VEHICLE electronics

The monthly magazine for automotive electronics engineers

Ford tests technology to predict traffic incidents

Ford is trialling technology to help foresee traffic incidents; it connects cars and sensors to improve road safety.

A Ford-led consortium is developing a predictive road safety tool, which, using data from connected vehicles and intelligent roadside sensors, could help make travel in towns and cities safer and easier.

The data-driven road safety tool will analyse information from connected vehicles, smart roadside sensors and local-authority data to predict the likely locations and possible root causes of potential road safety hotspots. The insights will enable cities to take pre-emptive action to address roads and junctions that pose the highest risks to road users.

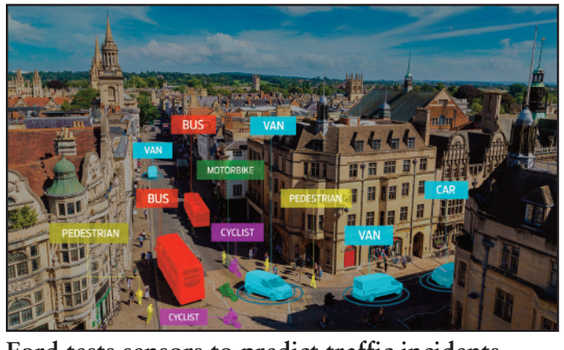
"Soon every new vehicle will be a connected vehicle, and we see this as an opportunity to reduce road traffic incidents and save lives in a significant way," said Jon Scott, project lead at Ford Mobility.

Ford is working alongside Oxfordshire County Council in the UK, AI sensor specialist Vivacity Labs, and academics from Loughborough University's Transport Safety Research Centre, with support from Transport for London.

Ford has conducted research into the opportunity for connected cars and predictive analytics to help improve road safety. Up to 700 passenger and commercial vehicles will be voluntarily connected across Oxfordshire and London as part of the 18-month project starting this summer.

Detailed telematics data from the fleet of vehicles – such as brake or accelerator pedal usage and steering wheel angle – will be analysed alongside information from up to 25 additional smart sensors to be provided by Vivacity Labs.

Ford is also working with authorities in Germany and Spain to identify further ways in which analysis of information from connected vehicles and infrastructure can benefit urban mobility.



Ford tests sensors to predict traffic incidents

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Rolling buys Sierra automotive module business

Rolling Wireless, a consortium led by Fibocom Wireless, has bought Sierra Wireless' China-based automotive embedded module product line for US$165m in cash.

"This transaction will improve our balance sheet and allow us to expand our R&D centre in Richmond, British Columbia, to accelerate our innovation in integrated IoT and 5G modules, gateways and routers," said Kent Thexton, CEO of Sierra Wireless.

The divested product line is part of the company's embedded broadband reporting segment. Sierra Wireless will exit automotive applications but will continue to invest in other product lines in the segment, specifically high-speed cellular modules typically used in enterprise applications.

The revenue for the automotive product line in 2019 was $166m.

The automotive embedded modules are developed in China by Sierra Wireless and manufactured in China by outsourced contract manufacturers for sale to global electronics companies for integration into new vehicles assembled in China, Europe and Mexico. No Canadian-based or US-based employees, operations or assets will be transferred as part of this transaction.

Sierra Wireless expects around 150 of its employees will become employees of Rolling Wireless. Some 120 of these are in mainland China, with the other 30 in Europe or the Apac region.

The transaction is expected to close before the end of this year and remains subject to customary closing conditions.

Rolling Wireless is owned 49% by Fibocom Wireless.

Nevs tackles privacy in self-driving fleet



Nevs believes it has solved the problem of privacy with the Sango self-driving vehicle, part of its Pons mobility ecosystem comprising autonomous vehicles with a user interface for linking with smart cities.

"We started by looking at why urban citizens have such strong desire to use their own cars rather than public transport, even if it means sitting in traffic jams for hours," said Anna Haupt, vice president at Nevs. "The reason is privacy. In your own car you feel safe, secure, relaxed and free."

There are six movable seats in three rows and privacy walls that can be raised and lowered. When raised, the vehicle is divided into four smaller areas for private journeys for up to four people. In social setting, the dividing walls are lowered to allow four people to travel together facing each other. In family setting, up to six people, seated in three rows, can travel comfortably together.

Nevs partnered with AutoX, an L4 autonomous driving technology company in Silicon Valley and Shenzhen. The AutoX AI will be driving the Sango. AutoX was chosen for its software-hardware integrated approach, safety and scalability, and ability to navigate in dense urban environments.

Toshiba enhances lidar with silicon photomultiplier

Targeting autonomous driving, Toshiba has introduced high-resolution, long-range light-receiving technology for deployment in solid-state lidar systems.

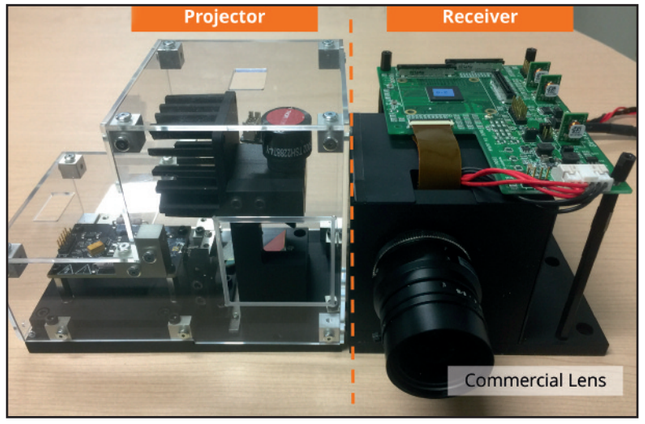
By removing the need for bulky mechanical components, the technology can realise cost and space savings and enhance operational reliability. At its heart is a proprietary compact, high-efficiency silicon photo-multiplier (SiPM).

In general, SiPMs are for long-range measurement as they are highly light sensitive. However, the light-receiving cells composed on a SiPM require recovery time after being triggered, and in strong ambient light they also need a large number of cells, since they must have reserve cells to react to reflected laser light.

With this technology, a transistor circuit reboots the cells to reduce the recovery time. The cells function more efficiently and fewer are needed, securing a smaller SiPM. This realises a higher-resolution SiPM array while maintaining sensitivity.

Current lidar systems require mechanical components to rotate continuously the laser emitters and their accompanying optical detection devices. Using solid-state lidar instead secures numerous operational advantages.

Field trials with a lidar prototype using commercially available lenses, from wide-angle to telephoto lenses, have demonstrated the system's effectiveness over a maximum distance of 200m. This can quadruple the capabilities of currently available solid-state lidar while maintaining resolution.



Field trial with a lidar prototype using commercially available lenses

Furthermore, Toshiba's lidar can be built with commercial lenses, which eliminates complex customisation and allows it to be applied in a wide variety of self-driving vehicles.

The technology's inherent compactness allows placement in multiple locations on vehicles, and it could broaden lidar applications outside of the automotive sector.

Toshiba is continuing R&D to extend the lidar measuring range, raise resolution and reduce size, with the target of practical use of the SiPM in 2022.

IST and Dekra sign functional safety MoU

Integrated Service Technology (IST), a Taiwan provider of electronic device verification services, has signed an MoU with Dekra, a specialist in testing, inspection and certification, to advance capacity in verifying, coaching and certifying automotive electronics functional safety.

The MoU aims to build a partnership in functional safety according to ISO 26262. Suppliers trying to get in the automotive electronics supply chain by qualifying for ISO 26262 may use the joint capabilities provided by IST and Dekra.

This can cover the whole process from pre-verification coaching and reliability verification to the design verification over submitted samples and application for audit certification.

The automotive industry is unique in its zero-tolerance approach to system failures, as they may result in personal injury or death. In case of product failures, the maker is required either to recall them or become trapped in lawsuits, compensation and a contaminated image.

"Benefited by its dominance in the Asian reliability verification market, IST is ready to provide not only environmental tests for automotive electronics products but also counselling and coaching for ISO 26262 specifications, covering process, production, development tool and SEooC (safety element out of context)," said Gerhard Rieger, senior VP at Dekra.

Sirius XM and Rapid SOS extend ecall data transfer

Sirius XM Connected Vehicle Services and Rapid SOS are jointly developing a way to transmit more vehicle crash data digitally to emergency services immediately following a crash.

By linking vehicle and crash data from Sirius XM's ACN+ automatic crash notification technology with the Rapid SOS emergency response data platform, emergency personnel can be notified quicker and first responders can receive more critical information about the nature and severity of the vehicle emergency before arriving at the scene.

Sirius XM provides emergency assistance services, including automatic crash notification, through technology integrated into more than ten million vehicles across multiple automotive makes and models in North America.

Last year, the company alerted 911 centres of hundreds of thousands of vehicle emergencies through verbal contact, providing responders with information about the emergency, the location, the vehicle, and its occupants, often in post-crash situations when the occupants can't respond or communicate clearly.

Supplementing this interface between Sirius XM's response centres and 911 with data through the Rapid SOS platform enables more information conveyed in a shorter time that is less susceptible to miscommunication.

Such data include location of the incident, airbag deployment status, crash impact data, occupancy, vehicle description, and driver and passenger information.

Rapid SOS, for subscribers with linked MedicAlert accounts, also provides demographic and medical information.

"The integration of Sirius XM's ACN+ service and the Rapid SOS emergency response data platform is a game changer for public safety," said Tyrell Morris, director at Orleans Parish Communication District. "This technology will help our 911 telecommunicators allocate resources more efficiently."



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R&S and TSN cooperate on timing measurements

Rohde & Schwarz and time-sensitive networks specialist TSN Systems have cooperated to produce precise timing measurements for in-vehicle networks using Automotive Ethernet 100baseT1.

Adas requires high bandwidth and low latency. Automotive Ethernet can handle these by offering higher data rates as well as time-sensitive network capabilities.

Together, R&S and TSN Systems have built a tester for engineers who need to perform precise timing measurements on in-vehicle networks with nanosecond accuracy for layers one to three.

In the collaboration, R&S provided a tailored oscilloscope while TSN contributed the TSN Box hardware interface to the network and TSN Tools measurement and analysis software.

The test setup monitors a 100baseT1 communication link consisting of TSN Box 3.0 acting as talker, listener and test access point (TAP) device. The TAP device provides information to a PC with TSN Tools based on layers two and three.

The TAP introduces 2x phy delay for 100baseT1 at around 1.5μs ±10ns.



The RTx-K35 software option enables high precision latency measurements

The oscilloscope was used with the R&S RTx-K35 bus measurements statistics option to measure and verify timing accuracy in the physical layer of the Automotive Ethernet signal layer one.

The mean time delay was measured to precisely 1.5μs with a maximum deviation of ±10.2ns. In addition, the Qbv traffic (IEEE802.1) was generated by the TSN Box with 500μs cycle time resulting in a jitter from 8 to 20ns, verified by the TSN Tools and the oscilloscope.

The combination of TSN Tools and Box provides functions to address validation and testing for time sensitive Automotive Ethernet. While Tools is a PC based analysis software performing visualisation and detail analysis, Box serves as an interface to the link. It can act as a generic talker and listener device with nanosecond precision.

The TAP can transparently synchronise itself to the gPTP master in the network. This allows applications that need correlation between payload time stamps and TAP time.

The RTx-K35 software option for the oscilloscope enables high precision latency measurements, for example monitoring the communication between two devices for a long period, and provides statistics on error rates as well as frame timing on the packets. The RT-ZF7 test fixture acts as the link in the middle and allows the monitoring between the transmitter and receiver device in both directions using the oscilloscope.

With the suitable decoding option, the 100baseT1 time data can be measured frame-to-frame, and engineers can get full bus error statistics such as frame error rate and rate of consecutive errors. Moreover, they can perform precise timing measurements for all automotive serial bus protocols such as Automotive Ethernet, Can, Can-FD, Lin and I²C.

"The advent of time sensitive communication in next generation EE architectures raises some serious challenges for the test and validation teams at OEMs and tier ones," said Juergen Scheuring, TSN managing director.

Hyundai and Aptiv name joint venture

Hyundai and Aptiv have decided to call their autonomous driving joint venture announced last year (*VE*, October 2019) Motional.

The venture was established to develop and commercialise autonomous vehicles.

"Motional, in all of its previous forms, has been leading driverless technology for decades," said Karl Iagnemma, president and CEO of Motional.

The technology will be available for robotaxi providers and fleet operators in 2022.

BreezoMeter brings air quality data to Tata dashboards

Tata Motors is working with air quality data specialist BreezoMeter so drivers can see real-time information about air quality from their car dashboards.

BreezoMeter is a location-specific, real-time global air pollution, pollen and active fires data provider.

Alerts will make drivers aware when they enter an area with poor air. An air quality map highlights the best and worst parts of any city, helping drivers plan the most non-polluted route.

It can also be used to activate the windows, sunroof, air conditioning and filtration automatically to keep the vehicle clear of pollutants.

BreezoMeter is accurate to five metres, it is updated hourly, has global coverage and provides a four-day forecast.

The multi-layered data approach to environmental reporting and machine learning was a good fit for Tata Motors.

Average drivers spend around three years of their life on the road in a setting where vehicle and passengers are regularly exposed to environmental hazards. A recent increase in awareness concerning personal health and car safety, during a time of heightened environmental challenges, requires smarter and safer cabins.



Drivers can see air quality data on the dashboard

"This partnership with the Tata Group is a great opportunity for BreezoMeter to enhance the safety and comfort to an increasing number of passengers," said Ran Korber, BreezoMeter CEO. "We are looking forward to a continued relationship with the mobility giant as we move forward with a shared mission to improve in-cabin safety and management."



Trustronic secures Megatronix OS

Tier-one automotive service provider Megatronix has chosen Trustonic to secure its intelligent operating system, SmartMega OS+, which brings connected services to smart vehicles.

The first vehicle model using this is the Hycan 007, which is on sale across China.

With a predicted surge in demand for connected vehicles, automotive makers are under pressure to provide more features to vehicle users, while guaranteeing security, privacy and data protection.

The SmartMega OS+ software has been designed to ensure the deployment and regular upgrade of customisable in-vehicle services to enable secure, reliable user experiences. It provides real-time cloud-based features that connect vehicles to the outside world and protect communications from the telematic control unit all the way to the connected cloud.

"Connected, autonomous, shared and electrified use cases are driving the automotive market forward and we're working to empower OEMs and tier ones to innovate while protecting data, IP and brands," said Dion Price, CEO of Trustonic. "Modern vehicles present new and complex challenges and we are delighted to be working with industry visionary Megatronix to put security at the heart of millions more connected vehicles."

Hycan 007 is the first product of GAC Nio New Energy automotive technology and the first product launch by Megatronix.

"It's no longer enough to simply provide basic entertainment; users are demanding connected experiences that integrate into their digital lifestyles," said Li Zhuang, CEO of Megatronix. "It is essential that data, applications and services are all protected to ensure user trust. With SmartMega OS+ we have a unique offering for the world's automotive market, a smart operating system that has security built-in by design. By integrating Trustonic's world leading automotive security platform, our customers can focus on building rich services in the knowledge that they are fully protected."



Megatronix SmartMega connects Hycan 007

SafeRide software protects Ethernet

SafeRide Technologies, a provider of AI-based vehicle health management, data analytics and cyber security for connected and autonomous vehicles, has developed software to protect Automotive Ethernet networks against cyber attacks.

The intrusion detection and prevention software (IDPS) is integrated into SafeRide's VSentry Edge AI software.

This embedded and real-time network IDPS is designed for central and zonal gateways. It combines a configurable deterministic and rule-based firewall with machine learning and deep learning technology.

It monitors the Can and Ethernet communications from multiple domains and performs deep packet inspection and payload analysis. The AI uses unsupervised learning with little burden on the OEM.

"The adoption of Automotive Ethernet is escalating the overall complexity of vehicles and creating unforeseen development challenges and cyber-security vulnerabilities," said Gil Reiter, SafeRide vice president. "VSentry Edge AI includes machine learning and deep learning technology that provides early detection of zero-day cyber attacks."

SafeRide demonstrated the VSentry Edge AI at TU-Automotive Detroit running on NXP's S32G vehicle network processor.

"VSentry Edge AI utilises the S32G hardware accelerators to offload the Ethernet packet processing from the microprocessor to enable real-time deep packet inspection and payload analysis down to the signal level," said Gil.

Xilinx powers adas for Subaru

Xilinx's technology is powering the latest version of Subaru's vision-based adas, EyeSight.

Integrated into the Subaru Levorg, EyeSight will provide features such as adaptive cruise control, lane-keep assist and pre-collision braking.

"At Subaru, we continuously strive to make the brand prominent in our customers' hearts and minds by focusing our efforts on providing enjoyment and peace of mind, and we believe adas is one of the technologies that will help us achieve that goal," said Tetsuo Fujinuki, chief technology officer at Subaru.

He said stereo cameras were at the heart of Subaru's adas applications.

The image processing technology scans everything captured by stereo cameras and creates high-precision 3D point clouds, enabling features such as pre-collision braking at an intersection and assisting with hands-off driving in traffic congestion on a highway.

"Xilinx technology plays an important role in this," said Fujinuki. "Because Xilinx automotive devices contain built-in capabilities that allow us to meet strict Asil requirements, they are unquestionably the best technology to implement Subaru's new adas vision system."



Xilinx is enabling adas for Subaru

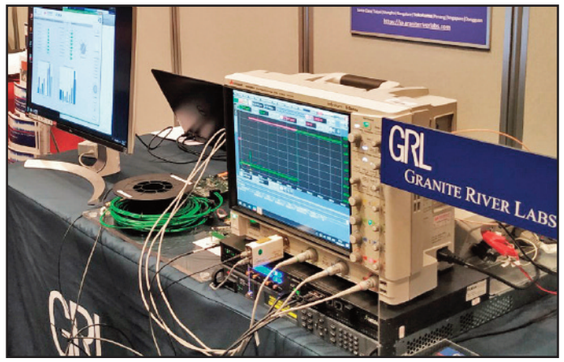
The Xilinx automotive-qualified Zynq UltraScale+ multi-processor system-on-a-chip 16nm technology provides the performance, latency and functional safety capabilities that the EyeSight system requires to depict and react to dynamic driving scenarios.

"We are excited to see Xilinx automotive devices enabling the new generation of automotive safety for Subaru," said Yousef Khalilollahi, vice president for Xilinx in the Asia-Pacific region. "Subaru's name has long been synonymous with road safety and reliability, and we're proud that our XA products have been selected to continue our shared vision of providing drivers with the most advanced safety features on the market."

GRL and KDPOF collaborate on Ethernet over fibre

Granite River Labs (GRL) and KDPOF are collaborating on ISO-standardised Automotive Ethernet over plastic optical fibre (POF).

GRL specialises in engineering services and testing for connectivity and charging. KDPOF supplies gigabit transceivers over POF.



GRL and KDPOF deliver Ethernet over POF

The ISO has adopted a specification for 1Gbit/s optical connectivity in vehicles.

Vamshi Kandalla, executive vice president of GRL, said: "Extending our Automotive Ethernet testing profile further supports automotive hardware developers, including ECU vendors, to confidently deploy robust, interoperable products and technologies."

The ISO published two standards for in-vehicle Ethernet series 21111, forming the basis for implementations of systems that realise in-vehicle 1Gbit/s optical Ethernet as a physical layer.

ISO 21111-3: 2020 specifies additional features to IEEE 802.3bv, such as wake-up and synchronised link sleep algorithms. ISO 21111-5: 2020 specifies requirements at the system level and a complete conformance and interoperability test plan for ECU providers that implement an optical 1Gbit/s physical layer as specified in ISO 21111-3.

Robok and Siemens create virtual world to test adas

Robok, a VC-backed University of Cambridge spinout, is collaborating with Siemens to create a virtual environment for developing, testing and validating adas.

Most traffic accidents are due to human error, but the cost and complexity of developing adas means the technology is often unavailable on lower-cost vehicles.

Hao Zheng is co-founder and CEO of Robok, which is using techniques in computer vision and deep learning to build 3D sensing and perception software for low-power computing platforms.



Hao Zheng: "Intelligent insights can be gained rapidly and efficiently."

"Advanced driving features, which range from collision avoidance and automatic lane-keeping through to fully automated driving, require miles of road test driving to ensure their safety," said Zheng. "Although simulation provides a resource-efficient alternative, it can be time-consuming. To accurately and realistically simulate all elements in the entire system, it can take many hours to run and process even a single driving scenario."

This proprietary software can run on general-purpose and low-power computing platforms, shortening the processing time from hours to seconds, improving the efficiency of system-level validation and testing.

"We have reduced the computation time by developing a significant new method for fusing raw data directly from a range of sensors, such as cameras, radars, GPS and IMU, as well as for performing depth estimation to gain 3D information, all running on low-power computing platforms," said Zheng. "This significantly reduces the memory and computing requirement. When this is combined with our novel and highly optimised AI-based perception modules, intelligent insights can be gained rapidly and efficiently, which is vital for fast decision-making."

The company has a number of industry partners and has been selected by Siemens to create a closed-loop simulation that can test an entire vehicle with an unlimited number of complex driving simulations.

To demonstrate the capabilities of the system – which is built upon Pave 360, a pre-silicon autonomous validation environment – Robok's 3D perception module has been used to develop a digital twin demonstration of an autonomous emergency braking system.

"Robok's novel 3D perception algorithms perform sensor fusion, enabling the virtual vehicle to see its environment," said David Fritz, senior director at Siemens Digital Industries Software. "The algorithms can process data in real time on the virtual platform. With this validation platform, AV and adas designers can make sure that every software or hardware design iteration can be tested and validated virtually, quickly and, most importantly, before any hardware is produced."

Robok is funded by investors including AI Seed, Amadeus Capital Partners, Martlet, U-Blox and Cambridge Enterprise.

Blackberry sails in Canoo EVs

The adas for electric vehicle start-up Canoo's membership-based semi-autonomous EVs will be powered by the Blackberry QNX operating system, including radar sensors, parking sensors and cameras.

Blackberry will license its QNX technology to Canoo, including its QNX OS for Safety 2.0 to serve as the safe and secure foundation for the autonomous features.

Canoo aims to bring its first production vehicles to market with level two or above autonomous features as standard at the end of 2021.

"The world's leading automakers, their tier-one suppliers, chip manufacturers and innovative start-ups such as Canoo continue to put their trust in Blackberry and our ability to provide them with the safety-certified and secure software on which they can build the next generation of cars," said John Wall, senior vice president at Blackberry.

QNX OS for Safety is an operating system that embedded developers can use to build safety-critical systems. Based on the QNX Neutrino rtos, it has been certified to ISO 26262 Asil D and IEC 61508 Sil 3.



Canoo EV will use Blackberry QNX OS

With a pre-certified microkernel rtos, it enables automakers and embedded software developers in various industries to accelerate their development timelines and reduce the cost in moving projects from research to production.

Sensata acquires Preco Electronics

Sensor firm Sesata has acquired vehicle safety technology company Preco Electronics.

The acquisition extends Sensata's capabilities in vehicle collision avoidance systems for industrial and heavy vehicle on- and off-road markets.

"The acquisition of Preco further extends Sensata's sensing content into areas related to the autonomous megatrend and builds scale in heavy-duty vehicle markets," said Jeff Cote, CEO of Sensata. "We are confident we can capitalise on the many growth opportunities on the horizon, as we strengthen our go-to-market capabilities and build on Preco's global reputation as the industry leader in collision mitigation and avoidance technology optimised for heavy-duty vehicles and equipment."

Preco was founded in 1947 in Idaho, and has grown rapidly by expanding its radar technology. For more than 20 years, it has introduced purpose-built blind spot products to the market, including PreView Xtreme, Side Defender II and the new Sentry X.

"We are excited to become a part of the Sensata family," said Jim Bean, head of Preco.

Ibeo signs lidar deal with Great Wall Motor

Ibeo Automotive is supplying solid-state lidar for Great Wall Motor (GWM), China's largest SUV and pick-up truck maker.

The IbeoNext lidar will be used in the Wey SUV. Ibeo has commissioned ZF Friedrichshafen to produce the sensors and the control unit.

GWM has commissioned its subsidiary Haomo Technology to develop the level-three autonomous driving system.

"The lidar series contract with Great Wall Motor is one of the largest ever signed worldwide," said Ulrich Lages, CEO of Ibeo. "We are the first supplier in China to use lidar sensors to enable level-three automated driving in a production vehicle there."

In the future, Ibeo will supply a system that enables a level-three highway pilot to drive semi-autonomously.

The system comprises the lidar, a control unit and perception software that recognises objects. The lidar will be applied in series starting in 2022. LiangDao Intelligence is responsible for testing and validation.

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Lucid makes dream start with adas

Lucid Motors has developed the DreamDrive adas that will debut in the Lucid Air next year. This will make it the first electric vehicle offered with the combination of an advanced sensor suite, high-resolution lidar, driver monitoring system and fully redundant platform

The DreamDrive suite supports 19 safety, driving and parking assist features that will be available upon start of production, with another eight features expected to be available later via over-the-air updates. Additional capabilities to enable level-three driving in certain conditions are also in development.



The Lucid Air has 32 sensors including lidar, radar, camera and ultrasonic

"We have developed Lucid DreamDrive to be among the most advanced adas to ever be offered to consumers," said Eugene Lee, senior director at Lucid Motors. "By prioritising safety and updateability, DreamDrive also sets the stage for offering increasingly sophisticated driver assistance features. We have ensured that the hardware and software platform not only offers a full suite of level-two features, but is also level-three ready, which means we'll be able to quickly add features and functions over-the-air through the life of Lucid Air and for future Lucid models."

The car will come to market with 32 sensors comprised of camera, radar and ultrasonic sensors, as well as a long-range, high-resolution lidar at the front of the car. Also included in this multimodal sensor suite is an in-car driver monitoring system designed to share relevant information with the driver while ensuring they are paying attention to the road. As with the vehicle's other software, upgrades will be delivered over-the-air including more adas functionality and service offerings.

The adas is built on a high-speed Ethernet ring, which also serves as a fully redundant platform for key functions such as steering, brakes and sensors. This includes redundant independent power sources and communications paths, fail-operational actuators, and fault-tolerant computation.

"Lucid Motors is laser-focused on delivering the world's best luxury car, embodying the most advanced powertrain and safety systems possible, all designed and developed in-house," said Peter Rawlinson, CEO of Lucid Motors. "Our customers expect that philosophy to extend to the Lucid Air's adas, and for that we've developed a highly advanced, future-proof system that brings forth an unparalleled combination of sensors and software."

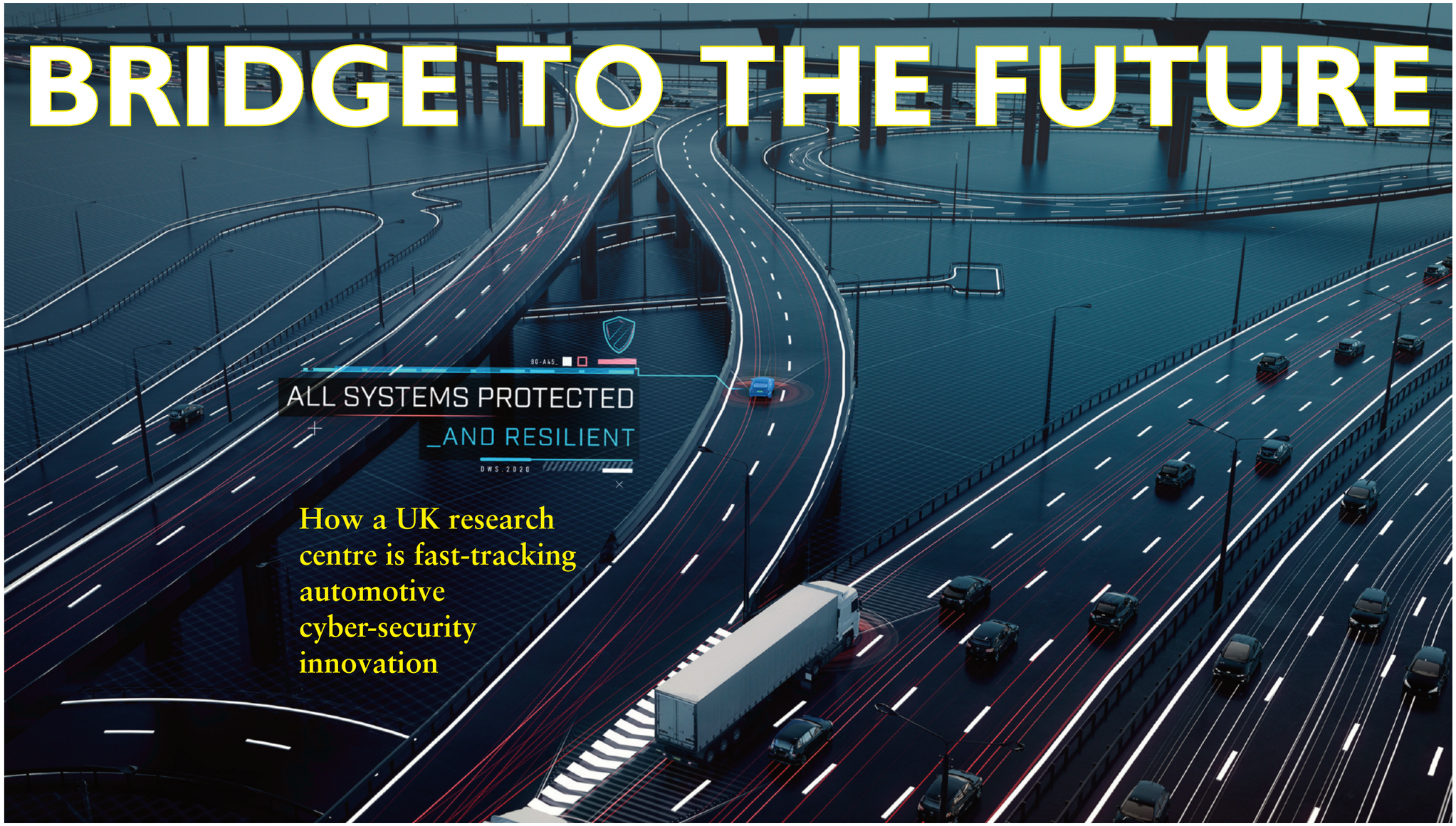
Lucid worked with commercial partners for the hardware, including Here, Continental and Bosch. Integrating these systems was conducted in-house.

The production version of the Lucid Air will debut in an online reveal this month and deliveries will start next year.

The car will have a more than 640km range and 0-95km/hr in less than 2.5s. Production will be at Lucid's factory in Casa Grande, Arizona.

SAFETY & SECURITY

BRIDGE TO THE FUTURE



How a UK research centre is fast-tracking automotive cyber-security innovation



Siraj Ahmed Shaikh: "It is vital that the industrial, academic and government expertise come together."

While it is hugely positive to see the great strides that the automotive industry continues to make in developing vehicles with increasing levels of connectivity and automation, it is vital that this is met with a diligent approach to managing the resultant cyber-security threat.

As with all networked computing devices, increased connectivity, after all, often means a greater risk of a cyber-security attack, which, in the case of systems controlling vehicles or vehicle related systems on busy roads, the consequences could be devastating.

Thus, amid increasing concern around automotive cyber security, Siraj Ahmed Shaikh, professor of systems security at the UK's Centre for Connected & Autonomous Automated Research (CCAAR) and director of research at the Institute for Future Transport & Cities (IFTC) at Coventry University, has examined the fundamental role research and development will play in meeting this complex future requirement.

"While once a distant vision, recent years have seen the journey towards connected and autonomous vehicle (CAV) deployment gain pace," he said. "In the UK alone, last October marked the first demonstration of an autonomous fleet driving in a complex urban environment in London, shortly followed by the completion of the first test case of using driverless cars to carry human passengers on Britain's roads."

Then, in a landmark for CAV development, this March saw a pioneering research project into the latest autonomous vehicle technologies complete a 370km self-navigated journey, constituting Britain's longest and most complex autonomous car journey to date, covering a multifaceted variety of road types, terrains and environmental conditions.

"Backed by a determinably ambitious government, which has declared aims to be a global forerunner in the commercialisation of CAVs and, subject to change in a post-coronavirus climate, the result is some major strides forward in the evolution towards CAV-enabled future mobility," said Shaikh.

Yet, among other areas, one major challenge remains in the development of the accordingly automotive cyber-security capabilities needed to ensure CAV vehicles will be able to operate safely and securely without the risk of being vulnerable to cyber-security attacks.

The reality is that as the next generation of CAV vehicles advance to become what has been widely analogised as mobile computers with wheels and an engine, they will become increasingly exposed to the same cyber-security attacks seen by any other type of computer.

One previous study, for

example, found that a team of hackers was able to take remote control of an autonomous vehicle from 19km away, and could interfere with everything from the car's brakes, door locks, dashboard computer screen and other electronically controlled features.

Looking towards a future of mass CAV deployment, the consequences of a cyber-security attack become much greater, with the potential for hackers to hijack multiple connected cars to cause a multi-vehicle accident, or worse.

"It will come as no surprise then that automotive cyber security continues to become a much higher priority within industry and the government, amid growing concern that current understanding and capabilities are far behind that of what will be required to ensure future safe CAV deployment, and thus must be addressed urgently," said Shaikh.

Urgent destination

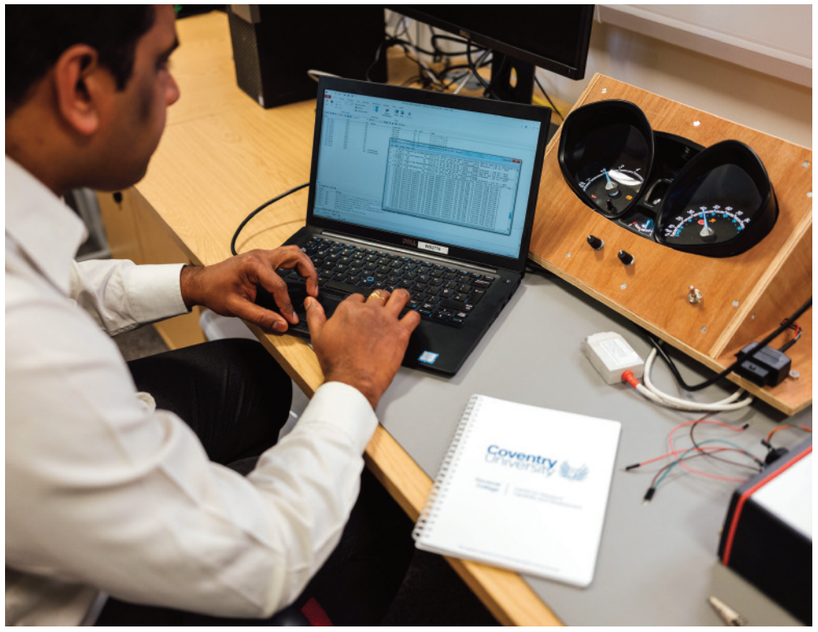
Recent years have seen the industry break new ground in its understanding of the role of future automotive cyber-security needs, driven by a number of major, government-funded collaborative research and development projects.

An example is ResiCAV, the very first project of its kind in the world to bring together industrial, academic and government expertise to ascertain how the mobility industry will detect, understand and respond to emerging cyber-security threats in real time.

Part-funded by the Centre for Connected & Autonomous Vehicles (CCAV) and supported by Innovate UK and Zenzic, the collaborative project saw numerous industry giants and research bodies come together in a three-month study designed to explore the feasibility of creating a UK cyber-security centre of excellence to detect, understand and respond to emerging cyber-security threats in real time across the mobility ecosystem.

The resulting progressive research not only provided insight into this still relatively untapped area and demonstrated the commercial viability for such a centre of excellence, it also showed the urgent requirement for a national road transport cyber-security programme in the UK.

"Yet this will only be achieved through an industry-wide approach," said Shaikh, "one that continues to invest in the fundamental research and development needed to drive better understanding, new ways of thinking and ultimately the innovation required to meet the complex challenge of automotive cyber security."

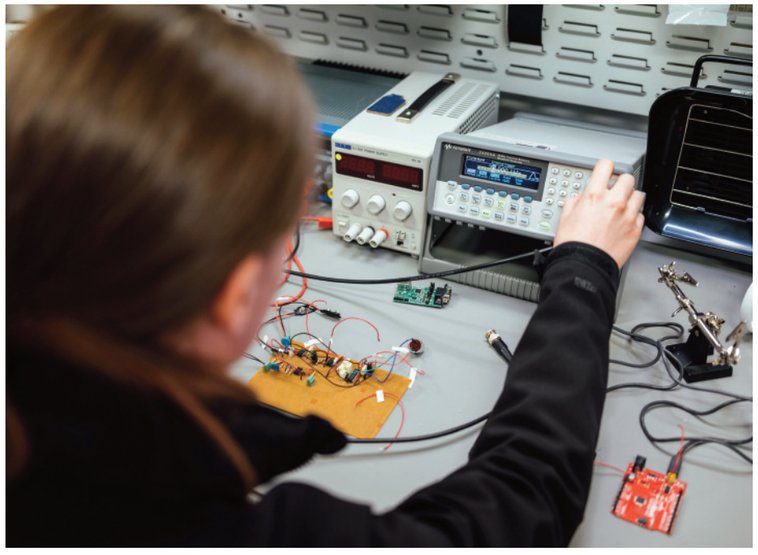


The CCAAR specialises in cyber-security technologies needed to introduce CAVs safely on public roads

Innovation

When it comes to providing the R&D engine required to develop the type of cyber-security technologies needed to introduce CAVs safely on public roads, the CCAAR remains in the fast lane on a global scale.

Located on the Mira Technology Park, the centre consists of a team made up of academic staff members and doctoral research students from Coventry University, alongside Horiba Mira's engineering and test team. The remit is to enable the next generation to play a vital role in developing intelligent, connected vehicle technologies.



Research provided insight into transport cyber security

In addition to supporting ResiCAV, this experimental approach to study continues to provide fresh thinking and underpinning academia needed to fuel a number of CAV projects.

One major area of focus, for example, is establishing an automotive cyber-security testing infrastructure, one that can validly test the safety of a vehicle in its entirety, along with its separate subsystems, such as entertainment or power systems, and even go to the granular detail of checking each and every individual component.

CCAAR believes this lies in novel thinking, from the transfer of knowledge from other sectors, such as aviation, telecomms and aerospace, through to the creation of original testing concepts.

"This is seen in the many incredibly progressive PhD students at the centre who have leveraged the unique access to specialist facilities at Horiba Mira, including live testing beds and living laboratory environments, to produce truly pioneering studies in this field," said Shaikh.

Examples from the many students at CCAAR include the proposed development of a systematic tool for testing in-cabin Bluetooth security and the application of fuzz testing within vehicle systems to help evaluate and reduce vulnerabilities, through to the creation of a systematic security testing approach of ECUs based on the success of an example case used in over-the-air software updates.

"In all cases, each pioneering concept has been well received by the industry and will go a long way in forming the basis of future practice, however it is important that we have much, much more of it, and from all associated sectors and disciplines," said Shaikh.

Conversely, another novel area of understanding CCAAR continues to research intensively is the role of drone technology in automotive cyber-security testing. While still very much underway, the knowledge points to a dynamic future automotive infrastructure which uses drone technology to test cyber security, enabling increased fluidity and capability.

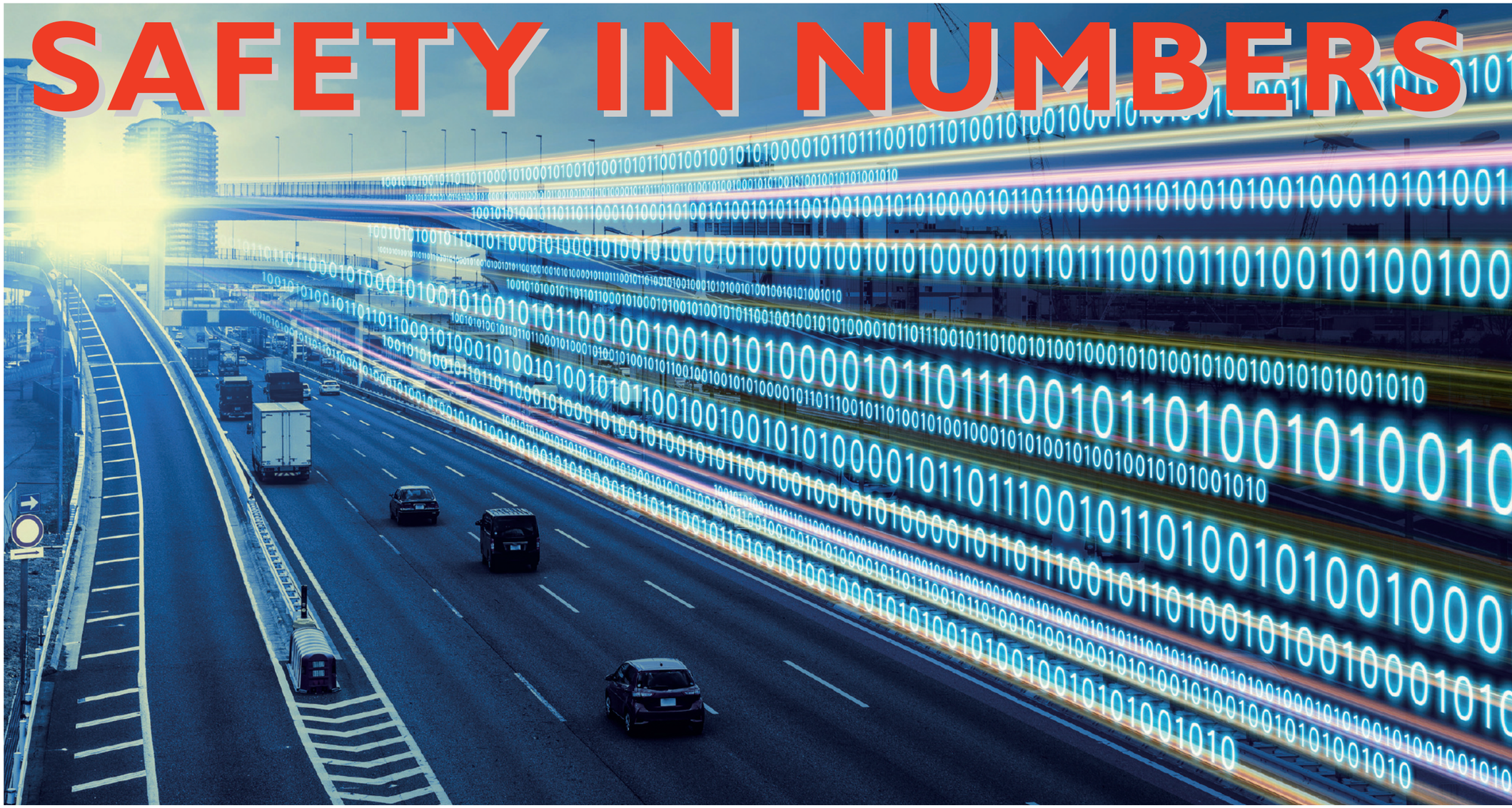
This approach could offer multiple benefits, from increased flexibility and enabling greater accessibility, to providing alternative ways to configure testing around a vehicle. It could also offer cost savings in reducing the need for human inspections, or even eliminating them entirely. Most pertinently in the current climate, this approach could also provide a contactless method of interacting with vehicles in real life, eliminating risk associated with human interaction.

"Again, this remains a concept in its infancy, but it is an important unchartered territory which will not only promote further new ways of thinking and spark discussion, but will, most likely, have some foundation in future practice," said Shaikh. "As we look ahead to the task of ensuring the UK takes a global leadership role in its approach to cyber security, it is vital that the industrial, academic and government expertise come together to progress the fundamental R&D needed to support a truly deliverable approach."

Indeed, it may be a vast and complex challenge, but by taking continual small but significant steps with fresh thinking, new learnings and disruptive concepts, Shaikh believes research can continue to make increased pace in the journey towards future automotive cyber security.

SAFETY & SECURITY

SAFETY IN NUMBERS



Stephan Janouch discusses the essentials of safety and security management

The automotive industry is undergoing a significant transformation, probably the biggest this mature industry has seen in decades. Megatrends such as connectivity between vehicles and everything else, electrification of powertrains, and autonomous driving will impact not only the players but processes as well, and will increase the risk of technology misuse.

It is therefore vital for management to understand the importance of safety and security from a software and hardware perspective in this realm.

Change seems to be the only constant within the automotive landscape these days. While in former times market trends influenced certain aspects of the technology, in modern times none of the so-called megatrends can be examined independently. With significant interdependencies, those trends will eventually lead to fully electric vehicles that operate autonomously while being connected to other vehicles, infrastructure or the cloud.

The ultimate goal is to enable cheap, safe and green mobility for everyone. However, along with the benefits brought by those future vehicles comes enormous risk: careless or intentional misuse can lead to a range of consequences from personal injury, loss of trust in the OEM or a fleet wide attack used to extort or as a weapon of mass disruption or destruction, see Fig. 1.

Therefore, it is not only recommended but it is imperative for management to understand the relationship between safety and security for both software and the hardware, understand what that means and what needs to be done.

Though this article focuses on the safety and security aspects of software, most of these principles can be applied when trying to decide on the right hardware for a safety-critical project. Of course, the approach differs when trying to assess the suitability of a given device; on a higher level it comes down to three key aspects:

- Does the device support all features and contain all modules to play its role in a secure system, for example secure boot, key storage, hardware security module and memory management unit?
- Is the device supported by the secure software layers, or would potentially insecure adaptation layers be required?
- Can security be guaranteed over the complete supply chain, that is fab, assembly, packaging, testing, storage, distribution and aftermarket servicing?

The specific requirements and therefore the details of each question may differ from project to project, but no aspect must be ignored as it would have a significant impact on the overall security design.

Safety versus security

In a simplified view, functional safety is the reduction of the probability that a machine such as a car could hurt a person. To reduce this, a detailed description of all use or safety cases is put together and a risk assessment and mitigation exercise performed resulting in measures to guarantee the expected behaviour.

Several techniques are typically used to make sure the system does exactly what it's supposed to do, for example an autonomous emergency braking system shall

conduct an emergency stop when particular objects appear in the vehicle's trajectory; these objects would include people, cars or even buildings but not minor objects such as beer cans or rubbish bags.

Further through the development process, techniques such as requirements traceability, design and code reviews and comprehensive testing must be used.

The safety of connected systems cannot be achieved without addressing security; security is important for non-connected systems as well, however the number of potential threats and the required effort are much lower.

Security should ensure that no person, as a result of an inadequate software design or development process, can cause harm or influence to a given device or system. In other words, security should protect the device or system so it can fulfil all tasks for which it was designed, and not be influenced by a third party trying to make the system operate in an unsafe manner.

To give an example, imagine a forward-looking camera that is supposed to detect specific traffic signs, say for speed limit. A hacker could change the reference data that the system is using for comparison with the camera image, causing the car to misinterpret the current speed limit, deliver bad information to the driver or adaptive cruise control and hence dramatically increase the risk of, or even cause, an accident.

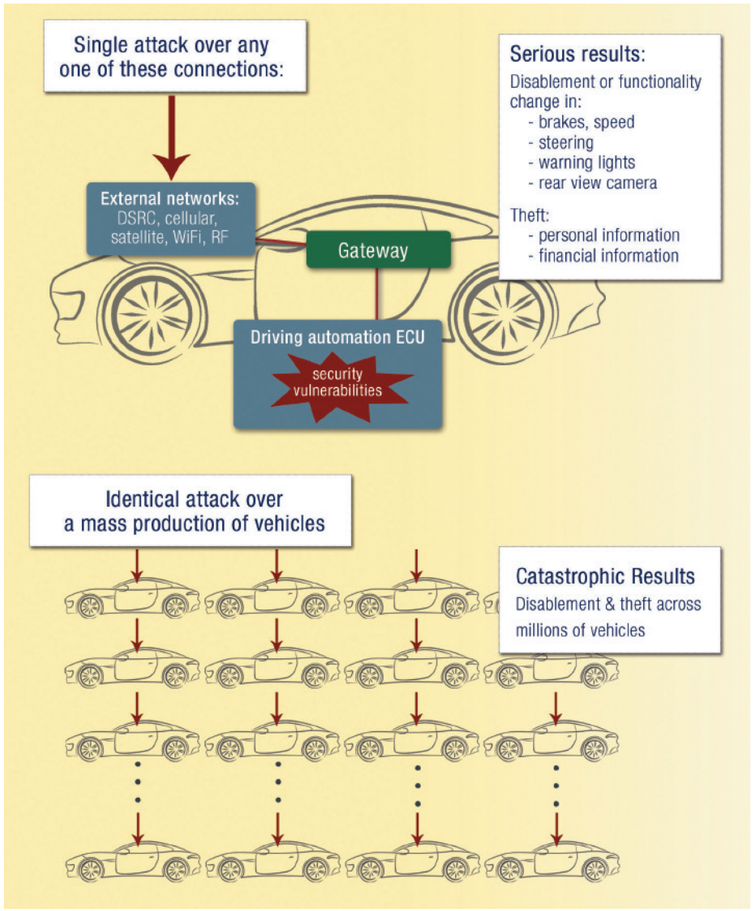


Fig. 1: Compared with a single-vehicle-hack, an attack targeting a vehicle fleet may lead to severe results

However, in a correctly architected system, an external hacker would not be able to gain access to any safety-critical functions, or the reference data they depend on, as they would be isolated from other non-critical components.

While achieving a certain level of safety for a system is difficult but quite well understood in the industry, as described above, reaching a high level of security requires a different approach. First, this is because one needs to identify and separate all security critical functions such as a rear-view camera (Fig. 2) from non-secure functions such as radio and MP3 media.

In correctly separated and designed systems, the hacker would simply not be able to gain access to safety-critical systems through open, non-secure systems and this approach, like a watertight container, would not need fixing or updating later. Any disruption would be limited to non-critical components of the car.

Assuming development is carried out according to the respective safety standards including thorough testing and verification, a system can be seen as safe as long as there is no major change in the environment that may or may not be covered by the initial safety concept.

For security, however, change is a constant. Increasing connectivity of automotive systems with consumer or networking infrastructure is opening new doors for hackers to access car systems on a daily basis, see Fig. 3.

Also, the availability of huge amounts of computational power in the future will render established cryptographic algorithms as obsolete. Hence, while some foundational security technologies may not need updating, certain defence mechanisms or cryptographic encryption methods will require it.

Ironically, the capability to update vehicles over-the-air (OTA) – which is necessary for security, safety and economic reasons – also adds security risks if not implemented properly. This is a serious threat to the millions of existing vehicles that have not adopted a reliable separation and isolation approach.



Fig. 2: A rear-view camera would be both a safety and security critical function in that it supports drivers to make sure they don't hit obstacles or people (safety) and needs to be secure in that a hacker can not change the display of the vehicle trajectories

Planning

Planning for safety and planning for security share one prerequisite: they must be done from the very start of the design process. As already discussed, a correct architecture is critical to achieving the highest levels of safety and security. Adding features to improve safety and/or security late in a project is extremely difficult, most times impossible, and adds significant costs and risk.

Especially when developing a system that requires a high level of security, upfront security planning is vital for the success of the project. One can think of this as trying to add an additional ECU to the E/E architecture of a vehicle that is already in production. In this case, it's not only the electrical and physical integration that causes pain and cost, but also the functional interdependencies and the resulting test effort. Further stress is generated by the modifications needed to the highly sophisticated production process.

Two methodologies have proven very valuable when defining a security architecture: inside-out-security and security-in-depth.

Security-in-depth is derived from an old and proven military defence strategy that assumes that any defence mechanism can and will be breached and hence a layered approach is necessary, see Fig. 4. Several layers of different security techniques will be used to secure the critical part of the system or information.

Inside-out-security is a symbiotic match to this model. It recommends thinking about security from the inside-out rather than out-to-in, that is starting at the core of the system. This means identifying which parts of the system need protection and those that don't. The secure parts are separated from non-security-relevant parts using hardware or software separation; whatever is available depends on the specific devices and software to be used.

Building on top of this separation, the layered security-in-depth strategy helps to build a secure system. The security-in-depth approach, however, is not a replacement for inside-out-security; it should be considered in addition to the foundational separation approach.

It now becomes obvious why security cannot be added to an existing system. Trying to add additional layers has major

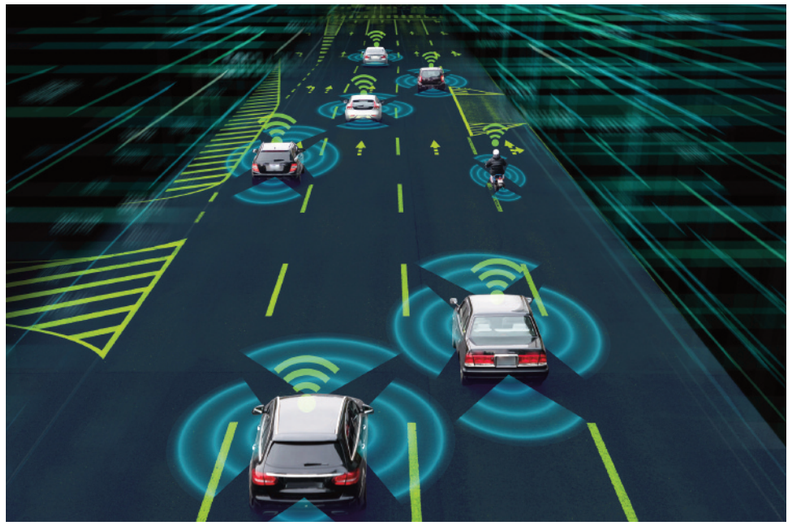


Fig. 3: The growing connectivity of vehicles allows for the implementation of additional safety applications but, at the same time, opens new doors for hackers

influence and interdependencies to the overall structure and may result in significant performance drop or complete malfunction.

Certifications

Each industry has developed its own set of standards and certifications regarding different segments, such as ISO 26262 for functional safety or the upcoming ISO/SAE 21434 for security in automotive systems. It is highly recommended to respect those certifications with two things in mind:

- A system that is completely built from, for example, Asil D rated components and tools, does not automatically lead to a system that can be certified to Asil D. While using pre-certified devices or software makes sense, designing the system correctly is of equal or more importance. The benefit of using pre-certified sub-systems or components typically eases the certification of the complete system, that is reaching Asil D sooner and for less cost.
- A certification can help verify statements or compare various offers. Especially when trying to build a highly secure system, finding the right components is critical. Standards such as the Common Criteria evaluation provide a solid security guideline, for example when choosing the right operating system. It is very unlikely that a secure system can be built using an operating system certified to EAL (evaluation assurance level) 4+ or lower, see Table 1. To reach the highest levels of security use a separation kernel architecture.

Making the right choice on the lowest software layers is crucial for the overall security of the system as the rtos not only controls all the hardware resources in the system, such as memory or communication interfaces, it is also separates and isolates different functions and applications within the system, which protects against adversaries that have already overcome higher level security measures within a separated function.

EAL1	Functionally tested	No security related threats expected.
EAL2	Structurally tested	Design according to good practice. No substantial investment in dedicated security measures.
EAL3	Methodically Tested and Checked	Moderate level of assured security.
EAL4	Methodically Designed, Tested and Reviewed	Moderate to high level of assured security. Highest economically feasible level for retrofit.
EAL5	Semiformally Designed and Tested	High level of assured security. System specifically designed to reach EAL5
EAL6	Semiformally Verified Design and Tested	Security for high-value assets against significant risks.
EAL7	Formally Verified Design and Tested	Security for extremely high risk and/or high value assets (whose value justifies the higher costs)

Table 1: Evaluation assurance levels (EALs) according to the Common Criteria security evaluation. Typically, a + behind the rating indicates that a product fulfils more than the requirements for a given level. (Source: Wikipedia)

Legal implications

Traditionally, whenever there was an incident while driving a vehicle, the driver was held liable and hence mandatory insurance was put in place. This made and makes sense as the driver is directly responsible for more than 90% of all accidents. However, considering the trend towards autonomous driving, more and more responsibility is taken away from the driver of the vehicle – if there is a driver at all – and transferred to the OEM that produced the vehicle.

For the OEM, this presents a difficult situation as it may or may not have complete insight into the exact implementation of a specific function, especially if the function relies on a vast amount of application software.

Of course, an increasing amount is managed in-house, for example the communication stack, to maintain interoperability between ECUs provided by different tier-one suppliers, but in many cases the application software for a specific feature is proprietary to a particular provider and might not be disclosed even to the OEM.

However, despite thorough specification, testing and validation, the OEM has to trust the competence of the supplier, and might forward indemnity claims to the supplier in case of a severe failure.

To protect against such legal actions, suppliers have to select carefully the hardware, software, processes and tools to be used for any development. One has to differentiate between practically approved techniques, best available techniques and state-of-the-art techniques.

While those three terms are often interchanged in legal arguments, they are not interchangeable – a fact that should not be ignored when formalising a development contract.

- The lowest level of this concept is the practically approved technique, which basically implies the use of whatever tool or methodology is mostly used within the community. A scientific backup or validation that this would be the best way to solve a given problem is not necessary.
- Best available techniques are getting a step closer to what is theoretically possible. It comprises methods and tools that, based on scientific findings, offer the most efficient and advanced means applicable.
- State-of-the-art techniques reflect the highest level, referring to anything that has been invented without taking into account whether their application makes sense technically or economically.

Looking at these somewhat subtle differences, it is highly recommended that requirements management is done thoroughly. Requirements, especially in areas where proper guidelines or legal frameworks are missing, have to be formalised in a very distinctive way.

Summary

It is widely known that no new development programmes can be completed successfully without taking safety and security aspects into consideration. In many cases, however, safety and specifically security are not planned right from the start. Despite not contributing to the actual function of a system, even the simplest component or sub-system can be transformed into a dangerous element when hacked.

The increased reliance on software and the change of car architectures to more IT-like systems contribute to this threat even more. It is a key function of management to understand this situation and prepare a development framework in which safety and security can thrive from day one of any development programme.

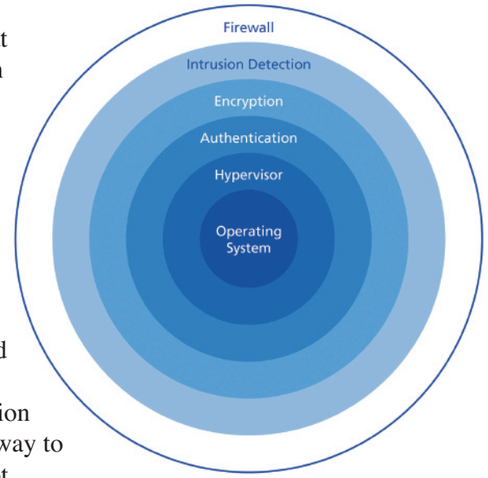


Fig. 4: Multi-layered defence strategy: security has to be taken into account on every level of the software architecture, starting with the operating system and then progressing towards the outer layers

Stephan Janouch is senior manager for business development in Emea at Green Hills Software



NEW HORIZONS



Frank Ferro explains how to meet the memory demands of high-level adas

Memory subsystems have increasing demands at higher adas levels, but which memory technologies offer the optimal balance between performance and practicality?

Level-one (L1) adas capabilities such as cruise control are now part of the standard specification for many vehicles. Adas level-two (L2), that is partial automation, and the initial level-three (L3) conditional automation systems, are also in the market, but the journey to full level-five (L5) automation still has some years to go.

Beyond the most basic adas levels, vehicles will have multiple lidar, radar and camera sensors at the front, rear, left and right of the vehicle, so that a 360deg view can be composed for situational awareness. This is generated using devices with a wide field of view (120deg) for short range, and other devices with a narrower view to provide longer range data.

In addition, fish-eye cameras can also be used to gain a panoramic view around the vehicle.

Analysis from just three years ago, which looks at a complete sensor suite comprising radar, lidar, cameras, ultrasonic, vehicle motion, satellite navigation and inertial measurement, estimated total sensor bandwidth at 40Gbit/s.

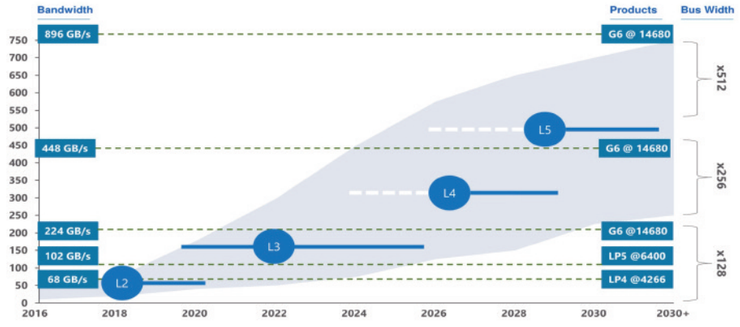


Fig. 1: Memory bandwidth demand by adas level

Since then, camera, lidar and radar resolutions have climbed to improve performance for more demanding adas levels. In fact, the latest radar sensor packages are designed to process 30Gbit/s each, which is just a subset of the data generated by the whole sensor suite.

The enormous growth in collected sensor data is feeding the machine-learning (ML) training of neural networks, which are producing increasingly complex inference models for deployment in self-driving cars. The sophisticated inference models required to deliver full L5 autonomy will require significant bandwidth between memory and processing elements to synthesise, analyse and act on the flood of incoming real-time sensor data.

ML training can be accelerated by scaling data centre-based systems to provide additional storage, bandwidth and compute capacity. That scaling, however, comes with its own set of challenges given the exponential growth in the size and complexity of training models. The data centre environment is far different from what adas will experience on the road.

Engineers working on in-vehicle inference are developing compute-intensive, high-bandwidth systems that are tightly constrained by cost, space and long-term reliability requirements. These bounds are not shared by systems designed for the data centre ML training environment. So while both training and inference are ML processes, each brings its own set of criteria for choice of memory.

For inference in-vehicle, whether on CPU, GPU or one of the AI and ML accelerator platforms, delivering real-time inference for full autonomy will require significant optimisation of memory-processor interfacing to maintain the required data throughput.

Fig. 1 illustrates bandwidth demands, which are predicted to rise significantly as adas capability increases.

Inference model size and complexity grow significantly with each step up in adas level, consequently increasing the memory-processor bandwidth needed. A current L2 adas is processing around 60Gbyte/s. Stepping up to L3 adas, with inputs from a sophisticated sensor suite, the system will require a memory bandwidth of at least 200Gbyte/s.

Memory choices

Adas is safety critical, so qualification standards are necessarily high. To reduce risk, road-tested memory systems such as DDR4, commonly used in laptops and desktop systems, LPDDR with billions of mobile phone deployments, and GDDR6 deployed in hundreds of millions of graphics cards, have been favoured for implementation in adas. Table 1 summarises their characteristics.

Table 1: Memory architecture options for L3 adas and beyond

Parameter	LPDDR4x	LPDDR5	DDR4	GDDR6
Bandwidth (Gbyte/s)/device	Low-Med (17)	Medium (25.6)	Medium (25.6)	High (64)
Data Rate (Gbit/s)	4.266	6.4	3.2	16
Interface width (bits)	32	32	64	32
Board area/system design	Large/Medium	Large/Medium	Large/Medium	Medium/Medium
Efficiency (mW/Gbit/s)	High (3)	High (3)	Moderate (10)	Moderate (10)
Cost	Medium	Medium	Low	Medium
Reliability/yield	Good	Good	Good	Good

Fig. 2 shows memory systems that would be capable of delivering 224Gbyte/s, exceeding the minimum bandwidth threshold of 200Gbyte/s for a realistic L3 implementation.

DDR4 is not shown, however using a 32bit wide bus, it would require 35 dram devices, rendering it impractical in a realistic design.

Using LPDDR4, 13 dram devices are required. This would still consume significant board and die area, which would likely be challenging to implement, and it would not be cost efficient.

Selecting LPDDR5 could significantly simplify the system, as only nine dram devices are needed to deliver 224Gbyte/s. Therefore this could be a pragmatic choice for a low-end L3 adas.

Looking down the road to L4 adas, bandwidth requirements rise to 300Gbyte/s. Here with an LPDDR5 interface running at 6.4Gbit/s, 12 dram devices would be required to hit that mark. With 12 drams, the beachfront of the SoC would be crowded with memory interfaces, complicating the logical layout of the SoC, and most likely rendering this approach impractical.

GDDR6 offers valuable design and space efficiencies over LPDDR and DDR4. GDDR6 would require just four dram packages to deliver 224Gbit/s, less than half the device count of the alternatives. At higher adas levels, GDDR6 becomes the only viable alternative. GDDR6 running at 16Gbit/s can deliver over 300Gbyte/s of bandwidth with five drams, and exceed the 500Gbyte/s needed for L5 adas with only eight dram devices.

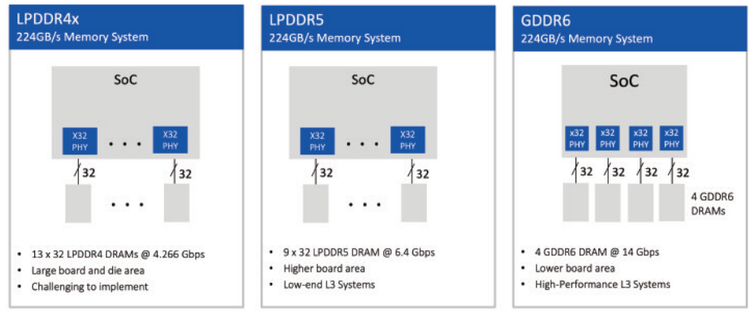


Fig. 2: Potential implementations for L3 adas memory systems

GDDR6 memory is built on tried-and-tested manufacturing processes, and has excellent performance characteristics, which make it ideal for AI inference. Its price-performance ratios are also attractive for volume manufacture.

Challenges

GDDR6's raw performance posed the primary challenges for implementation. Ensuring signal integrity (SI) at 16Gbit/s at a 1.35V operating voltage requires deep expertise in transitioning between the analogue and digital worlds. There are numerous interdependencies between the behaviour of the memory and processor interfaces, package and board. To maintain SI, these interdependencies need to be managed and include crosstalk, insertion loss and reflections.

This risk can be mitigated by using commercially available silicon-proven GDDR6 IP and design support packages. The latest of these can support the high bandwidth, low-latency needs of adas memory processor inferencing.

Selecting a GDDR6 memory subsystem comprising co-verified phy and digital controller, together with an engineering support package – PCB and package reference designs – to optimise full-system signal and power integrity will significantly cut design cycles.

Conclusion

GDDR6 enables highly optimised memory system designs for adas. The combination of bandwidth, capacity, power efficiency, reliability and price-performance cannot be beaten for the vast majority of designs.

GDDR6 interface designs, verified in silicon, and with full support through characterisation and debug, are now available, performing at up to 16Gbit/s. These offer the scope for designers to select GDDR6 confidently for current and next generation adas designs.

Frank Ferro is senior director of product marketing for memory interface IP at Rambus



SAFE NAVIGATION



Rong Chen Leng and Ralf Reuter explain the benefits of a compact test system for radar

Without highly advanced sensors, autonomous driving is only a dream. But sensor development is making rapid progress. Radar sensors can now deliver image-like resolution, but only if they are calibrated.

The EU has a relatively good record when it comes to traffic safety. Nevertheless, according to a publication of the European Parliament, there are still more than 25,000 fatalities every year on roads in the EU, and another 135,000 persons suffer severe injuries. The socioeconomic consequences alone are estimated at €120bn annually.

These figures could be reduced by improving the safety systems in vehicles. Adas, such as blind spot warning and braking assistants, have been state of the art for many years. In February 2019, forty countries under the leadership of Japan and the European Union agreed to require new passenger vehicles and light commercial vehicles to be equipped with automatic emergency braking from 2022 onward.

In addition, Euro NCap evaluates vehicles on the basis of safety features to increase user awareness and push adas deployment by vehicle manufacturers.

Radar

Even without legislative requirements, the adas development trend is being explicitly promoted because autonomous vehicles – the ultimate goal of all development efforts – are otherwise simply not feasible. The sensor front end, which is intended to replace the driver's eyes and ears, is making especially rapid progress.

Vehicles at autonomy levels four and five will presumably make use of an extensive sensor set consisting of cameras, ultrasonic sensors, lidar and radar sensors. Along with functional aspects, the costs of these components are decisive for their use.

Lidar sensors are lagging behind radar sensors and are still relatively expensive. They have higher spatial resolution, but their reliance on optical systems impairs their capability under poor weather conditions. Radars are not affected by this and, since their performance has improved dramatically in recent years and they are relatively low cost, they form the backbone of current adas.

The latest 77 and 79GHz radar sensors have bandwidths of up to 4GHz, compared with 200MHz with traditional 24GHz sensors. The higher frequency band allows smaller antennas while significantly improving resolution capability and accuracy. The increasingly high levels of sensor integration are another important factor contributing to miniaturisation and improved performance.

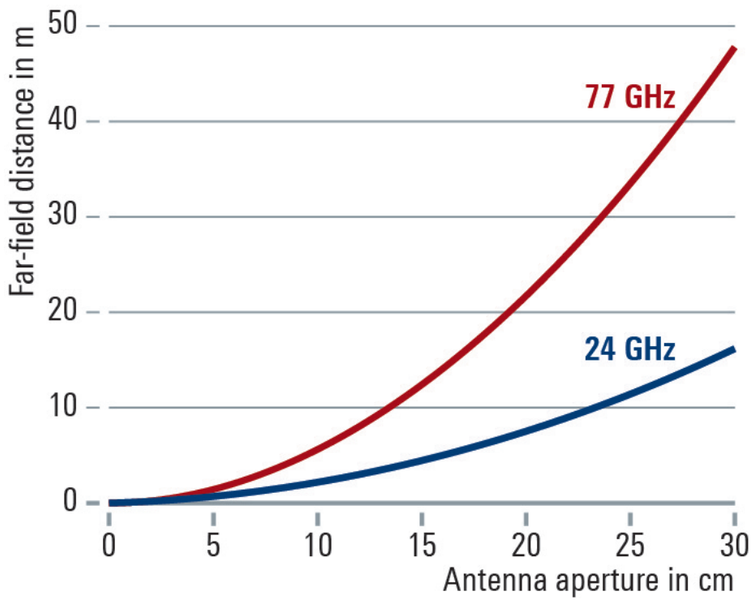


Fig. 1: The large far-field distance of a 77GHz automotive radar compels T&M manufacturers to come up with innovations to keep measurement set-ups compact

Test conditions

R&D, optimisation, validation and calibration of automotive radar sensors must be subjected to accurate tests because road safety is directly dependent on precision. In addition to measuring the RF parameters, target simulation must be used to evaluate whether a sensor can determine the positions and speeds of objects in its field of view (FoV) within the required resolution.

This is a demanding task due to the high frequency band and the need to make measurements under far-field conditions to achieve accurate results.

The Fraunhofer formula shows that measuring a 77GHz radar with a 15cm aperture requires a target distance of at least 11.5m (Fig. 1) to obtain the necessary electromagnetic field uniformity (quiet zone, Fig. 2).

The industry is striving for higher angular resolution, so the trend is to integrate more antennas per module, leading to the deployment of antenna arrays with larger apertures. Aperture sizes of more than 20cm are not unusual, especially in the prototype phase. Far-field test chambers are impractical for these conditions, so near-field to far-field transformation methods can be used instead.

Using the latest techniques, including near-field to far-field transformation, it is possible to create an automotive radar test chamber based on compact antenna test ranges (CATRs) that are small enough to fit easily in relatively small labs and are especially beneficial in production environments (Fig. 3).

When combined with a high-performance radar echo generator, this can form part of a comprehensive method for testing automotive radar sensors.

Performance

Radar sensors are in the category of automotive devices that have to be individually tested. Each and every sensor has to be verified, both for safety reasons and because the RF features make individual calibration necessary.

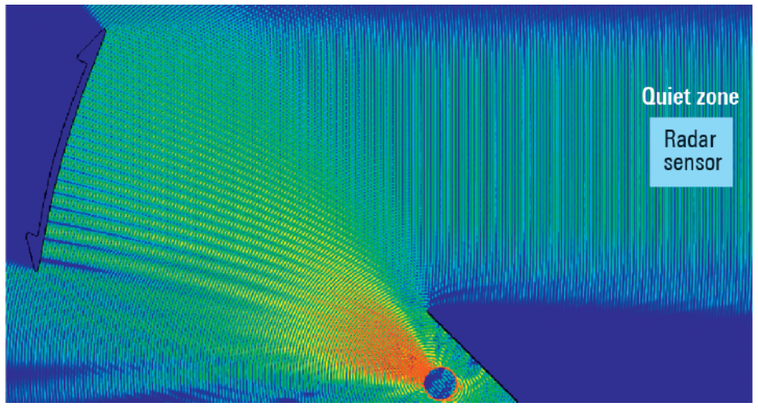
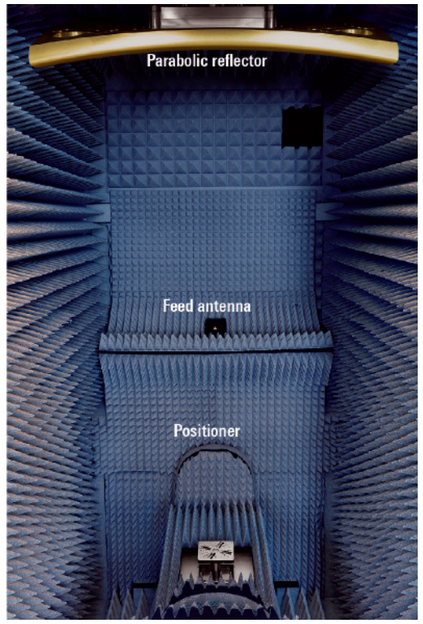


Fig. 2: The precision parabolic reflector in the test chamber transforms the spherical near-field waves from the feed antenna into planar far-field waves, resulting in a quiet zone with a diameter of 30cm where the radar under test is placed

Fig. 3: The test set-up for automotive radar sensors, consisting of the automotive radar test chamber and radar echo generator; for operation, the remotely controlled echo generator is mounted on the rear wall of the chamber





This is done by simulating a target with a known position, size and speed.

The gain, phase and coupling of the antenna path are calibrated for this target, which means that unique calibration data are assigned to them and stored in the module.

The industry is independently trying to do everything necessary to make radars reliable, and now the competent standardisation bodies are also tackling this issue. For example, Etsi has published automotive radar standards that are applicable within the EU and specify measurements under far-field conditions. Given the importance of radars for future road traffic, similar standards can be expected for other regions.

Like all devices that transmit and receive signals, radar sensors must also be certified in line with the legal regulations for EMI. The limit values in Europe are specified by the Radio Equipment Directive (RED) and the associated Etsi standards. The FCC has issued similar standards for the USA.

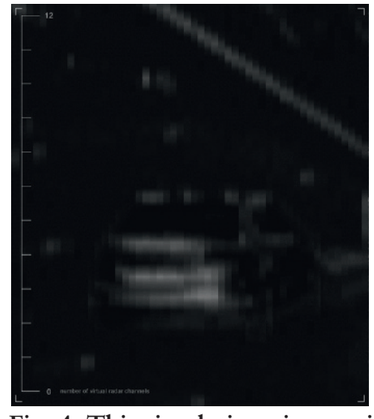
Summary

Radar sensors are the most import source of information about the vehicle environment. Advanced imaging sensors (4D imaging radars) already provide sufficiently high resolution to allow complex environment models to be generated from the data and used as the basis for making vehicle driving decisions.

The sensors, which use ever larger antenna arrays and mimo transceivers, achieve this performance only after precise calibration, which must be performed for each unit on the production line. A compact test system consisting of a shielded CATR test chamber and a radar target simulator allows even the latest generation of complex sensors to be calibrated in less than a minute.

The 30cm diameter quiet zone in the chamber, where far-field conditions prevail, provides enough space for large-aperture sensors, making it suitable for future sensor generations.

Rong Chen Leng is from Rohde & Schwarz and Ralf Reuter from Uhnder Technologies



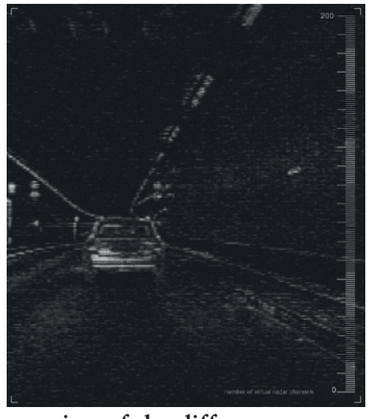


Fig. 4: This simulation gives an impression of the difference between an imaging radar and a conventional automotive radar; its resolution is so high that it can detect and separate objects that are close together, such as a pedestrian next to a cyclist, and process their individual 4D coordinates

How composite materials helped place an Italian racing team in pole position

WINNING FORMULA

Motor racing has always been at the forefront of research and development as every team looks to glean an advantage over rivals and shed away those few precious seconds per lap. To help develop automotive engineers of the future, the Formula Society of Automotive Engineers (Formula SAE) is a global student competition that pits university teams against each other to develop small, Formula-style race cars.

Student projects aren't often considered to be at the head of design sophistication, but while the racing department at Italian university Politecnico di Milano, Dynamis PRC, is a student-led organisation, its practices are anything but amateur. Based at one of Italy's premier engineering universities, Dynamis focuses on designing and building formula-style vehicles to compete in the Formula SAE. While the roster may be filled with students, its hierarchy is business-like and so is its determination to learn and innovate.

After a reasonably successful year in 2018, when the team was able to secure top ten finishes in all its competitions, Dynamis was looking for a method to push the following year's Formula SAE car further than ever before and achieve a pole position. So, in 2019, it started the search for a material to improve the performance of its car's steering column and suspensions. To help, it got in touch with composite technology company Exel Composites.

"We had just come off the end of a successful year, but the team knew that our vehicle could perform better," said Andrea Vezzoli, technical director at Dynamis. "There were two main objectives we wanted to achieve for that year's model, named the DP11. The first was reduce the weight of the car and the second was to improve the suspension because we felt that in the previous year, this is what had held us back."

Singling out the steering column as the main area for weight reduction, Dynamis began searching for new materials. Making weight improvements was



Dynamis PRC is student-led organisation but its practices are anything but amateur

critical because every other team would also be finessing their cars, many of which had received support from major car manufacturers.

When researching new materials, Dynamis encountered Politecnico di Milano alumni Francesco Ierullo, who is head of sales at Exel Composites.

"When they reached out, I had a flashback to my own experiences studying engineering at the Politecnico," said Ierullo. "I had been aware of the Formula SAE during my time studying and have been pleasantly surprised by its growth and the calibre of the design skills that many of the students in these teams possess. We are always looking for ways to get composites into the hands of students, because they are the engineers of the future and the more experience they have with composites now, the better equipped they will be when they work in the field. More and more fields of industry are using composites, but direct student exposure to the material remains low. Whatever we can do to help is always crucially important to us."

Time and weight

After reviewing the focus areas with the racing team, Exel was able to suggest a variety of carbon fibre tubes.

"During the meeting, it was great to see their passion for the project and we did our best to suggest potential methods to help with their design," said Ierullo.

Vezzoli added: "We reviewed a few different carbon fibre options before choosing the tubes we felt best suited our needs. Using carbon fibre was a real breakthrough for reducing the weight of the driving column. We were able to shed 15kg of weight, which helped shave two seconds off our lap time."

Another bonus of carbon fibre is its strength. The car's driving column must be able to resist three times the peak load, which for this design was 100Nm. Using carbon fibre let the team push it to 140Nm and the material was still functional unlike with many metals that would snap.

"We were impressed by the performance of the material," said Ernesto Riccardo, head of the suspension and drivetrain department at Dynamis. "We built a database of materials and used an algorithm to indicate which material was best for certain components. Once we input the properties of the products into the database, the algorithm told us to use it every time without fail. It was on another level compared to everything else we had tried before."

The tubes were also used to increase the rigidity of the vehicle's suspension without increasing its weight. With many other materials, the forces would deform the car's parts and reduce their effectiveness, but using carbon fibre completely avoids this issue.

Innovation

There were two main potential issues that could arise when transitioning to composites. The first issue is the difference in the methods used to cut and work the material. The risk with composites is that they become delaminated during cutting, especially while using tools such as water jets, which can cause the material to lose properties and can compromise its stability.

Another issue is that to fix the composites in place, the frame must be modified because composites cannot be welded in place. Instead, they must be glued. These modifications can alter the weight of the vehicle's profiles, meaning it is imperative that gluing is carried out correctly.

Exel was able to prevent these problems from occurring by recommending options for composite material connectors, while also explaining the best way to cut each material.

"The integration process of the parts was very smooth," said Vezzoli. "Exel Composites explained some necessities to us, but for the most part it was getting accustomed to gluing instead of welding. The whole team was equally surprised by how easy it was to work the material; we were expecting to encounter some hiccoughs, but the quality of the material meant that the changeover was seamless."

Hitting the road

While Formula SAE is a racing event, there is no single race to decide a winner. Instead, each team competes in a variety of events that measure the different qualities of the cars. Stopping time, acceleration and agility are all tested at different stages and teams are awarded points for each focus area, with the team scoring the most points winning the competition.

With the carbon fibre pieces installed, Dynamis was able to take the car to four races. The first race took place in Holland, where the team won overall. Returning to Italy for the third race, Dynamis saw another victory.

Held in Germany, the homeland of many of the world's largest car manufacturers, the final race was the toughest.

"We were ready for a challenging competition," said Vezzoli. "Many of the Germany teams are directly linked with their local car manufacturers, so we knew the car would have to perform well to help us hit our targets."

Even against some of the most competitive teams in the world, Dynamis was able to achieve a strong third-place, making the season one of its most successful to date.

Forward drive

While the 2020 season has been delayed, the Dynamis team is looking forward to its next challenge.

"One of our long-term plans was to begin competing in the electric car version of Formula SAE," said Vezzoli. "This was one of the reasons behind our strategic weight shedding focus for the 2019 season."

Riccardi added: "Using composites has been a breakthrough for our designs. In fact, for the next season, we are looking to start incorporating some of Exel's fibreglass elements in our aerodynamic wings for a new phase of light-weighting."

Conclusion

Composites are becoming a mainstay in the automotive industry. Whether car makers opt for carbon fibre or fibreglass, the potential benefits for performance, strength and weight savings can really push what cars can achieve.

Electric vehicle battery enclosures are just one instance that demonstrates how the power of a lightweight composite material holds the potential to support the increasing need for e-cars.

Racing is a constant source of innovation, not only for technology but also for the engineers that work on the cars. Material choice is at the heart of many of these innovations, with composites demonstrating numerous benefits that can make vehicles lighter, stronger and more efficient.

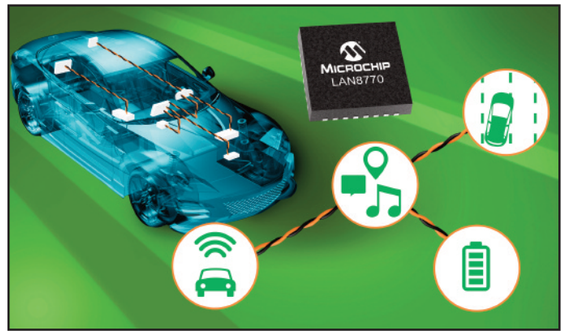


The focus is on designing and building formula-style vehicles to compete in the Formula SAE

Ethernet phy simplifies ISO 26262 certification

A single-pair Ethernet phy from Microchip is functional safety ready.

The LAN8770 is an IEEE 802.3bw-compliant 100baseT1 phy in a 5 by 5mm or 6 by 6mm wettable-flanks QFN package for space-constrained automotive applications.



Automotive networks rely heavily on partial networking in which some segments are hibernated and woken up on demand. This Open Alliance TC10 sleep standard Ethernet physical layer transceiver (phy) has a sleep current less than 15μA, said to be around four times lower than other available devices.

It complies with the IEEE 802.3bw-2015 specification and is suitable for use in the infotainment head unit, telematics modules or adas.

It provides 100Mbit/s transmit and receive capability over a single UTP, exceeds automotive electromagnetic interference requirements and is grade one (-40 to +125˚C) AEC-Q100 qualified.

The device is designed to simplify end-product ISO 26262 safety certification with the support of hardware safety features, failure modes, effects, diagnostic analysis and safety manual.

The LAN8770M and LAN8770R support communications with an Ethernet mac via standard MII and RMII, and MII, RMII and RGMII interfaces, respectively. An optional 125 or 50MHz reference clock output is also provided for RGMII and RMII applications, often enabling elimination of an external reference clock.

EtherGreen energy efficiency technology provides low-power operation along with low-power sleep and wake-up modes. Power efficiency is enhanced with optional integrated linear regulator and Microchip's FlexPWR technology for variable xMII and IO supply voltages, providing flexible design options and more opportunities to save power.

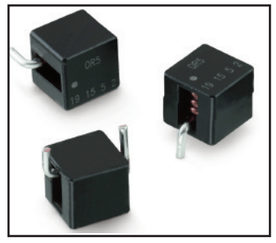
Phy diagnostics provide the user with troubleshooting capabilities through the integrated LinkMD cable diagnostic system designed to detect cable defects, shorts or opens. The device also provides a receiver signal quality indicator, overtemperature and undervoltage protection, and status-interrupt support along with various loopback and test modes.

The family is backed by the free LanCheck online design service that reviews designs, ensuring that best design practices are used. Autosar, Linux and rtos software drivers are available.

A separate 100baseT1 to 100baseTX media converter evaluation kit is available. A 100baseT1 daughter card evaluation board can be used with the ATSAMV71-XULT Xplained Ultra microcontroller kit as well as the SAMA5D3-EDS microprocessor kit.

High-current inductor

A high-current inductor from Würth Elektronik is for applications in automotive electronic systems.



The WE-HCIT inductors are robust THT inductors for use in vibration-sensitive applications. They are characterised by a current capability of up to 28A and an RDC between 0.44 and 0.88mΩ. They have a soft saturation behaviour.

Applications include DC-DC converters for infotainment and communication systems, EMI products for motors in car seats, mirrors and windshield wipers, power applications, and battery-management systems.

The component is designed for operating temperatures from -40 to +150˚C to AEC-Q200 grade one.

It is available in two construction sizes – 1010 and 1008.

ICs generate audible notifications

Automotive speech synthesis ICs from Rohm subsidiary Lapis Semiconductor are for audible notifications and sound effects in adas and acoustic vehicle alerting systems.

The ML2253x ICs provide features for higher safety and flexibility at application level, thus reducing overall costs and simplifying the hardware and software design.

Using the HQ-ADPCM compression method, the series provides audio playback with reduced memory usage for storing audio data.

The integrated sound continuity detection redigitises the analogue speaker output signal and compares it with the playback data stored in the internal or external memory.

The main MCU receives a feedback in case the data are exceeding a predefined value, such as in the case of skipping.

Built-in functions do include short-circuit, high-temperature and command transfer error detection.

The memory content can be updated through the main MCU once connected to a communication network.

The SDCK3 development tool lets users create voice data as well as prepare, write and listen to rom data stored in the IC. Combining the tool with an optional reference board enables evaluation for both hardware and software.

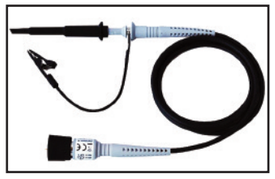


Passive oscilloscope probes

For evaluating and environmental testing of sensors and actuators in automotive and other applications, Yokogawa has introduced passive oscilloscope probes.

The 701949 and 702907 probes expand the usability of the DLM3000 mixed signal oscilloscope.

The 701949 10:1 miniature probe is for high density PCBs, with a slim probe head providing visibility during operation.



Accessories are available for high-speed signals such as ICs and high-density mounting boards. Frequency bandwidths are DC to 500MHz, with an input of ±400V RMS.

The 702907 has an operating range of -40 to +85˚C and a probe length of 2.5m to keep the measuring instrument away from the high temperature measurement point. Longer probes are needed to connect the measuring instrument to a temperature-controlled chamber.

Frequency bandwidths are DC to 200MHz, with an input of ±1000V DC plus AC peak.

TCXO integrates cmos clock output

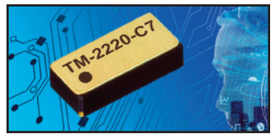
An AEC-Q200 qualified stable temperature compensated oscillator from Micro Crystal has integrated X-Tal and cmos clock signal output.

The TM-2220-C7 is a plug-and-play frequency reference for applications where a reliable and accurate oscillator is needed without frequency jump.

It comes in a hermetically sealed reflow solderable DFN package measuring 3.2 by 1.5 by 0.8mm, with four connections and 1.5μA maximum current consumption associated to frequency stability of ±5ppm over the industrial temperature range.

This factory calibrated embedded device has better stability than separate components on a PCB. It does not require any oscillator adjustment during OEM design phase, reducing integration constraints thus lowering development cost and time to market.

Operating voltage is 1.1 to 3.63V and it is for asynchronous clocking in battery-operated devices such as in automotive, as well as IoT, healthcare, wearables and metering.



Film capacitors in boxes and canisters

Three series of film capacitors from Kemet are for expanding green energy and automotive applications.

The C44U-M, C44P-R and R75H are for power conversion and power density applications.

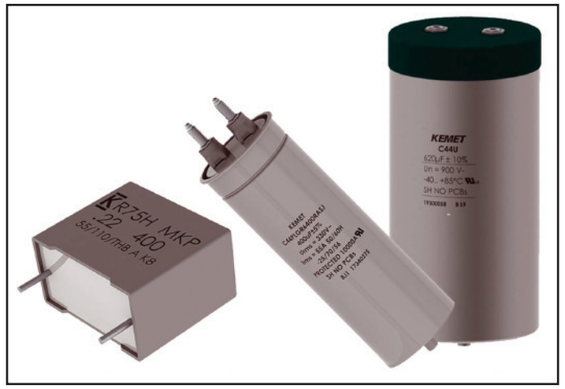
Constructed with an aluminium canister design, both the C44U-M and C44P-R address green energy and industrial applications. These capacitors also support power conversion in energy storage systems, IGBT and wide band gap semiconductor devices.

The R75H, a radial box pulse capacitor, also addresses the automotive sector.

Designed with a radial box style for PCB mounting, the R75H pulse series meets reliability standards with its voltage range up to 2kV DC, high capacitance, dv/dt capability and AEC-Q200 certified design.

These automotive-grade capacitors can support power conversion for on-board electronics and battery management systems in vehicles, micro-inverters in solar panels and semiconductor devices in power supply systems.

Temperature humidity bias test capability is up to +85˚C, 85RH, and operating temperature up to +125˚C. The high temperature capability suits applications that require miniaturisation and fewer capacitors due to elevated temperatures and frequencies.





Hybrid capacitors

Panasonic is extending its ZS conductive polymer hybrid capacitors SMD portfolio with a smaller size and expanding the capacitance and doubling ripple current.

It is rated at 4000 hours endurance at +125˚C. With the same 10mm footprint, the length is 12mm against 16mm for the existing product.

The AECQ-200 devices range from 25 to 63V, with 560μF capacitance, ESR down to 11mΩ and ripple current of 4A rms.

Virtual prototyping aids EV development

A virtual prototyping system from Synopsys is for the development of electric vehicle (EV) electronics hardware and software.

The integrated system leverages the company's virtual prototyping technologies, including Virtualizer, Silver, TestWeaver and Saber RD, enhanced for the needs of EV development.

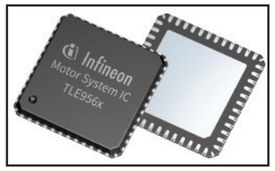
From power electronics through software development and test, the multi-discipline integrated system can enable earlier and more productive development, and rapid scaling of test activities by removing the dependency on a physical hardware set up.

Developers have hardware design, software development and testing challenges, such as early design space exploration, electrical component selection, expensive prototypes, model availability, complex software development and integration, functional safety testing, and large-scale high bandwidth secure multi-protocol verification.

Virtual prototyping tools allow for earlier, more productive and broadly scalable development.

The integrated multi-discipline system is based on industry-proven virtual prototyping technologies that have been enhanced to support the specific needs of EV design including EV model libraries for power electronic, microcontrollers and Autosar components.

Features provided include: multi-level fast simulation from abstract to high fidelity for detailed analysis; debug, analysis and test functionality to support functional safety, hardware and software debug, variation analysis, coverage analysis and calibration design tasks; and APIs for integration into additional automotive flows and tools including support for the FMI functional mock-up interface.



ICs control small motors

Motor system ICs from Infineon have applications in power lift gates, sunroofs, electric seat adjustment and fuel pumps in modern cars.

These ICs are multiple half-bridge drivers for mosfets with integrated power supply and communication interfaces.

The patented adaptive mosfet driver can improve electromagnetic compatibility and reduce switching losses. This control algorithm can compensate for mosfet parameter spread by automatically adjusting the gate current.

There are seven variants, all in a VQFN-48 7 by 7mm package.

The devices contain up to four half-bridge drivers for external n-channel mosfets. An integrated linear voltage regulator supplies 5V with an output current of 250mA.

For communications, there is a Can-FD transceiver with 5Mbit/s according to ISO 11898-2:2016 including partial networking option and/or a Lin transceiver according to 2.2A, ISO 17987-4 and SAE J2602.

Pressure sensor signal conditioner with Lin



An automotive pressure sensor signal conditioner (SSC) from Renesas has an integrated certified Lin v2.2a interface.

The single-package device is for hvac applications in plug-in hybrid, battery and fuel-cell electric vehicle climate control systems.

The ZSSC4132 can be configured for nearly all resistive bridge sensors. It has AEC-Q100 Grade 0 qualification.

It combines analogue front end technology for SSC with digital calibration to reduce the noise sensitivity and improve accuracy for pressure and temperature readings.

It has Lin v2.2a certification with backwards compatibility to Lin v1.3, 2.0 and 2.1.

A differential bridge sensor input enables accuracy at ±0.5% full-scale output for temperatures from -40 to +150˚C. There is 12 to 14bit ADC resolution.

A slave node position detection feature at the Lin bus allows the SSC to assign a unique ID to the device.

Features include over-voltage and reverse-polarity protection circuitry, electromagnetic compatibility, and multiple diagnostic options.

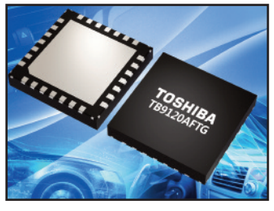
The device is available in a 4 by 4mm, 24-lead QFN package.

An evaluation kit is also available.

Motor driver IC includes mixed decay mode

A constant-current two-phase bipolar stepping motor driver from Toshiba Electronics is for automotive use where it can streamline motor system implementations.

The TB9120AFTG delivers a sine-wave output with up to 1/32 incremental steps supported while requiring only a simple clock input. There is no need for a microcontroller or dedicated software.



Each AEC-Q100-compliant driver IC incorporates low on-resistance dmos fets, and can deliver a 1.5A maximum current.

Thanks to the large number of micro-steps they support, motor noise can be reduced, with smoother operation and more precise control. The built-in mixed decay mode helps stabilise the current waveforms.

Protection mechanisms include over-current and over-temperature detection, plus thermal shutdown. There is also a stall detection function.

They come in 6.0 by 6.0mm VQFN packages with wettable flanks to allow the use of automated optical inspection to ensure the quality of solder joints.

Operating temperature is -40 to +125˚C.

Evaluation platform checks high voltages

An automotive high-voltage evaluation platform from Arrow Electronics provides developers with a range of tools with which to explore the trends in the electrification of vehicles.

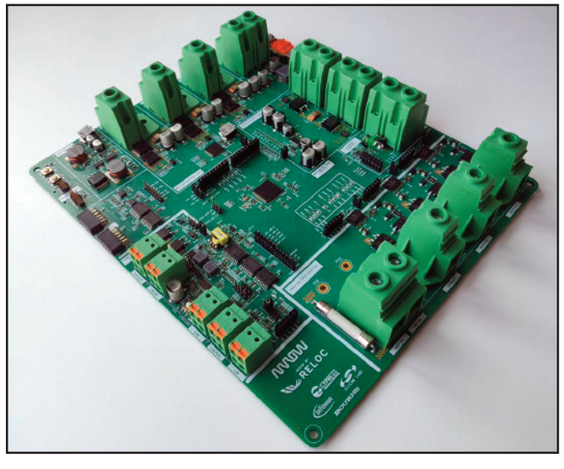
The universal platform is for applications and designs associated with a 48 to 400V power distribution network in cars.

As the transition from combustion engines to electric vehicles and hybrid electric vehicles accelerates, designers face a large number of newly emerging requirements including battery disconnect switches, cell balancing modules, battery junction boxes, battery management controllers, DC-DC conversion, on-board charging, superchargers, traction inverters, hvac and supercapacitors.

On top of these can be added the isolation of communications, power management, motor control, load switches and current sensing, as well as ensuring safety and security.

Featuring an automotive microcontroller with Arm Cortex-M4F core, the platform has a modular design that allows 12, 48 and 400V circuits to be evaluated independently.

It is suitable for applications including 48V BLDC motor control, 48V battery disconnect, 400V motor control, isolated current sensors and body applications up to Asil B.





Lidar sensor creates extra camera image

A lidar sensor based on photon laser measurement technology works without moving parts.

The solid-state sensor from Ibeo also generates an extra black-and-white camera-style image.

The IbeoNext sensor is for driver assistance systems as well as for automated driving at levels three and four. Software will be available for environmental perception and classification of objects.

It generates a high-resolution 3D point cloud for object detection.

The additionally generated intensity image also allows it to function as a kind of black-and-white camera. The intensity image can be useful for lane recognition while driving.

The solid-state technology has a long range and high spatial resolution when scanning the environment. This allows for exact modelling. Accordingly, changes in the course of the road are detected faster and more accurately.

Lidar systems emit laser pulses and evaluate the light reflected from different objects. Software calculates the distance to the surrounding objects by using the light travel time, that is the time the reflected laser pulse needs until it reaches the sensor again.

In conventional lidar, a rotating mirror covers the field of view. In this sensor that moving part no longer exists because semiconductor technology is used instead. It can process many laser pulses in parallel.

The result is a 3D model of the environment that recognises crash barriers and road markings as well as cars, cyclists and pedestrians, as well as their respective position and direction of movement.

ECU and display software is available. It can process over a million distance values a second.

Buck converters suit point-of-load

Automotive-compliant, 3.5A synchronous buck converters from Diodes are for point-of-load applications.

The AP6435xQ combines a low quiescent current with an input voltage of 3.8 to 40V.

The devices have been developed for use in automotive applications including infotainment, instrument clusters, telematics, adas and forward lighting.

With an integrated 75mΩ high-side power mosfet and 45mΩ low-side power mosfet, it provides high-efficiency step-down DC-DC conversion. The design of the gate drive and bootstrap lets the device operate in low drop out mode, allowing near 100% duty cycle.



To increase efficiency as the load current approaches zero, the devices enter pulse frequency modulation, resulting in a quiescent current of 22μA.

They also feature frequency spread spectrum with a switching frequency jitter of ±6% and a proprietary gate driver scheme, which reduces high-frequency radiated EMI noise caused by mosfet switching.

The AP64350Q, AP64351Q and AP64352Q have distinct feature sets that optimise performance in slightly different ways.

The AP64350Q and AP64352Q have an adjustable switching frequency from 100kHz to 2.2MHz and can be synchronised to an external clock. This provides the design flexibility to deliver a choice of low frequency with high efficiency, or high frequency for small form factor with switching frequency outside the AM band.

The AP64351Q and AP64352Q have programmable soft-start, which reduces in-rush currents, while the AP64350Q and AP64351Q have external compensation to optimise loop response.

Al three are qualified to AEC-Q100 grade one, support PPAP documentation, and are manufactured in IATF 16949 certified facilities. The devices come in SO-8EP packages.

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