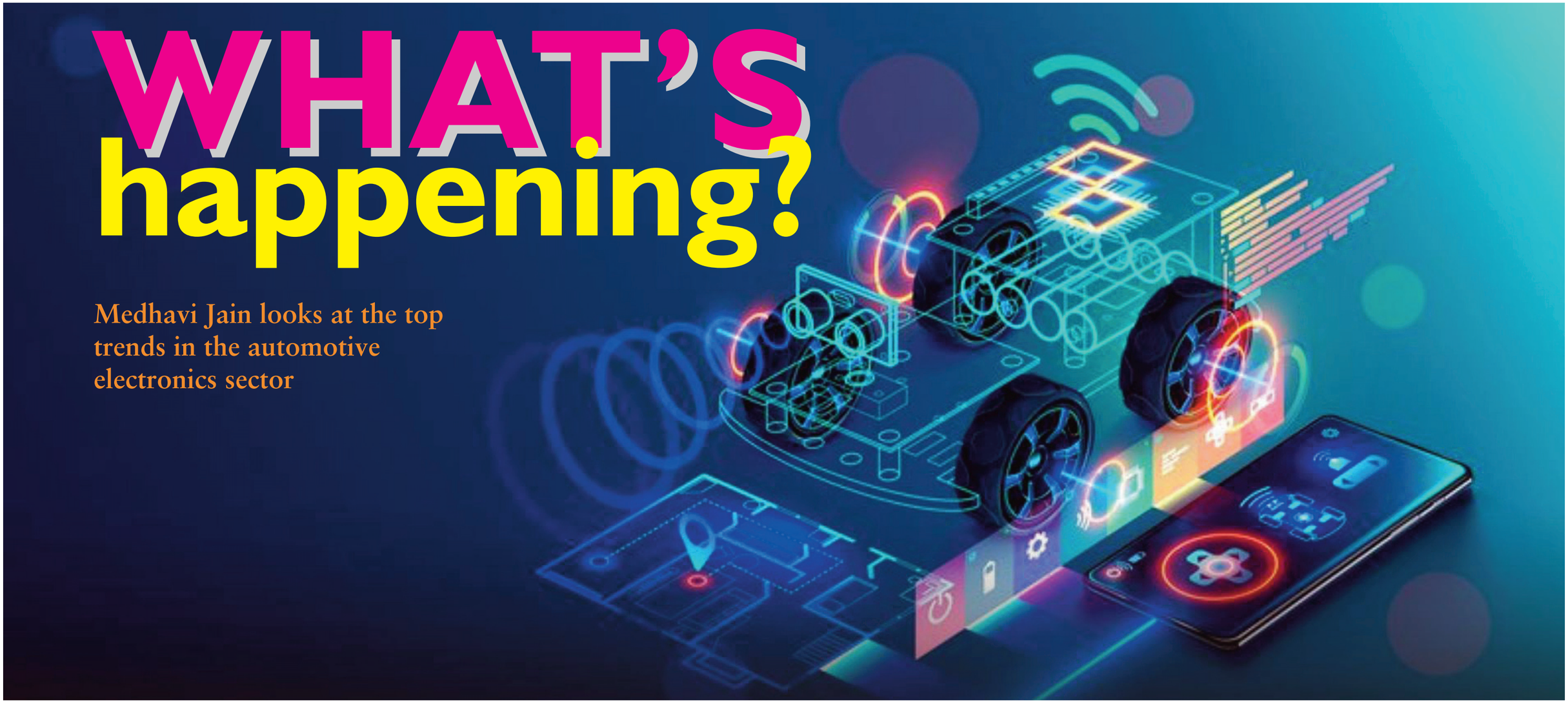


Lidar point clouds must be synchronised and sent to a vehicle's central computer with precise and predictable timing

TRENDS

WHAT'S happening?

Medhavi Jain looks at the top trends in the automotive electronics sector



Imagine stepping into a vehicle that not only drives itself but also connects seamlessly with the world around it, all while reducing environmental impact. The automotive electronics sector is transforming how we think about mobility.

From electric vehicles dominating roads to systems ensuring safety and efficiency, these innovations are reshaping the industry.

A prominent trend last year was the rapid shift towards electrification. As global initiatives push for cleaner energy, EVs are becoming mainstream.

This change relies heavily on electronics such as battery management systems that monitor health and optimise performance. Inverters and converters ensure efficient power usage, while electric drive units power motors effectively.

Power electronics play a crucial role here, using wide-bandgap semiconductors and algorithms to improve charging efficiency and extend battery life. Wireless charging is also gaining traction, allowing vehicles to charge without cables through electric field coupling.

In regions such as India, the production of electric vehicles has surged, increasing the need for these components.

The electronic content in EVs is expected to rise significantly compared with traditional vehicles, with power devices such as IGBTs and mosfets in high demand.

This trend supports reduced carbon emissions and better vehicle design. These advancements are set to make EVs more accessible and reliable, paving the way for widespread adoption.

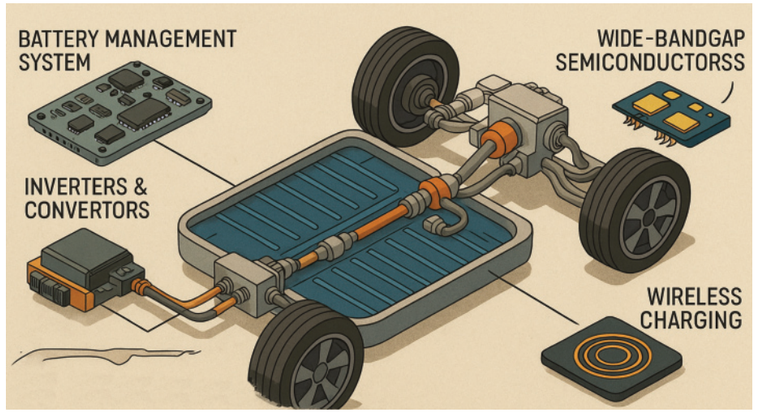
The automotive electronics market was valued at $273.2bn in 2024 and is projected to double, reaching $548.4bn by 2032, at a notable CAGR of 9.1%.

Connectivity

Connectivity was another game-changer in 2025. Vehicles are evolving into part of the internet of vehicles (IoV), enabling seamless communication with other cars, infrastructure and devices. This includes vehicle-to-everything (V2X) technology that improves traffic management and safety.

Key components such as connectivity modules support 5G and in-vehicle wifi for high-speed data transfer. Telematics systems provide real-time vehicle data, while infotainment setups enhance in-car experiences.

The global market for machine-to-machine cellular modules is



Trends in automotive electronics

projected to grow substantially, reflecting the demand for these features.

Connected cars are expected to make up a large portion of passenger vehicles. This connectivity allows for remote control and personalised services, making driving more convenient. However, it also underscores the need for robust systems to handle the increasing data flow.

Autonomous

Autonomous driving is accelerating, with electronics enabling safer, more efficient roads. Advanced driver assistance systems, such as adaptive cruise control and automated emergency braking, rely on sophisticated sensors and processors.

Technologies such as lidar, radar and computer vision processors detect objects and make real-time decisions. AI-powered systems process data to reduce human error, supporting features such as lane departure warnings and parking assist. Sensor chips capture environmental data, including hyperspectral imaging for better monitoring.

The push towards higher levels of autonomy is driving investments in these areas. These innovations are expected to become more integrated, making self-driving vehicles a closer reality and enhancing overall road safety.

Cyber security

With vehicles becoming more connected, cyber security emerges as a critical trend. Protecting against cyber threats is essential to maintain data integrity and vehicle safety.

Options include encryption protocols, intrusion detection systems and secure over-the-air updates.

These measures safeguard communication and prevent unauthorised access. The automotive cyber-security market is anticipated to expand significantly, as incidents targeting mobility assets rise.

AI-powered tools for risk management and automated testing for electronic control units are becoming standard. This focus ensures that, as vehicles digitise, they remain secure, building trust in connected technologies.

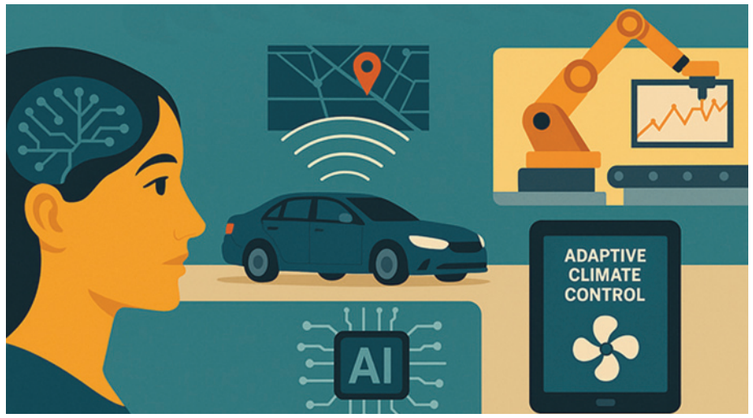


Evolution of V2X

Machine learning

AI and machine learning are deeply embedded in automotive electronics. These technologies enhance vehicle performance, from predictive maintenance that forecasts issues to personalised experiences such as adaptive climate control.

AI optimises routes through traffic management and supports



Integrating AI and machine learning in automotive electronics

edge computing for faster decisions. In manufacturing, AI drives efficiency with automation and data analytics under Industry 4.0 principles.

System-on-chip designs consolidate functions, incorporating AI for compact, powerful setups. This integration is key to smart mobility, making vehicles more intuitive and efficient.

Sensors

Sensors and interfaces are evolving to improve user interaction and vehicle capabilities. Sensor chips provide real-time data for safety features, while novel interfaces such as touchscreens, gesture recognition and augmented reality heads-up displays reduce distractions.

Voice assistants and predictive features offer intuitive control. The sensor chip market is poised for growth, driven by demands for multi-sensor packages.

These advancements create personalised user profiles and enhance the driving experience. By integrating with other systems, they contribute to safer and more engaging vehicles.

Here are some crucial innovations in this area: full-spectrum imaging for detailed environmental analysis; low-power voice control chips for hands-free operation; and AR displays with multi-layer depth for better visibility.

Sustainability

Sustainability is a core trend, with electronics focusing on eco-friendly practices. Recyclable materials, low-power designs and energy harvesting systems such as regenerative braking reduce environmental impact.

Thermal management systems maintain optimal temperatures for components, especially in electrified vehicles.

Liquid cooling, heat pipes and intelligent algorithms prevent overheating, extending component life.

The automotive thermal management market is expected to grow, reflecting the importance of these systems. Energy-efficient electronics align with emission regulations, supporting green innovation across the sector.

Manufacturing

Manufacturing innovations are transforming how automotive electronics are produced. Robotic systems ensure precision, with collaborative robots and AI vision for flexible lines.

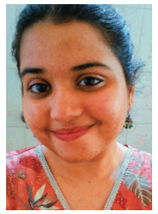
In regions such as India, the electronics manufacturing services sector is booming, driven by government incentives and a shift to original design manufacturing. This includes end-to-end options and localisation efforts to reduce import dependency.

The PCB assembly market is growing rapidly, supporting high-margin automotive segments. Initiatives for semiconductor production are fostering local ecosystems, enhancing supply chains.

Conclusion

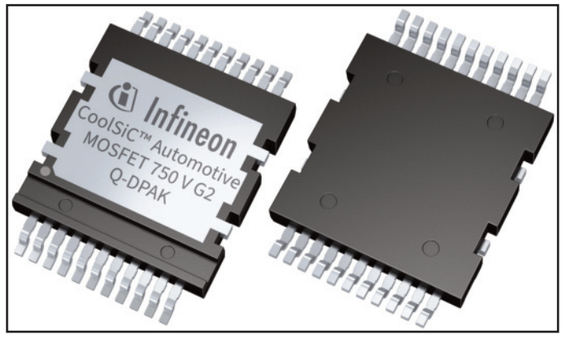
The automotive electronics sector is at the forefront of innovation, driven by electrification, connectivity, autonomy and sustainability. These trends not only enhance vehicle performance and safety but also align with global goals for cleaner, smarter mobility.

As technologies such as AI, sensors and robust cyber security integrate further, the future of driving looks promising. Staying ahead of these developments will be key for industry and consumers ensuring a seamless transition to the next era of automotive excellence.



Medhavi Jain is a content specialist at DataM Intelligence

Packages aid efficiency and power density



Packages for Infineon's CoolSiC 750V G2 mosfet technology are engineered to deliver efficiency and power density in automotive and industrial power conversion applications.

This is available in a range of packages, including Q-DPak and D2Pak, offering a portfolio with typical $R_{DS(on)}$ values up to 60mΩ at +25°C.

The portfolio extension includes products for various applications, such as onboard chargers and HV-LV DC-DC converters in the automotive sector, and server and telecom SMPS, along with EV charging infrastructure.

The low $R_{DS(on)}$ values of 4mΩ enable applications that require static-switching performance, such as e-fuse, high-voltage battery disconnect switches, solid-state circuit breakers and solid-state relays.

The top-side cooled Q-DPak package provides optimal thermal performance and reliability. This is designed to handle high-power applications with ease, making it attractive for designers seeking to push the boundaries of power density and efficiency.

The technology also exhibits good $R_{DS(on)}$ x QOSS and best-in-class $R_{DS(on)}$ x Qfr, contributing to reduced switching loss in hard- and soft-switching topologies with efficiency in hard-switching use cases.

Additionally, the G2 offer a combination of high threshold voltage VGS(th) typical of 4.5V at +25°C and low QGD:QGS ratio, which reinforce robustness against parasitic turn-on.

Furthermore, the technology allows for extended gate driving capabilities, supporting static gate voltages down to -7V and transient gate voltages down to -11V. This voltage tolerance provides engineers with greater design margins and best compatibility with other devices in the market.

Q-DPak 4, 7, 20, 33, 40 and 50mΩ and D2Pak 7, 25, 33, 40, 50 and 60mΩ samples are available now.

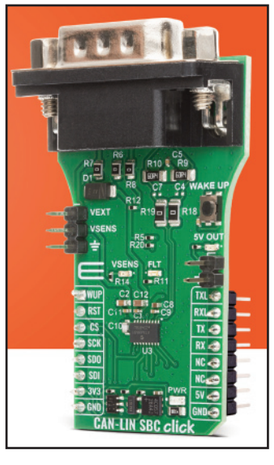
Board communicates over Can and Lin

A Click board from Mikroe provides high-speed communication over Can and Lin, ensuring robust, dual-protocol connectivity between automotive and industrial subsystems.

The Can-Lin SBC Click add-on board helps developers rapidly provide proof-of-concept, then prototype and code embedded projects.

It suits automotive body electronics, industrial automation and embedded systems that require simultaneous dual-protocol Can and Lin communication with power management and fault protection.

The board is based on the Microchip ATA6586 system basis chip (SBC) that integrates a high-speed Can transceiver compliant with ISO 11898-2: 2016 supporting up to 5Mbit/s Can-FD and a Lin transceiver compliant with Lin 2.2A, ISO 17987-4 and SAE J2602-2 standards.



It supports partial networking, low-power operation with local and remote wake-up, bus biasing, diagnostic and protection features, and EMC and ESD performance in harsh areas.

The board also features the ClickID function, which enables automatic identification by the host system, simplifying use.

They can be used on any host supporting the MikroBus standard, and come with the MikroSDK open-source libraries, offering flexibility for evaluation and customisation.

Thermal power sensor provides DC to 150GHz

Equipped with a coaxial 0.8mm RF connector supporting frequencies up to 150GHz, the Rohde & Schwarz NRP150T thermal power sensor provides what is claimed to be the world's widest non-banded frequency range of any commercially available RF power sensor.

This unlocks applications in high-frequency power measurement, including upcoming automotive radar bands. In addition, the wideband power sensor also streamlines the validation and calibration of RF instruments.

It covers all automotive radar frequency bands, including the higher 150GHz band. Here, the adas and AD community is working with standard authorities to define frequencies up to 148.5GHz for radar sensors.

The sensor achieves up to 500 measurements per second. Combined with its wide frequency range, this allows for single-sweep measurements across the entire spectrum, accelerating the validation and calibration of vector network analysers and other RF instruments.

Dynamic range is -35 to +20dBm and it provides long-term stability. It compensates for environmental temperature fluctuations within its 0 to +50°C operating range and drift performance remains resilient to external temperature changes and out-of-band signals.

With a maximum VSWR of 1.7, the sensor ensures matching and efficient power transmission. It is easy to use thanks to USB connectivity, compatible with standard PCs and Android mobile devices using a free remote-control app, or through the firm's NRX base unit.

Like all power sensors in the NRPxT series, this offers traceability to national metrology institutes (NMIs), which is a prerequisite for commercial and industrial use of a frequency band.

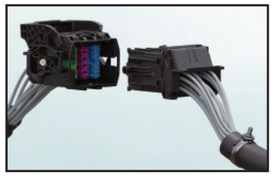
The Physikalisch-Technische-Bundesanstalt and other European NMIs collaborated with R&S and were first to establish NMI traceability for D-band ranging from 110 to 170GHz. This includes the frequencies up to 150GHz used by these power sensors.



Connectors unify power, signal and data

Data-signal hybrid connectors from Molex unify power, signal and high-speed data connectivity in a single system.

The MX-Dash modular wire-to-wire connectors use multiple, versatile cartridges in one housing to simplify wiring and harness architecture while improving automotive design flexibility, adaptability and scalability across multiple vehicle models and applications.



Each connector is based on an unsealed, cartridge-based hybrid platform that consolidates multiple connectors and types in one connector.

This building block approach optimises vehicle harnesses, which can result in weight, size and cost savings.

Purpose-built for zonal architectures, the connectors suit high-content connection points, including instrument panel-to-body harness connections, seat power and signal connections, and electrical-electronic architecture components.

Wiring and module engineers can also change cartridges within the housing, making it easier to add features or swap out pins and cartridges.

The connector adheres to USCar2 and USCar49 specifications.

Positive-locking features, blade stabilisation and vibration resistance help boost reliability.

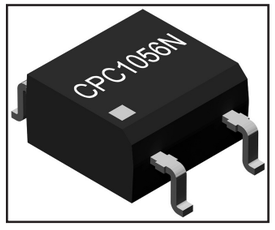
Maximum pin count is 70 circuits, with maximum circuit count per cartridge 26 circuits for 0.5mm cartridges, 14 circuits for 1.2mm cartridges, four circuits for 2.8mm cartridges, and three circuits for 4.8 and 6.3mm cartridges.

Asymmetrical TVS diodes cut losses in 12V systems

Asymmetrical TVS diodes from Littelfuse are for 12V battery anti-reverse protection, delivering better performance than traditional symmetrical bi-directional TVS products.

Unlike conventional approaches requiring multiple components, the TPSMB series provides a single component that protects anti-reverse mosfets, diodes and DC-DC converter ICs from positive and negative surges.

The asymmetrical clamping capability ensures much lower clamping voltage from negative surges, allowing engineers to select lower-rated mosfets or diodes. This reduces conduction losses, simplifies design and lowers overall costs.



They provide asymmetrical protection with low positive clamping (24-30V) and low negative clamping (12-18V).

A single device replaces multiple Zener and TVS diodes, streamlining PCB design.

Specifications include 600W peak pulse power, less than 1ns response time and up to 30kV ESD dissipation.

They are AEC-Q101 compliant with a -65 to +175˚C junction temperature range, and come in a DO-214AA surface-mount package.

They are suitable for automotive applications requiring 12V battery anti-reverse protection, including domain and zonal controllers, body control modules, infotainment and lighting systems, ECUs and power seats, motor pre-tensioner safety belts, and adas.

Asymmetrical clamping results in significantly lower clamping voltage during negative surges. This lets designers use lower-rated mosfets or diodes, reducing conduction losses and costs.

They meet automotive surge and ESD requirements, including ISO 7637-2 pulses. This ensures they deliver reliable protection in 12V battery environments.

Thermistor meets AEC-Q200

An AEC-Q200 qualified, glass protected NTC thermistor from Vishay comes in the 0.5 by 0.5 by 1mm 0402 case size.

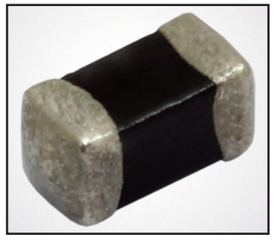
The BC Components NTCS-0402 E3104*XT combines a high beta (B25/85) value of 4311K with an electrical resistance value at +25˚C (R25) of 100kΩ.

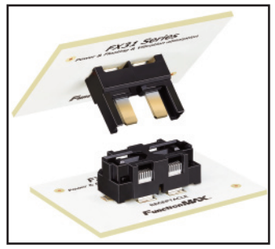
Fully glass coated and protected, the thermistor offers tolerances down to ±1% for its R25 and B25/85 values for precise temperature sensing, protection, and compensation from -55 to +150˚C.

The device offers ESD withstand of more than 25kV in accordance with the HBM human body model.

With its standard size, it provides a drop-in replacement for competing products in automotive LED modules, ECUs, sensor clusters, battery packs, and camera, radar and lidar modules; energy meters; office equipment; and industrial smoke and fire detectors.

For fast design-in, a Spice model is available.





Connector

A high-current board-to-board connector from Hirose is for harsh environments including automotive powertrain and ECU connections.

Supporting up to 25A per pin, the two-pin FX31 combines high-vibration resistance with high-heat resistance up to +125˚C to deliver reliable performance in severe environmental conditions.

Featuring a floating contact structure, it has a displacement absorption range of ±0.5mm in the x-y direction and ±1.5mm in the z direction. Floating connectors reduce mechanical stress on solder joints and contacts, lowering the risk of solder cracks, contact buckling and other failures.

This is valuable in automated or high-speed manufacturing.

Reducing soldering and screw-fastening workloads, it has a design that permits direct busbar insertion. This supports higher-density layouts while reducing overall system size.

Pitch is 9.5mm and stacking height 20mm.

LED drivers suit exterior and interior lighting

LED driver ICs from Novosense are for exterior and interior lighting.

With high-side and low-side linear drivers as well as integrated MCUs for RGB and RGBW ambient control, these ICs deliver current regulation, diagnostics and thermal management, helping automakers and tier-one suppliers build safer, more energy-efficient and customisable lighting systems.

The NSL21912, 16 and 24 are high-side LED drivers delivering 100mA per channel with 12bit PWM dimming, and support automatic thermal sharing via VS shunt resistors to improve thermal performance.

They also have configurable LED fault detection, integrated eeprom for fail-safe functions, a uart interface up to 2Mbit/s, and optional Asil-B functional safety support.

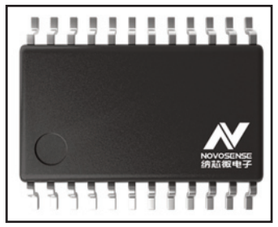
The NSL23716x is a 16-channel automotive low-side LED driver with 100mA per channel and 12bit independent PWM dimming. It integrates programmable thermal derating, LED open- and short-circuit detection, and overheat protection with automatic shutdown.

Built-in OTP memory supports fail-safe functions, while the optional Can phy interface eliminates the need for an external transceiver, simplifying design and improving reliability.

The NSL2163x is a three-channel automotive linear LED driver delivering up to 200mA per channel and operating directly from a 5 to 40V battery. It supports thermal sharing via external shunt resistors, offers an optional low-power EN-pin version, and integrates LED open and short detection with thermal shutdown for enhanced reliability.

Integrating an Arm Cortex-M3 core and four-channel precision current-mode LED drivers, the NSUC1500 provides 16bit independent PWM dimming and 6bit analogue dimming capabilities, and enables more accurate dimming and colour mixing control while compensating for lumen depreciation.

It complies with AEC-Q100 grade one and Cispr 25 class five EMC standards.



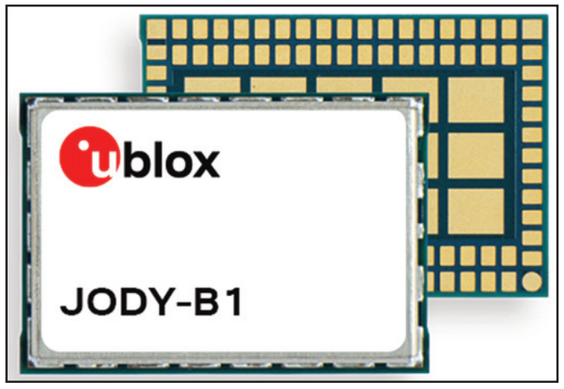
Module enables dual-mode Bluetooth connections

An automotive-qualified Bluetooth module from U-Blox can maintain multiple simultaneous Bluetooth dual-mode Classic + LE connections.

As vehicles evolve into connected entertainment spaces, passengers increasingly expect individual control over their in-car audio and gaming experiences. While traditional combo modules support a few Bluetooth connections, they cannot scale to deliver a complete Bluetooth experience to all passengers in the vehicle.

The Jody-B1 module overcomes this limitation by enabling additional Bluetooth connections, each operating independently, so every passenger can connect personal devices such as headsets, controllers or tablets without interference or additional system complexity.

Based on the Snapdragon auto connectivity platform from Qualcomm and the QCA8695AU automotive-grade chipset, the module combines LE Audio support, operating temperature up to +105˚C, and a 13.8 by 19.8mm form factor to deliver connectivity in a space-constrained automotive environment.



Its host-based uart interface and global certifications (FCC, RED, ISED, UKCA, Bluetooth Sig) simplify system integration, allowing tier-one suppliers and OEMs to deploy multiple Bluetooth instances quickly.

With its multi-connection capability, automotive qualification and pre-certified global compliance, it gives automakers a ready-to-use, future-proof module that simplifies design, reduces risk and enhances the in-vehicle experience.

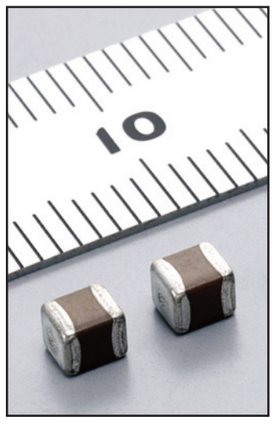
MLCC remains stable in high-voltage conditions

A multilayer ceramic capacitor (MLCC) from Murata has a capacitance of 15nF, rated voltage of 1.25kV and C0G characteristics in the compact 3225M (3.2 by 2.5mm) size.

This product delivers efficient power conversion and stable performance under high-voltage conditions, making it suitable for onboard chargers in electric vehicles and power supply circuits in high-performance consumer devices.

Resonant and snubber circuits are essential for efficient power conversion and suppressing current and voltage peaks.

In both circuits, repeated exposure to high voltage and high current can cause even slight changes in component performance, leading to efficiency loss or heat generation, and potentially causing malfunction or failure.



Recent trends also show a shift in power supply switching devices from silicon to silicon carbide (SiC) mosfets, which enable higher efficiency and faster switching.

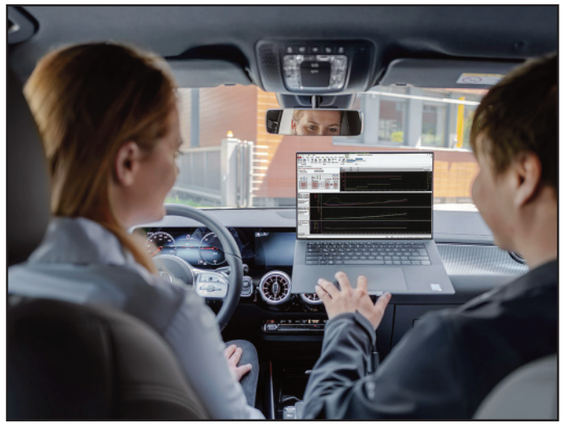
SiC mosfet applications require breakdown voltages of 1.2kV, driving demand for capacitors with ratings exceeding this specification.

These applications, therefore, require capacitors that maintain stable performance across wide temperature ranges, reduce power loss and withstand high operating voltages.

Leveraging proprietary ceramic and electrode materials, thin-layer moulding technology, and high-precision stacking technology, the 1.25kV MLCC addresses these needs.

The inherent advantages of C0G in accordance with EIA standards – low loss and stable capacitance over an operating temperature from -55 to +125°C – make the product suitable for resonant and snubber circuits.

For design flexibility, the capacitance range spans from 4.7 to 15nF, with a tolerance of ±1% to ±5%.



Tool aids calibration in modern vehicles

Vector Informatik has launched Canape 24, the latest version of its tool for precise measurement and calibration in modern vehicle architectures.

Automotive engineers and developers benefit from enhanced functions for the acquisition, analysis and calibration of zonal ECUs and high-performance computers.

It now supports the Asam CMP protocol, broadening options for precise measurements.

Communication remains compatible via established standards such as Can, Flexray, Lin and Ethernet (xbaseT1).

The software tool also enables the calibration and visualisation of complex ECU architectures, including dynamic Some-/IP data structures.

Another innovation is the direct validation of adas algorithms. Developers can visualise detected drivable areas (free space) and obstacles in real time, immediately evaluating results from camera, radar or lidar-based sensors.

This accelerates optimisation of safety-critical functions.

The vLogger Control Room is a tool for live monitoring of vehicles equipped with GL Logger or Smart Logger.

A configurable dashboard provides real-time information on vehicle positions, signal values such as speed and the status of the data loggers.

Canape 24 includes 100Gbyte of cloud storage for logging projects and enables secure data exchange.

Hard disc encryption within the VP75x1 logging and processing platform ensures protection of recorded data.

Buck converter optimised for PoL applications

An automotive-compliant 5.5V, 4A synchronous buck converter from Diodes has an I²C interface and low quiescent current (I_Q).

The I²C interface of the AP61406Q allows the programming of various parameters enabling it to meet the growing demand for compact design and high efficiency in automotive point-of-load (PoL) applications, including infotainment, instrument clusters, telematics and adas.

The I²C 3.0-compatible serial interface supports SCL clock rates up to 3.4MHz. This interface enables programmability for various parameters, including PFM and PWM modes, 1, 1.5, 2 and 2.5MHz frequencies, and output currents of 1, 2, 3 and 4A.

The device also provides 20mV increment V_{OUT} adjustability and fault status reports.

It is available in a W-QFN1520-8 SWP (type UX) package, so it can operate at high ambient temperatures.

A proprietary gate driver scheme resists switching node ringing without compromising mosfet turn-on and turn-off times, thereby reducing high frequency radiated EMI noise.

Input voltage range is 2.3 to 5.5V. It integrates a 75mΩ high-side and a 33mΩ low-side power mosfet to provide efficient step-down DC-DC conversion.

Constant on-time control reduces external component count, facilitates loop stabilisation and results in low output voltage ripple.

The multi-function enable input also controls the mode of operation. This capability enables flexibility for low I_Q (20μA), high-load efficiency in fixed PFM mode or equal ripple across load conditions in PWM mode.

Additional features include an accurate power good indicator with an internal 5MΩ pull-up resistor with a ±5% window comparator circuit.

High-side and low-side current sense protection during output short circuits increases reliability in PoL use.

Other protection features include undervoltage lockout, over-voltage protection, peak and valley current limiting, and thermal shutdown.



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