VEHICLE electronics

The monthly magazine for automotive electronics engineers

Warwick researchers set 5G data speed record

Researchers at the University of Warwick in the UK have set a 5G communications speed record to a level-four low-speed autonomous vehicle in the 28GHz millimetre wave band.

The Warwick Manufacturing Group (WMG) scientists hit 2.867Gbit/s in over-the-air transmissions, which is nearly 40 times faster than current fixed line broadband speeds. It is equivalent to sending a detailed satellite navigation map of the UK in a single second.

However, this wireless communications technology is not just being designed to deliver HD content to in-car entertainment systems, but it will allow autonomous vehicles to share large quantities of data with each other and with traffic management systems.

This will include precise 3D road maps created by lidar, high definition video images of the vehicles surroundings and traffic information.



Slow pod receives fast data

WMG's research team of Matthew Higgins and Erik Kampert used their new 5G mm-wave test facility to set the record. Working with an autonomous pod built by RDM, they optimised antenna placement inside the pod and on roadside infrastructure, such as a traffic light.

"These controlled trials are critical to better understand the capabilities of 5G in millimetre wave bands, and how infrastructure providers and vehicle manufacturers must carefully plan and deploy their 5G service and application rollout over the next few years," said Higgins. "This project, which includes real-world 5G mm-wave trials on the University of Warwick's campus, will also attempt to examine how the dynamics of both the vehicle and the environment affect performance between infrastructure and connected and autonomous vehicles."

The WMG research project is supported by the Wireless Infrastructure Group, National Instruments and HVM Catapult.

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Qualcomm, Qianxun and Quectel develop GNSS positioning for China

Qualcomm has teamed up with positioning service provider Qianxun Spatial Intelligence and Quectel Wireless to develop precision positioning GNSS for China's automotive industry.

It supports single frequency GNSS using real-time kinematic technology based on the GNSS receiver in Qualcomm Snapdragon LTE modems and Qianxun's precise positioning technology integrated in an automotive grade LTE module from Quectel.

"The AG35 is our newest generation of automotive grade modules that enables 4G connectivity and lane-level positioning simultaneously, allowing the adoption of LTE-V2X and HD map technologies on a broad scale," said Penghe Qian, CEO of Quectel.

Using 3D dead reckoning, the positioning framework will give car makers 3D navigation combining multi-constellation GNSS precise positioning, inertial measurement units and other automotive sensors to support vehicle capabilities, including connected navigation and LTE-V2X for enhanced road safety, improved traffic efficiency and autonomous driving.

The framework can facilitate open sky positioning performance from up to three metres to less than one metre, supporting lane-level positioning and potentially achieving accurate locations from a centimetre to a few decimetres when combined with select third-party GNSS correction services.

This framework can support a safer and convenient automated driving experiences at level two and above, as well as LTE-V2X applications based on positioning, velocity and heading information. Integrated into telematics modules based on the Snapdragon LTE modems, the framework could support a cost-effective system for car makers already including cellular connectivity into their vehicles.

Asleep, but not at the wheel



Fancy a nap while you're driving? That could be possible with the Volvo 360c concept car, part of the company's vision for the future of travel.

"The 360c explores what becomes possible when we remove the human driver, using new freedoms in design and recapturing time," said Mårten Levenstam, senior vice president at Volvo Cars. "It's a glimpse at how autonomous drive technology will change the world as we know it. The possibilities are mind-boggling."

The 360c reimagines how people travel, how they engage with friends, family and contacts, and how they can recapture time while travelling.

The concept presents four potential uses of autonomous driving vehicles – a sleeping environment, mobile office, living room and entertainment space, representing a travel option that Volvo believes could rival air, bus and train providers, but with competitive advantages in comfort, convenience and privacy.

"We regard the 360c as a conversation starter, with more ideas and answers to come as we learn more," said Levenstam.

STM and Leti collaborate on GaN-on-Si technology

ST Microelectronics and Leti, a research institute of CEA Tech, are cooperating to industrialise gallium nitride-on-silicon technologies for power switching devices. This power GaN-on-Si technology will help STM address high-efficiency, high-power applications, including automotive on-board chargers for hybrid and electric vehicles, wireless charging, and servers.

The collaboration focuses on developing and qualifying power GaN-on-Si diode and transistor architectures on 200mm wafers. They are developing the process technology on Leti's 200mm R&D line and expect to have validated engineering samples in 2019. In parallel, STM will set up a fully qualified manufacturing line, including GaN-Si hetero-epitaxy, for initial production running in STM's front-end wafer fab in Tours, France, by 2020.

They are also assessing techniques to improve device packaging for assembling high power-density power modules.

"Recognising the incredible value of wide-bandgap semiconductors, STM's contributions in power GaN-on-Si manufacturing and packaging technologies with CEA-Leti move to arm us with the industry's most complete portfolio of GaN and SiC products and capabilities, on top of our proven competence to manufacture high-quality, reliable products in volume," said Marco Monti, president of STM's automotive group.

Leti CEO Emmanuel Sabonnadiere said: "Leveraging Leti's 200mm generic platform, Leti's team is fully committed to supporting STM's strategic GaN-on-Si power-electronics roadmap and is ready to transfer the technology onto STM's dedicated GaN-on-Si manufacturing line. This co-development, involving teams from both sides, leverages the IRT Nanoelec framework programme to broaden the required expertise, and innovate from the start at device and system levels."

As a wide-bandgap semiconductor material, GaN devices inherently allow operation at much higher voltages, frequencies and temperatures than conventional semiconductors such as silicon. STM is also working on two other wide-bandgap technologies – silicon carbide (SiC) and RF gallium nitride.

Nissan integrates Maxim battery monitor in Leaf

Nissan has integrated Maxim's battery monitoring IC into its latest Leaf zero-emission electric vehicle. The Asil D-compliant technology enhances communications and cost savings for lithium-ion battery packs.

The IC is said to meet high safety standards with diagnostics, deliver communications and reduce the isolation bill of material costs.

It supports ISO 26262 and Asil D requirements and is also applicable for Asil C.

Its differential uart using capacitive isolation reduces costs and failure-in-time rates. The flexible uart enables communications in noisy environments.

Using Maxim's proprietary daisy-chain architecture and a successive-approximation-register analogue-to-digital converter, the IC captures fast, accurate voltage measurements and delivers high electromagnetic capability. A diagnostic feature complies with bulk current injection requirements that are designed to promote safe and smart future vehicles.

"Maxim emphasises the development of automotive products, and our battery management system has been highly regarded by many automobile manufacturers," said Randall Wollschlager, vice president and general manager of the automotive business unit at Maxim. "We regard this adoption of Maxim's battery monitoring IC into the new Nissan Leaf as a major step towards our continued automotive business expansion."



The Nissan Leaf is using Maxim battery monitor

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Mando gets autonomous green light from California

Mando, part of the Halla Group, has become the second Korean company to receive an autonomous vehicle permit from California after Samsung Electronics.

Silicon Valley in California is a competitive arena for automobile technologies, with autonomous driving technology companies including Waymo, Baidu, Tesla, Intel and Zoox conducting research, development and test drives. In addition, the region has a high concentration of academic institutions including Stanford, UC Berkeley and San Jose State University.

Mando expects that the Hockey autonomous driving platform it is developing will now advance more quickly. In addition, the company hopes the R&D centre it opened in Silicon Valley last year will expand technological exchanges and collaborations with companies in the area, in addition to finding and nurturing promising start-up companies.



Mando autonomous driving test vehicle

A Mando official said the company's objective in autonomous driving technology was to create a level-four platform based on technologies independently developed by the company, which will enable its safety systems to be effectively integrated into autonomous vehicles.

Hockey, an autonomous vehicle featuring sensors independently developed by Mando, received an autonomous driving permit from the Korean Ministry of Land, Infrastructure & Transport last year.

The company also established Next M, a technology institute in Pangyo Complex 2 in Korea, last May, in addition to signing an MoU regarding autonomous driving technology with Korean software company, Naver Labs.

Denso invests in deep-learning start-up

Denso has led a $65m series C funding round in Thin CI, a deep-learning start-up based in California with teams in India and the UK.

The close of the funding round was also led by Temasek, with other investors including GGV Capital, Mirai Creation Fund – backed by Toyota – and Daimler. Denso was also the lead investor in Thin CI's last funding round in 2016.

Thin CI's programmable computing architecture can accelerate deep learning, AI and other algorithms relevant to the automotive industry.

"Thin CI has the capabilities to help us usher in the next era of transportation," said Tony Cannestra, Denso director. "The company's technology provides the computing power to make autonomous driving and advanced electric vehicles the industry norm. The move to level four and five autonomy in the automotive industry will require huge amounts of flexible computing power. It's not feasible for car owners to have autonomous vehicles with server racks in their trunks, so there is a need to get that computing power out of the trunk and into a set of chips."

Since 2016, Denso and Thin CI have worked to commercialise a data flow processor (DFP) and enhance its development. A DFP can enhance the functionality of central and graphic processing units, meaning they can rapidly perform multiple complex calculations at once. A DFP can instantaneously optimise its calculating areas according to the amount and content of information, reducing power consumption and heat generation.

"The quality of investors coming together to invest in Thin CI validates our vision of industries adopting AI by leveraging our hardware and accompanying software stack," said Thin CI CEO Dinakar Munagala. "The interest from our automotive investors demonstrates their confidence that we can build on our early access partnerships with select automotive players and that our silicon will deliver the performance required to meet all five levels of autonomous driving."

NXP acquires automotive Ethernet firm Omniphy

NXP Semiconductors has acquired Omniphy, a Silicon Valley provider of automotive Ethernet subsystem technology.

Financial terms were not disclosed.

"One of the vexing questions of the autonomous age is how to move data around the car as fast as possible," said Ian Riches, executive director at Strategy Analytics. "Cameras and displays will ramp the number of high-speed links in the car to 150 million by 2020 and by 2030 autonomous car systems will aggressively drive that number to 1.1 billion high-speed links."

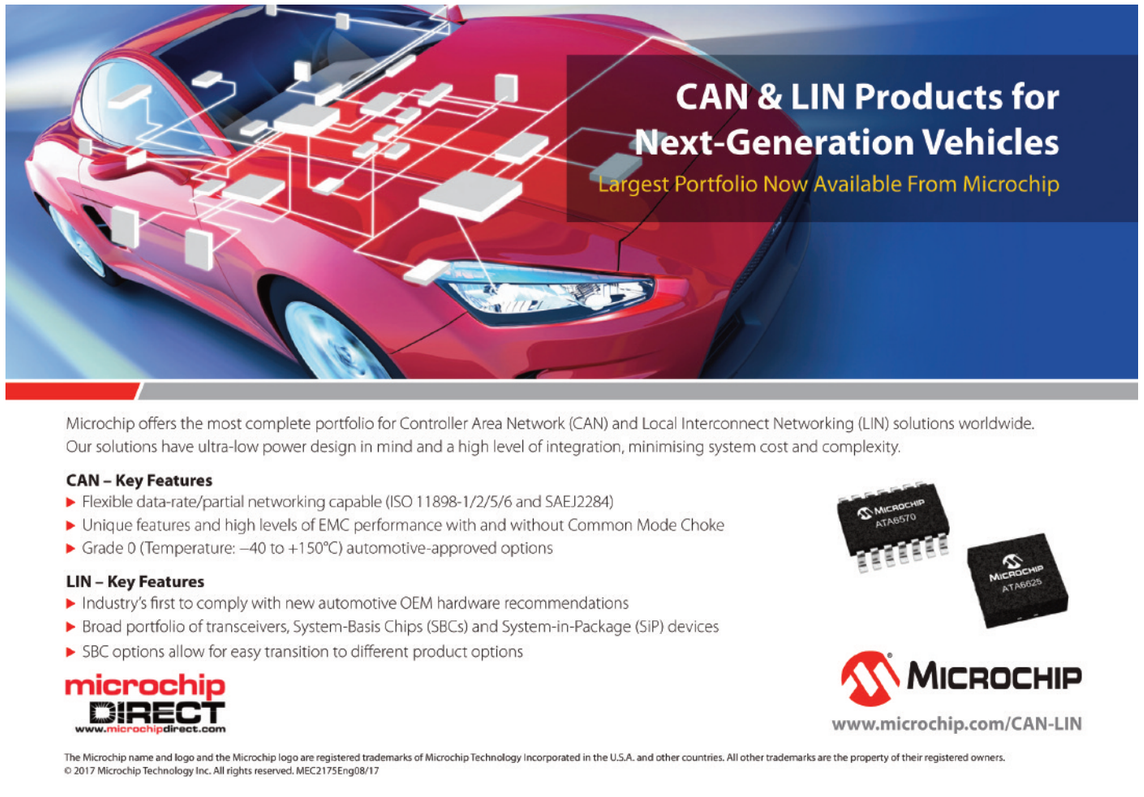
NXP's acquisition of Omniphy has already begun to translate 1000baseT1 Ethernet for the automotive space.

"Our heritage in vehicle networks is rich and, with our leadership positions in Can, Lin and Flexray, we hold a unique viewpoint on automotive networks," said Alexander Tan, vice president of NXP. "The team and technology from Omniphy give us the missing piece in an extensive high-bandwidth networking portfolio."

Omniphy specialises in high-speed automotive Ethernet IP and automotive qualified IP for 100baseT1 and 1000baseT1 standards. Over its six-year history, it has worked with some of the largest consumer companies and has developed first-silicon-right products for emerging markets such as automotive and industrial Ethernet.

"We are very excited to join NXP for a front-row seat to the autonomous driving revolution, one that will deliver profound change to the way people live," said Ritesh Saraf, CEO of Omniphy. "The combination of our teams and technology will accelerate and advance the delivery of automotive Ethernet providing our customers with high quality and world-class automotive Ethernet innovation."

Omniphy interface IP and comms technology along with NXP's automotive portfolio could form a one-stop shop for automotive Ethernet. The companies' technology synergies will centre on 1.25 to 28Gbit/s phy designs and 10, 100 and 1000baseT1 Ethernet.



Ford and Vodafone help drivers create emergency corridors

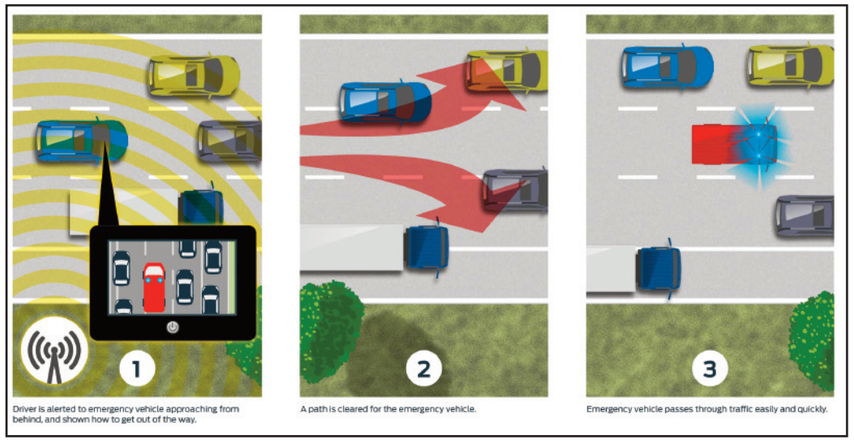
Ford and Vodafone are testing connected vehicle technology that can automatically warn other drivers of accidents ahead and show how to let emergency vehicles pass.

The prototype shows drivers how to create an emergency corridor so fire engines, ambulances and police vehicles can travel unhindered

The technology could alert drivers to an accident ahead moments after it has happened. And the system can provide early warning that emergency vehicles are approaching and which side of the road they should move towards to avoid being an obstruction

The technology is being trialled as part of Komod (Kooperative Mobilität im digitalen Testfeld Düsseldorf), a €15m project for the practical testing of new connected car technologies and automated driving.

"Connected and automated driving are key technologies of the future," said Gunnar Herrmann, CEO of Ford in Germany. "Ford has a long history of developing and testing vehicle-to-traffic infrastructure and vehicle-to-vehicle communications that can contribute to greater road safety and efficiency across the world. Together with Vodafone and in cooperation with the other companies involved, we will gain decisive insights on the Düsseldorf testing grounds to further advance the networking of vehicles."



Creating an emergency corridor

Already, in the event of an accident, ecall functionality, which is available on the Ford Focus, can automatically call emergency services, and enables occupants to do so manually by pushing a button inside the car.

Anticipating a future where all vehicles communicate with each other via mobile phone networks and embedded modems, Ford and Vodafone are exploring how ecall might also inform other drivers that there is an accident ahead, across a range of up to 500m. Attending emergency vehicles would also issue the warning, using in-car displays to show the correct emergency corridor formation.

On two-lane roads, emergency corridors are created between the two lanes by drivers pulling over to either side. If there are more than two lanes, it depends whether the rule of the road is to drive on the left or the right. For those countries where motorists drive on the right, the corridor is created between the lane on the far left and the lane directly alongside.

But even in those countries where it is already a legal requirement for drivers to take this approach, many drivers still do not comply.

The new technology complements emergency vehicle warning technology that Ford is also testing at Komod. This sends a signal from the ambulance, fire engine or police car directly to nearby drivers, so they will know the exact location of the vehicle and how far away it is. This can be especially useful in urban areas, for example at a crossroads where it might be difficult for drivers to immediately know where the siren is coming from.

"The digital revolution is bringing new forms of mobility which may help save lives on our roads," said Hannes Ametsreiter, CEO of Vodafone in Germany.

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VW adopts virtual validation for adas

Volkswagen plans to make driver assistance systems production-ready faster using virtual validation. The assistance systems of the next generation will then learn from virtually generated driving and traffic situations.

The brand expects this approach to make development processes faster and more efficient. In the long term, it is conceivable that millions of test kilometres required for validating automated driving could be completed in virtual environments.

Experts from Volkswagen are already testing software developed in-house to simulate such driving in traffic situations. This software is to be used for teaching assistance systems for the ID model family.

"We are continually developing Volkswagen vehicles and taking innovations into all segments," said board member for development Frank Welsch. "We are building on our strong global development team and grasping all the opportunities offered by digitalisation. This also includes virtual validation. We are developing this technology for our work as it will make for faster and more efficient development processes."

Volkswagen is aiming for two main benefits with virtual validation. Firstly, assistance systems can be trained continuously over days and weeks in any scenario desired; this approach accelerates the learning speed of the systems concerned.

With virtual validation, Volkswagen also expects to develop a rapidly growing number of systems and networked vehicle functions to production maturity.

To date, assistance systems have been tested using a hardware-based approach by connecting components to test rigs via data interfaces. As the number of networked functions grows, this means more hardware-based tests are necessary. Virtual validation will reduce the volume required, as physical test rigs will no longer be essential.



Frank Welsch

The software for the simulation of complex environments is called SimFas and developers want to generate any virtual traffic and driving situation that may be required. A new assistance system will then be connected to these virtual scenarios.

Visteon domain controller debuts in Mercedes A class

Making its debut in Daimler's Mercedes-Benz A Class, Visteon's SmartCore intelligent integrated cockpit domain controller uses a single silicon chip with multiple CPUs to provide a digital user experience.

As the focal point of the A Class' redesigned luxury interior, SmartCore powers the vehicle's instrument cluster and infotainment displays through a seamless and intuitive HMI. It lets drivers personalise their experience with a swipe of the touchscreen, the touch pad or remote controls on the steering wheel.



Mercedes A Class with cockpit domain controller

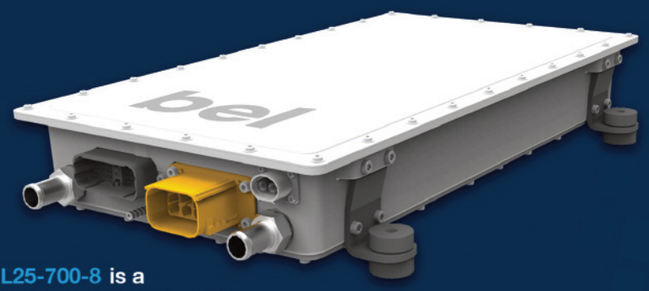
The user experience is based on two digital displays while the domain controller facilitates seamless instrument cluster, vehicle controls, multimedia, wireless Apple CarPlay and Android Auto features. The system also incorporates multiple display modes that are user selectable, offering customisation of the overall look and feel of the intelligent system.

The architecture, which is based on a hypervisor, lets the system drive the A Class' intelligent infotainment domain, running on Linux, beside an instrument cluster domain incorporating Asil-B requirements without any risk of interference between the two.

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Bosch partners SiTime for mems development

Bosch has formed a technology partnership with SiTime, a wholly owned subsidiary of Japan's MegaChips, to accelerate innovation in micro-electro-mechanical systems (mems) timing.

SiTime will work with Bosch to develop processes for mems resonator products. These resonators can increase the reliability of driver assistance systems in automotive.

Bosch will use its expertise in mems manufacturing to produce these resonators for SiTime and ensure availability of high-volume capacity.



Size comparison: mems resonator and grain of rice

"Since 2009 SiTime has counted on Bosch to manufacture more than a billion mems resonators," said Rajesh Vashist, CEO of SiTime. "Over the next decade, the 5G, IoT and automotive markets will drive the growth of the timing industry by creating a 200 billion unit opportunity. Automation, communications and computing applications in these markets will require more features, higher accuracy and reliability from timing components."

SiTime claims to have revolutionised the $6bn timing industry with its mems timing products. It has shipped over a billion units into all electronics markets, has over 90 per cent share of the mems timing market, and has partnered with companies such as Intel to drive timing innovation in 5G.

"Stable, reliable mems timing devices are needed for successful operation of new, high-bandwidth 5G, IoT and driver assistance systems," said Jens Fabrowsky, executive vice president at Bosch. "Without ultra-precise timing, the benefits and opportunities for next generation systems will not be achieved. With Bosch's mems leadership and manufacturing excellence, and SiTime's ground-breaking mems timing technology, this partnership will make possible unique new features and mission-critical services in 5G, IoT and automotive applications."

Bosch has sold more than 9.5bn mems sensors. The company developed the manufacturing process behind mems technology nearly 25 years ago.

"Bosch's strong mems process capabilities are a foundation on which we can develop our next generation of higher performance mems resonators," said Vashist. "Our partnership with Bosch will help extend our leadership into the coming decades."

CalAmp licenses Katasi IP to block texts while driving

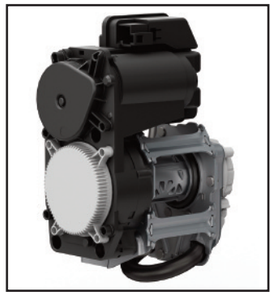
CalAmp has licensed intellectual property from Katasi to develop network-based distracted driving avoidance technology as a component of its expanding vehicle safety application suite.

Distracted driving from mobile texting continues to plague fleet operators and consumers, and presents increasing liability for insurers.

The CalAmp product will be available as a standalone micro-service or as part of a bundle with other services such as CrashBoxx, LoJack SureDrive and the firm's fleet management applications. The micro-services will let CalAmp deploy driver safety technology to a large percentage of its telematics device installed base.

"Technology plays an enormous role in creating a safer driving environment, and through our growing suite of road safety micro-services, CalAmp is invested in bringing to market ways to reduce risk on the roads that can save lives," said Michael Burdiek, president of CalAmp. "We're looking forward to unveiling new and valuable services to our enterprise customers and LoJack subscribers while at the same time making a positive impact on road safety."

Katasi's patented technology works in concert with telematics products and paired mobile devices to block text messages at the source network level. This should assure more robust distracted driving avoidance for anyone whose telematics services are powered by CalAmp technology. It is seamless to the driver and is automatically engaged while the vehicle is in motion.



Smart seat belt

ZF is beginning volume production of its ACR8 active control retractor that combines active and passive vehicle safety and is designed to tighten the seat belt in critical situations in advance of a potential impact.

It can be triggered by information from on-board active safety and driver assist systems and can work with systems such as autonomous emergency braking or evasive steering assist. The system helps keep the occupant in a better position while working with other occupant restraints such as airbags during a crash.

It can be an integral part of automated driving systems. When switching from automated to manual driving, the active control retractor can prompt the driver to take over by pulsating the strap at high frequency.

This allows the seat belt system to be integrated into automated vehicles' user interfaces as an effective way of gaining the driver's attention.

Netradyne raises $21m so AI can improve driver safety

Artificial intelligence start-up Netradyne has raised $21m in series B funding to help it develop technology for driver and fleet safety.

The money will help the San Diego and Bangalore-based company invest in AI and deep learning within the commercial vehicle space and in new industry segments.

Founded in 2015, Netradyne uses AI, machine learning and edge computing to enhance road and driver safety. The investment will be used to expand the team that has developed Driveri, a vision-based driver recognition and fleet safety platform that captures and analyses every minute of every driving experience, providing commercial fleet managers with insights into positive driving and identifying opportunities for individual coaching.

The result is reduced driving incidents, more awareness around risk and ability to reward positive driving, all of which improves driver retention.

"In a very short period of time, Netradyne has made major strides in commercialising next generation AI in ways that deliver tangible impact to real businesses," said Avneesh Agrawal, Netradyne's founder and CEO. "We look forward to the next chapter in Netradyne's growth where we extend our value proposition within the commercial fleet industry, while creating new paths into emerging technology segments."

The company will be investing in the application of AI and deep learning in dynamic 3D and HD mapping to provide real-time, crowd-sourced, high definition maps using commercially deployed Driveri devices.

HD maps enable improved transportation data analytics and autonomous vehicle research and development.

The company is also working on data analytics to give real-time insight into numerous aspects of driving.





DOORWAY TO THE FUTURE

Steve Rogerson reports from last month's Mentor IESF Automotive conference in Michigan

That the automotive industry is in a period of flux like never before seen is not in doubt. Autonomous vehicles, electrification and smart mobility have become focuses for all automotive companies. And the growing use of software is seeing a tenfold increase in the number of lines of code in each generation vehicles, a trend that is likely to continue.

It was against this background that engineers gathered in Plymouth, Michigan, for this year's IESF Automotive conference, run by Mentor, now part of Siemens.

"The whole market is evolving quickly," said Don Kurelich, a Mentor vice president, as he opened the one-day event. "In the next ten years, the business is going to be dominated by the electrical content of vehicles. We need a hundredfold improvement, we have to get the size down, we have to get the power down, we have to get the functionality up. We are going on a journey that will last the next twenty or so years."

Thus, he said, the industry was seeing new sensors with higher resolution, new microprocessors and digital signal processors, and every few years a new process technology.

"Every time that happens, you need to relook at the architecture," he said. "And we are going to have to do that time and time again."

He predicted that in twenty years time that autonomous driving would no longer be that interesting as the problems of integration, compactness and extremely low power would have been solved. But what is unknown is who by then will own the IP, whether it will be the OEMs, the tier-one suppliers, or even tier twos with unique offerings. And who is going to own the data? Could it be Google, Apple or Amazon, people not traditionally in the automotive space?

But that journey will not be easy, especially for new entrants who have to bring ideas to fruition.

"The valley of death is between an idea and getting a product to market," said Mouse McCoy, co-founder of digital industrial start-up Hackrod. "With a car, that is a billion dollar journey with all the prototyping, testing, marketing, manufacturing. The compromises that make great designs fail need to be eliminated. We are going to a future where kids with a dream can build what they want."

But when it comes to electric vehicles, the sheer volume of new entrants creates its own challenges.

"There are over 345 companies that have announced in the last year that they are going to introduce electric cars and trucks," said Wally Rhines, CEO



Puneet Sinha: "Thermal design will play a vital role."

of Mentor. "They are not all going to be successful but they challenge what we do. Electric cars are going to be a very exciting part of the business going forward."

And, as Tony Hemmelgarn, CEO of Siemens PLM, pointed out, an automobile has 20,000 to 30,000 requirements.

"You can't do that with a spreadsheet," he said, adding that with autonomous vehicles everything would need to be validated in a virtual world.

"You can't drive eight billion miles to test all this," he said.

Thermal

One of the highlights of the event was the announcement by parent company Siemens that it had pulled together three separate software components into an offering for design-centric thermal simulation in autonomous electric vehicles. The Simcenter software combines Flue FD cad-embedded computational fluid dynamics (CFD), the Motorsolve electric motor designer and the Flomaster powertrain thermal energy manager.

The combination has been designed to tackle critical thermal problems such as extending electric drive range, optimising in-cabin comfort, designing sensors and improving the reliability of autonomous drive systems.

"Thermal design will play a vital role in the market adoption of autonomous vehicles," said Puneet Sinha, MAD automotive manager at Mentor Graphics. "Existing software tools cannot just be glued together to solve these issues."

He said improper thermal design was a leading reason for electrical failure. And he said with this tool thermal design could be achieved without ever leaving the cad environment.

The package uses CFD technology for mainstream automotive engineers, generating accurate thermal digital twin simulations of the powertrain, processors, sensors and other enabling technologies.

Capabilities include co-simulation of thermal and electric powertrain performance, connectivity between simulation of electric motor performance and system simulation for electrical



Wally Rhines: "You are not going to change an electrical engineer into a mechanical engineer."



Don Kurelich: "We are going on a journey."

and thermal management, and design space exploration using thermal digital twin models. It also features seamless connectivity to electronic design automation tools and cad design platforms, helping engineers account for design co-dependencies across electronic, electrical and mechanical domains from the earliest stages of development.

"You are not going to change an electrical engineer into a mechanical engineer," said Rhines. "You have to exchange the data you need so both groups can work together."

Doug Burcicki, automotive director at Mentor, described the architectural challenges as "monumental".

"It is not an electrical challenge, it is not a mechanical challenge, it is not a software challenge," he said. "It is combining them all together. This is where the concept of a digital twin comes in. You are implementing and changing the design before ever implanting it in a physical vehicle. And you can feed back real-time data into the design."

An area where thermal management is vitally important is the battery, both for its functionality and its lifetime.

"Model-based system engineering is supporting growing complexity in systems engineering," said Katrien Wyckaert, director of automotive industry systems at Siemens. "You need to have a balancing act between range, fuel economy and emissions while driving performance and passenger comfort. You have to apply generative concepts early in the design stage. When you look at subsystem design you also have to look at the effects on the system design."



Doug Burcicki: "Architectural challenges are monumental."

For batteries, she said it was possible to provide scalable models for choosing the cell chemistry and size to build integrated system and show how they will function.

"Model-based engineering supports this battery design method," she said. "You can test cell balancing, state of charge, integration and so on. The battery pack then needs to be integrated into the vehicle design."

Generative design can also help reduce the amount of wiring in a vehicle.

"There is a limit to the amount



Mouse McCoy: "The compromises that make great designs fail need to be eliminated."



Tony Hemmelgarn: "You can't drive eight billion miles to test."

of wiring you can put in a car," said Martin O'Brien, senior vice president at Mentor. "Printing the wires directly onto the panels could see harnesses produced in an entirely different way. That is part of the prototyping work that is going on today. Generative design can shorten the design cycle. The opportunity is being driven by new entrants. You need people who think laterally about this. Introducing a generative system takes a year with a new car maker but can take five years with an existing car maker."

Noise

One area that is attracting a lot of interest with electric vehicles is noise. Electrical engines are much quieter than internal combustion engines but when the noise is low, other noises become more prominent.

"You don't have the noise of the engine, but you have new noises to deal with," said Hemmelgarn. These can include wind noise and road noise.

"These can be more annoying," said Wyckaert. "Daimler has invested in a wind tunnel to look at how to reduce wind noise using simulation technology."

The quietness also causes safety problems in urban driving. Pedestrians often rely on engine noise to alert them of nearby vehicles, which is why legislation is coming into play in the USA and Europe to ensure a minimum sound level.

"Some are looking at putting speakers in the bumper to give out a sound that sounds like a car," said Wyckaert. "Also, companies are looking at generating sound inside to give the impression of power. You need to look at where to put the loud speakers and Simcenter can help with that."

One challenge with this is joining together active and passive noise reduction technology.

"We are proposing an integrated approach using testing and simulation," said Bart Vandenplas, team manager at Siemens PLM.

Passive methods block the noise using physical materials.

These have the disadvantage of adding weight to the car.

Active noise cancellation creates an anti-noise that is 180 degrees out of phase.

An example would be engine noise cancellation, though this is not a problem with electric vehicles.



Martin O'Brien: "There is a limit to the amount of wiring you can put in a car."



Bart Vandenplas: "We are proposing an integrated approach."

"Another is road noise cancellation, which is new and we are working very hard on that," said Anil Khanna, director of audio technologies at Mentor. "You can also create new sounds to give a new experience. As cars stop being cars and become rooms



Katrien Wyckaert: "You need to have a balancing act."

Connected cars and smart cities



Connected vehicles and smart cities go hand in hand, according to Priscilla Boyd (pictured), senior product manager at Siemens Mobility. A big driver behind this is safety.

In the USA, the Department of Transport wants to replace non-impaired crashes by four-fifths; these accounted for nearly 27,000 deaths in 2016 compared with 10,500 death caused by drivers impaired by the effects of alcohol.

The second problem is congestion, estimated at costing $305bn in the USA in 2017 with an hour per week being the average time per person spent on commuting. And the third challenge is poor air quality, often a result of congestion.

"Connected vehicles can help with these challenges," said Boyd. "Here is where you start talking about vehicle-to-infrastructure (V2I) technology."

Dynamic short-range communications can see vehicles talking with each other. "This can help quite significantly with safety by predicting crash situations," she said. "Vulnerable road users such as cyclists and pedestrians can link into this through their smartphones."

Next is linking the traffic system to vehicles. This can keep cars travelling at an optimal speed to hit green lights always.

"All of this can be linked into a traffic management system," said Boyd. "However, there are no mass-market produced cars with this technology, so should cities deploy the infrastructure now? Cities have very tight budgets."

Funding though is available from government for trials and public-private partnerships are becoming common as car makers and infrastructure providers want to test their technologies. Also, connected vehicle technology could replace the vehicle detection technology that cities already deploy.

on wheels, the sound level will be important."

He said it was important to have a combined approach looking at passive and active methods much earlier in the design cycle.

"Doing it all at the beginning can help improve weight issues," Khanna said.

He said there was also work taking place on predictive maintenance. Parts of a car can generate specific sounds when things start to go wrong. Training the system to listen for these sounds can be used to trigger an alert to the driver to have the car checked.

Safety

The use of model-based systems engineering is also affecting the functional safety field, according to Kyle Post, technical lead for functional safety at Ford, who discussed the draft ISO 21448 standard that is looking at the concept of safety of the intended functionality (sotif).

"You start with the system as designed and look at the intended functionality, the hazards and risks, and whether the risk is acceptable," he said. "You can't get rid of all the risks so you have to look at when they are acceptable. The end goal is to get to an acceptable risk level and then you can release the product."

He said this was an iterative process that had the added benefit of increasing cyber security.

"But the big elephant in the room is validation," he said. "You have to evaluate unknown hazardous scenarios. There is a lot of debate on figuring out the targets for this."

Another problem with functional safety is integrating different aspects such as software tools, legacy data, people and so on.

"You need access to the right information," said Kareem Al-Senan, technical marketing engineer at Mentor. "You need to integrate and implement different safety standards. You are always going to have risk, but you have to analyse and minimise the risk."

He said people worked in silos and were good at what they did but that brought connectivity constraints.

"You have buckets of data and these come from different places and are in different formats," he said. "You have to bring this together and you need to automate the process."



Anil Khanna: "Doing it all at the beginning can help improve weight issues."

Doing this, he said, brought added benefits such as more informed decision-making, higher efficiency and more confidence in the work.

Conclusion

Never in the IESF's 18-year history have the challenges for designing the electronic and electrical systems in vehicles been higher than they are today. But when more than a thousand engineers gather as they did last month in Michigan then it is clear that the best minds are working at solving the problems to bring forth the next generation of vehicles as the industry continues its path to autonomous driving.



Kareem Al-Senan: "You have buckets of data."



Kyle Post: "The end goal is to get to an acceptable risk level."

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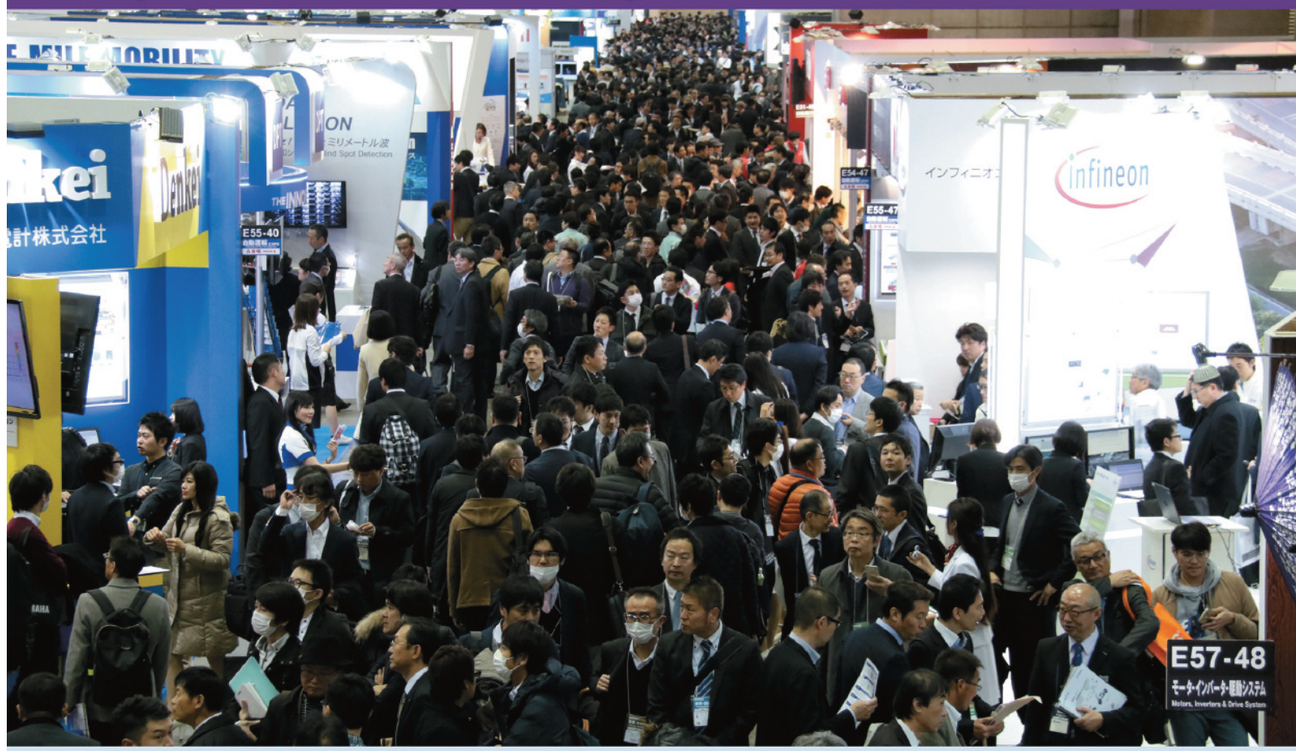
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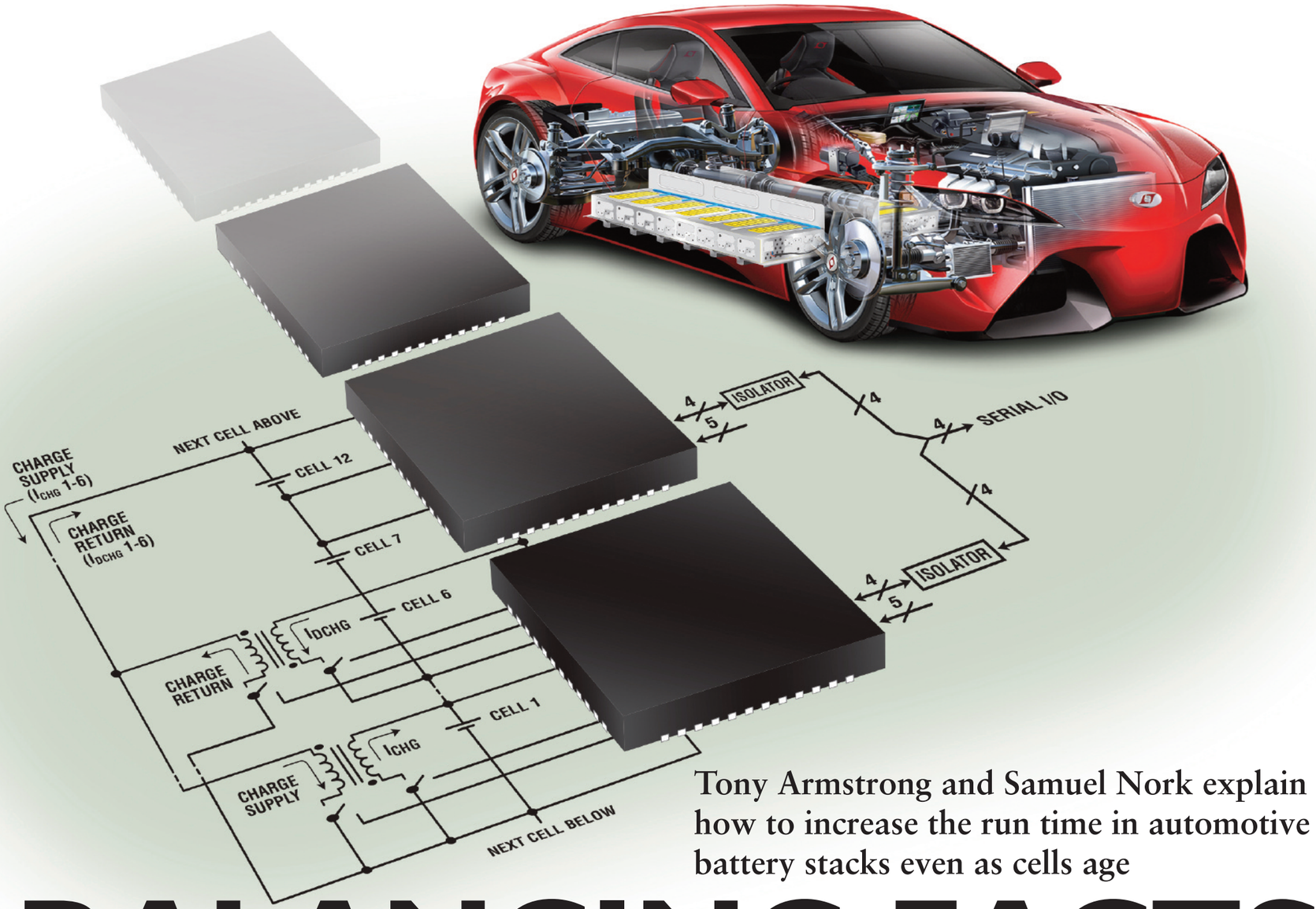
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POWER TECHNOLOGIES



Tony Armstrong and Samuel Nork explain how to increase the run time in automotive battery stacks even as cells age

BALANCING FACTS

Large battery stacks consisting of series-connected, high energy density, high peak power lithium polymer or lithium-iron phosphate ($LiFePO_4$) cells are commonplace in applications ranging from all-electric vehicles (EVs or BEVs) and hybrid petrol-electric vehicles (HEVs and plug-in hybrid electric vehicles or PHEVs) to energy storage systems (ESSs).

The EV market is projected to create tremendous demand for large arrays of series and parallel connected battery cells. The 2016 global PHEV sales were 775,000 units, with a forecast of 1.13 million units for 2017. Despite the growing demand for high capacity cells, battery prices have remained quite high and represent the highest priced component in an EV or PHEV, with prices typically in the $10,000 range for batteries capable of a few hundreds of kilometres of driving range.

The high cost may be mitigated by the use of low cost and refurbished cells, but such cells will also have a greater capacity mismatch, which, in turn, reduces the usable run time or drivable distance on a single charge. Even the higher cost, higher quality cells will age and mismatch with repeated use.

Increasing stack capacity with mismatched cells can be done in two ways: either by starting with bigger batteries, which is not very cost effective, or by using active balancing, a technique to recover battery capacity in the pack that is quickly gaining momentum.

Balance

The cells in a battery stack are balanced when every cell in the stack possesses the same state of charge (SoC). SoC refers to the remaining capacity of a cell relative to its maximum capacity as the cell charges and discharges. For example, a 10A/hr cell with 5A/hr of remaining capacity has a 50% SoC.

All battery cells must be kept within a SoC range to avoid damage or lifetime degradation. The allowable SoC minimum and maximum levels vary from application to application. Where battery run time is of primary importance, all cells may operate between a minimum SoC of 20% and a maximum of 100% (or a fully charged state). Applications that demand the longest battery lifetime may constrain the SoC range from 30% to 70%. These are typical SoC limits found in electric vehicles and grid storage systems, which use very large and expensive batteries with an extremely high replacement cost.

The primary role of the battery management system (BMS) is to monitor all cells in the stack carefully and ensure that none of the cells are charged or discharged beyond the minimum and maximum SoC limits of the application.

With a series-parallel array of cells, it is generally safe to assume the cells connected in parallel will autobalance with respect to each other. That is, over time, the state of charge will automatically equalise between parallel connected cells as long as a conducting path exists between the cell terminals. It is also safe to assume that the state of charge for cells connected in series will tend to diverge over time due to a number of factors.

Gradual SoC changes may occur due to temperature gradients throughout the pack or differences in impedance, self-discharge rates or loading cell-to-cell. Although the battery pack charging and discharging currents tend to dwarf these cell-to-cell variations, the accumulated mismatch will grow unabated unless the cells are periodically balanced.

Compensating for gradual changes in SoC from cell to cell is the most basic reason for balancing series connected batteries. Typically, a passive or dissipative balancing scheme is adequate to rebalance SoC in a stack of cells with closely matched capacities.

As illustrated in Fig. 1a, passive balancing is simple and inexpensive. However, passive balancing is also very slow, generates unwanted heat inside the battery pack and balances by reducing the remaining capacity in all cells to match the lowest SoC cell in the stack. Passive balancing also lacks the ability to address SoC errors effectively due to another common occurrence –

capacity mismatch.

All cells lose capacity as they age and they tend to do so at different rates for the same reasons state of charge cells in a series tend to diverge over time. Since the stack current flows in and out of all series cells equally, the usable capacity of the stack is determined by the lowest capacity cell in the stack. Only active balancing methods such as those shown in Figs. 1b and 1c can redistribute charge throughout the stack and compensate for lost capacity, due to mismatch from cell to cell.

Mismatch

Cell-to-cell mismatch in either capacity or SoC may severely reduce the usable battery stack capacity unless the cells are balanced. Increasing stack capacity requires that the cells are balanced both during stack charging, as well as stack discharging.

In the example shown in Fig. 2, a ten-cell series stack comprised of nominal 100A/hr cells with a ±10% capacity error from the minimum capacity cell to the maximum is charged and discharged until predetermined SoC limits are reached. If SoC levels are constrained to between 30 and 70% and no balancing is performed, the usable stack capacity is reduced by 25% after a complete charge-discharge cycle relative to the theoretical usable capacity of the cells.

Passive balancing could theoretically equalise each cell's SoC during the stack-charging phase, but could do nothing to prevent cell ten from reaching its 30% SoC level before the others during discharge. Even with passive balancing during stack charging, significant capacity is lost (not usable) during stack discharge. Only active balancing can achieve capacity recovery by redistributing charge from high SoC cells to low SoC cells during stack discharging.

Fig. 3 illustrates how the use of ideal active balancing enables 100% recovery of the lost capacity due to cell-to-cell mismatch. During steady state use when the stack is discharging from its 70% SoC fully recharged state, stored charge must in effect be taken from cell one (the highest capacity cell) and transferred to cell ten (the lowest capacity cell), otherwise cell ten reaches its 30% minimum SoC point before the rest of the cells and the stack discharging must stop to prevent further lifetime degradation. Similarly, charge must be removed from cell ten and redistributed to cell one during the charging phase, otherwise cell ten reaches its 70% upper SoC limit first and the charging cycle must stop.

At some point over the operating life of a battery stack, variations in cell aging will inevitably create cell-to-cell capacity mismatch. Only active balancing can achieve capacity recovery by redistributing charge from high SoC cells to low SoC cells as needed. Achieving maximum battery stack capacity over the life of the battery stack requires active balancing to charge and discharge individual cells efficiently to maintain SoC balance throughout the stack.

Recovery

The device in Fig. 4 can address the need for high performance active balancing. It is a high efficiency, bidirectional, active balance control IC that is a key piece of a high performance BMS system. Each IC can

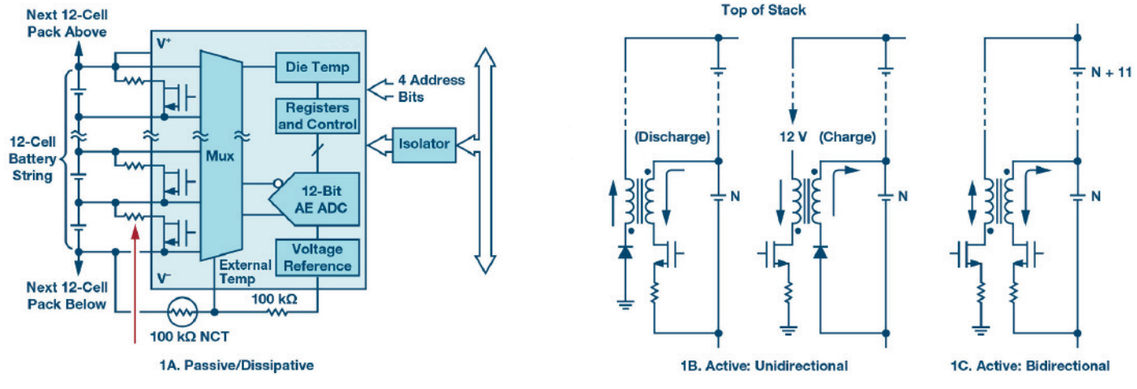


Fig. 1: Typical cell balancing topologies

simultaneously balance up to six Li-ion or $LiFePO_4$ cells connected in series.

SoC balance is achieved by redistributing charge between a selected cell and a substack of up to 12 or more adjacent cells. The balancing decisions and balancing algorithms must be handled by a separate monitoring device and processor that controls the IC.

Charge is redistributed from a selected cell to a group of 12 or more neighbouring cells to discharge the cell. Similarly, charge is transferred to a selected cell from a group of 12 or more neighbour cells to charge the cell. All balancers may operate simultaneously, in either direction, to reduce stack balancing time.

Each balancer in the device uses a non-isolated boundary mode synchronous flyback power stage to achieve high efficiency charging and discharging of each individual cell. Each of the six balancers requires its own transformer.

The primary side of each transformer is connected across the cell to be balanced, and the secondary side is connected across 12 or more adjacent cells, including the cell to be balanced. The number of cells on the secondary side is limited only by the breakdown voltage of the external components. Cell charge and discharge currents are programmed by external sense resistors to values as high as 10A+, with corresponding scaling of the external switches and transformers.

High efficiency is achieved through synchronous operation and the proper choice of components. Individual balancers

No Active Balancing (30% to 70% SoC Limits)

Cell #	Initial Capacity (A/hr)	Initial SoC (%)	Post-Discharge Capacity (A/hr)	Post-Discharge SoC (%)	Post-Discharge Capacity (A/hr)	Post-Discharge SoC (%)
1	110	100	47	43	77	70
2	100	100	37	37	67	67
3	100	100	37	37	67	67
4	100	100	37	37	67	67
5	100	100	37	37	67	67
6	100	100	37	37	67	67
7	100	100	37	37	67	67
8	100	100	37	37	67	67
9	100	100	37	37	67	67
10	90	100	27	30	57	63
Stack Capacity	1000		370		670	

No Balance ← No Balance ←

Usable Stack Capacity: 670 A/hr to 370 A/hr = 300 A/hr
(75% of 400 A/hr Theoretical Max Capacity ⟶ 100 A/hr lost)

Fig. 2: Stack capacity loss example due to cell-to-cell mismatch

100% Efficient (30% to 70% SoC Limits)

Cell #	Initial Capacity (A/hr)	Initial SoC (%)	Post-Discharge Capacity (A/hr)	Post-Discharge SoC (%)	Post-Discharge Capacity (A/hr)	Post-Discharge SoC (%)
1	110	100	33	30	77	70
2	100	100	30	30	70	70
3	100	100	30	30	70	70
4	100	100	30	30	70	70
5	100	100	30	30	70	70
6	100	100	30	30	70	70
7	100	100	30	30	70	70
8	100	100	30	30	70	70
9	100	100	30	30	70	70
10	90	100	27	30	63	70
Stack Capacity	1000		370		700	

Active Balance ← Active Balance ←

Usable Stack Capacity: 700 A/hr to 370 A/hr = 400 A/hr
(100% of 400 A/hr Theoretical Max Capacity)

Fig. 3: Capacity recovery due to ideal active balancing

are enabled via the BMS processor and they will remain enabled until the BMS commands balancing to stop or a fault condition is detected.

Efficiency

One of the biggest enemies faced by a battery pack is heat. High ambient temperatures rapidly degrade battery lifetime and performance. Unfortunately, in high current battery systems, the balancing currents must also be high to extend run times or to achieve fast charging of the pack.

Poor balancer efficiency results in unwanted heat inside the battery system and must be addressed by reducing the number of balancers that can run at a given time or through expensive thermal mitigation methods.

As shown in Fig. 5, the IC

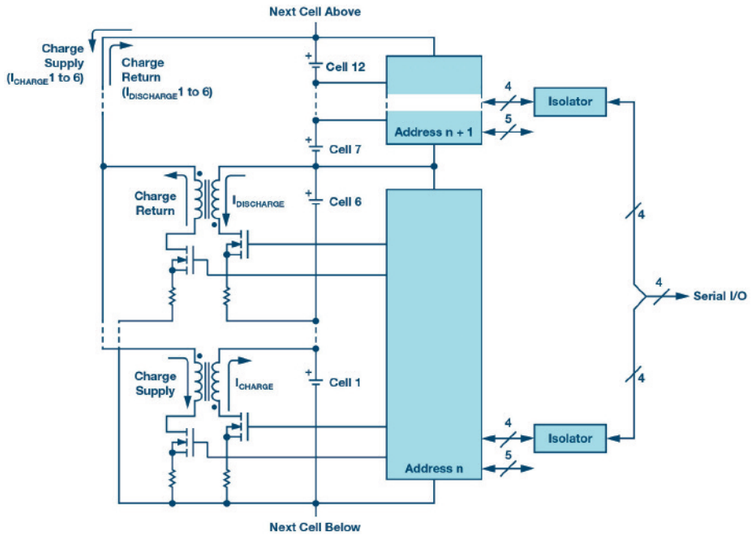


Fig. 4: High efficiency, bidirectional, multi-cell active balancer

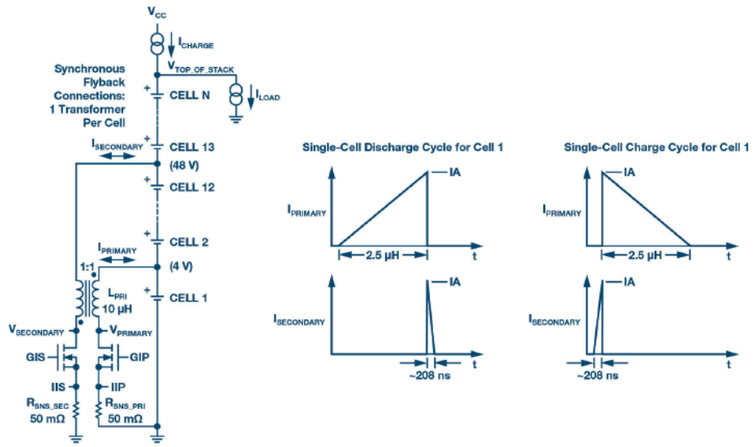


Fig. 5: Power stage performance

achieves better than 90% efficiency in both the charging and discharging directions, which allows the balance current to be more than doubled relative to an 80% efficient setup with equal balancer power dissipation. Furthermore, higher balancer efficiency produces more effective charge redistribution, which, in turn, produces more effective capacity recovery and faster charging.

Conclusion

Applications in EVs, PHEVs and ESSs are growing rapidly. The consumer expectation of a long operating life for batteries and reliable operation without performance loss remains unchanged. Automobiles, whether they be battery or petrol powered, are expected to last for over five years without any perceptible degradation in performance.

In the case of an EV or PHEV, performance equates to drivable range under battery power. EV and PHEV suppliers must provide not only high battery performance, but also a multiyear warranty that covers a minimum range to remain competitive.

As the number and age of EVs continues to grow, irregular cell aging within the battery pack is emerging as a chronic problem and primary source of run-time reduction. The operating time of a series-connected battery is always limited by the lowest capacity cell in the stack. It only takes one weak cell to compromise the whole battery.

For the vehicle suppliers, replacing or refurbishing a battery under warranty due to insufficient range is a very expensive proposition. Preventing such a costly event can be accomplished by using larger, more expensive batteries for each and every cell, or by adopting a high performance active balancer to compensate for cell-to-cell capacity mismatch due to non-uniform aging of the cells. With such a device, a severely mismatched stack of cells has nearly the same run time as a perfectly matched stack of cells with the same average cell capacity.

Tony Armstrong is marketing director of power products at Analog Devices





and Sam Nork is director of the company's Boston design centre



POWER POINT

Steve Rogerson looks at Yokogawa's latest precision power analyser that is claiming a world record in accuracy

The electric vehicle industry still has work to do if battery-powered vehicles are going to be the dominant means of transport in years to come. Among the areas that need to be addressed are range anxiety – drivers want to be confident the vehicle will get to where it is going without running out of power – and charging time; nobody wants to sit around for hours at a service station waiting for the car to charge.

To achieve this, strides still have to be made in terms of powertrain efficiency. And for engineers to succeed in this, improvements will also be needed in the test and measurement equipment they use.

"The engineers are the architects of all the challenges around us," said Anoop Gangadharan, product marketing manager for Yokogawa in Europe. "They always have to be on the money."

He was speaking at the launch of the WT5000, a precision power analyser that has a measurement accuracy of ±0.03%, a figure that the Japanese company claims is a world record, and one it hopes will go a long way to helping automotive engineers achieve the efficiency they desire.

"When they are making their products, they want to make data-driven development decisions," he said. "And they want to avoid product recalls. And their testing conditions are changing constantly. What we have created is not just a power analyser but an extensible power management platform. It is an evolving product; users will be able to add more capabilities over the years."

As well as electric vehicles, the company is targeting markets in renewable energy, home and office appliances, and industrial equipment.

A key part of this is its modular design. The rear contains seven swappable input modules. Different modules can be put in depending on the application, and Yokogawa has promised to introduce new modules as market demands change. In an automotive application, for example, it can be configured to measure up to four motors simultaneously. It will be looking at electromechanical parameters for multi-phase motors, torque sensors and rotation sensors for measuring the likes of rotation speed, rotation direction, torque,

mechanical power, synchronous speed, slip, electrical angle and motor efficiency.

"Automotive is a very important market, with electric vehicles booming like there is no tomorrow," said Gangadharan. "It is a very exciting market. The biggest names in automotive have all started work on electric vehicles. It will be one of the fastest growing markets for us."

However, he said consumer adoption of electric vehicles had not taken as much as the car makers wanted for reasons such as range anxiety and charging time.

"It will be some time before it takes off like we hope," he said. "We need to reduce charging time to under 30 minutes. The one area of testing that will be increasingly important is improving the efficiency of the powertrain. The ±0.03% accuracy stands automakers in good stead, but we may need to improve that as automotive standards evolve."

Powertrain development involves taking measurements form multiple phases for battery, inverter and motor to evaluate the likes of torque, rotation speed and



Lee Thomas: "It works fine."



Anoop Gangadharan: "It is an evolving product."

direction, and slip. Multiple six-phase motor systems need to be evaluated and there also needs to be harmonic evaluation of inverter signals due to superimposition from switching circuits.

The WT5000's accuracy and the ability to evaluate four motors simultaneously could be important here along with its wide input range, sensor compatibility and the seven swappable input modules slots, which fit into a chassis that has the same dimensions as existing models in the WT series.

With a seven elements input capability, multi-system measurement is increased in harmonic measurements on three-phase systems, for example. The unit can carry out two harmonic measurement functions simultaneously, each at up the 500th order and up to 300kHz fundamental waveform. This makes it possible to measure the carrier frequency component from the rotational speed of the motor in the inverter drive and to check the influence of the carrier frequency on the motor drive.

At the moment, only two modules are available – one for 30A and one for 5A – and two more are in the pipeline.

"As the industry progresses, there will be more depending on what the market is asking for," said Gangadharan. "You will be able to have a library of modules and just plug in the ones you want. It is power to the people."

Lee Thomas, a Yokogawa sales manager, added: "What excites me most about this is the modularity. This stops engineers having to invest in new instruments. This is future proof for power measurement applications."

The instrument itself, without modules, comes in at just under £10,000; the modules will be priced according to their functionality.

The ±0.03% accuracy at 44 to 66Hz is made up of ±0.01% of reading and 0.02% of range. This drops for DC measurements to ±0.02% of reading and ±0.05% of range.

"The ±0.03% figure is the world's best accuracy," said Gangadharan.

One of the essential elements for determining the performance of a power measuring instrument is the analogue-to-digital converter. To obtain the measurement accuracy, the unit uses an 18bit converter with a sampling frequency of up to 10MS/s. As a result, it becomes possible to capture waveforms accurately from the latest high-speed inverter devices. It is said to be very effective for stable measurement results.

The unit will also be able to be controlled remotely, with a laptop in charge of multiple units. As of now though, the free software will only control a single unit but paid-for software is due out by the end



Engineers want improvements in test and measurement

of this financial year to allow control of multiple units.

Another plus is its noise resistance.

"It doesn't suffer when the instrument is, say, close to a hybrid powertrain that is electrically noisy," said Thomas. "It works fine."

The instrument has gone out to car makers for evaluation, but many of them fed information during the design of the machine.

"There have been more primitive versions out with them to look at, but not the finished version until now," said Gangadharan.



The rear contains seven swappable input modules

LIGHTING

SAFETY LIGHTS

Mark Patrick explains how to make roads safer by implementing the latest automotive lighting technology

The Mercedes-Benz E Class has adaptive front lighting capabilities

Vehicle Electronics

Studies have shown that light conditions can have a profound effect on the likelihood of road accidents occurring. In EU member states, an average of over 10,000 such accidents each year take place during the night. This is effectively double the figure in the day, relative to the number of road users at that time.

Driving in darkness or low light conditions can mean there is less time to identify and subsequently react to a situation on the road ahead. It also has a detrimental effect on the ability of vehicle drivers to estimate distances accurately, thus making it more challenging to judge what the best course of action will be or to execute difficult manoeuvres correctly.

The automotive industry is consequently keen to upgrade the lighting capabilities of car models, so that visibility levels can be improved and road users can be subject to a higher degree of protection. Pivotal to this will be replacing the halogen and high-intensity discharge (HID) lamps that have traditionally been the source of illumination in vehicle designs with modern solid-state alternatives.

Over the course of the last decade, there have been significant advances in LED technology with improvements in performance and reductions in the associated unit price both being witnessed. As a result, car manufacturers are now looking to use it throughout vehicle designs. No longer just restricting it to interior lighting, side lights and such like, but going for wholesale implementation, including front lights, brake lights and so on.



Among the companies to develop devices to support the uptake of the smart automotive lighting is Osram Opto Semiconductors. Its Oslon Black Flat S series of surface mount LEDs provide automobile design engineers with up to five individually controllable emitter elements in each package. These allow both the shaping of the headlight beam and the blocking out of defined areas. An output of 1650 lumens is supported, with a 1:65 contrast radio.

Analyst firm TrendForce expects that, based on this, there will be a significant ramp in LED demand within the automotive sector. Its research suggests that the automotive LED market will grow by almost 12.5 per cent between the end of 2017 and the end of 2018.

It is widely recognised that LED-based illumination has numerous benefits within an automotive context. As well as being extremely reliable and supporting extensive operational lifespans with minimal change in their output characteristics over time, such devices are able to exhibit high energy efficiency levels, which means they have less impact on vehicle fuel consumption and help support greater fuel economy.

Since more energy is converted into light and less into heat, they require less thermal management, with cost and space saving benefits therefore being derived. In addition, they can deal with extreme temperatures and switch on and off at high speeds.

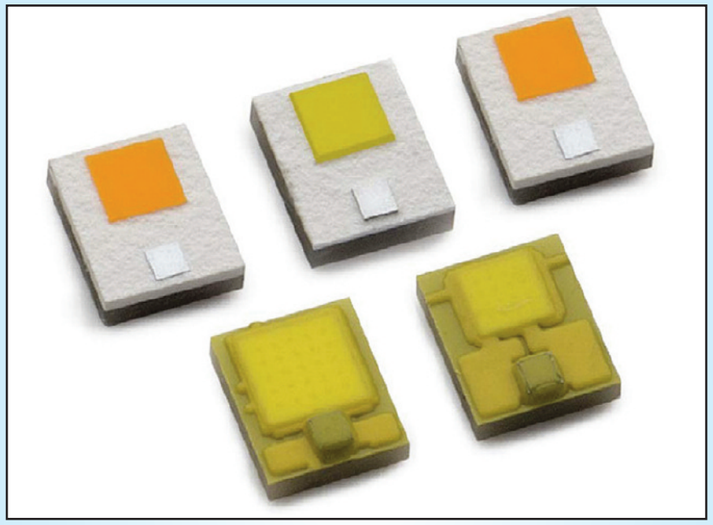
Crucially, they can also support a much more expansive array of functionality than conventional automotive lighting components. One of the key ways in which this is being realised is through pixel-light technology, where areas of the front light can be blocked out to prevent the drivers of vehicles travelling in the opposite direction, pedestrians and even wildlife from being dazzled by front light beams, thereby lowering the chance of an accident occurring.

LEDs also offer the possibility to change the shape of the beam produced, so as to respond to the environment that the car is travelling through, but without the need for motors, actuators or other electromechanical elements to be incorporated.

The method for making such changes to the beam shape is referred to as adaptive front lighting technology. This lets the beam be adjusted in accordance with the contours of the road, changing the angle of the beam vertically when the vehicle is going uphill or downhill, or if it is negotiating its way over bumps. Likewise, the direction of the beam can be changed in relation to the horizontal axis in response to bends in the road, to ensure that light is always directed to where it is most needed. Furthermore, the range of the beam can be extended as the vehicle's speed increases, so as to give the driver more time to identify any obstacle that may require an evasive manoeuvre, for example.

To do all this, data concerning the vehicle's speed, its pitch relative to the road and its turning rate must be acquired. This is done using a multitude of sensors that are positioned all over its chassis and fed back via Can or Ethernet network infrastructure.

The latest Mercedes-Benz E Class models feature adaptive front lighting capabilities. Each of their headlamps comprises 84 individually activated high performance LEDs arranged into a matrix that delivers precision-controlled, high brightness illumination. Through four ECUs, the vehicle can calculate the most appropriate light pattern at any given time. This pattern can be updated at a rate of 100 times per second.



The Lumileds LFMH/A Luxeon F LEDs deliver a typical output of 203 lumens and have a typical viewing angle of 188°. Supplied in a 1.9 by 2.3mm format package, they address the space limitations that tend to be endemic of automotive environments. These devices rely on phosphor technology and are available in either 1x2 or 1x4 configuration options, both with or without spade lugs included. As well as white light LEDs for front lighting, there are also phosphor-converted amber versions that are suitable for turn lights. Tested for use at temperatures up to +85°C, they adhere to ECE and SAE colour specifications. Their thermal resistance means the room taken up by heatsinking can be kept low. Production part approval process documentation is available when required.

Opportunities

Opportunities for optoelectronics in automotive are continuing to open up. Osram, for example, is heavily involved in laser-based front lighting. Its laser modules are incorporated into the BMW i8 series allowing a 600m illumination range and are now starting to be designed into other luxury car models.

There are still engineering challenges though. Solid-state lighting needs to become more cost effective if it is to witness further proliferation. Despite LEDs being cheap to produce, the surrounding electronics assembly can still demand a relatively high price tag.

Things are going in the right direction, however, and bill of material costs are steadily falling. So it is no longer a question of whether LED front lighting will make it into mid-range and economy vehicles, just how quickly.

Mark Patrick is technical marketing manager for Mouser Electronics



TELEMATICS



When it snows

Integrating road weather guidance in vehicle telematics is key to safety and productivity, says Glen Denny

Delivery of better weather guidance to drivers is essential, especially real-time updates on the elements drivers face on the roads. These data enable pre-planning of employee schedules, supply chains and assets that could be in jeopardy when there are dangerous road or weather conditions.

New technology is available that can easily integrate weather data into next generation vehicle telematics platforms, including navigation, routing and planning software, mobile apps, and other in-vehicle deployments.

Specific weather data can also be integrated with smart vehicle safety features as part of the development of autonomous vehicles.

Demand

Telematics platforms are developed by automotive manufacturers and service providers such as manufacturers of navigation and in-car mapping systems. While a primary concern of trucking, shipping and insurance markets, weather information is also of interest to other public safety organisations, including schools, hospitals, departments of transportation and large employers. In short, anyone with assets on the road benefits from high quality localised weather condition information.

Consumers in general recognise the importance of weather data for their connected vehicles. While a recent study of 14,000 car owners showed that map apps are the number one choice for those with connected cars, 49 per cent of survey participants cited weather apps as the second most important type of vehicle app. Being informed about the weather helps people plan ahead and feel prepared, even scheduling work days based on predicted conditions.

Many drivers rely on current conditions or the forecast of bad roads from local television weather reporters. But when driving is involved, both businesses and consumers need more than just basic weather information such as the chance of rain or the day's high. Drivers need guidance regarding how the weather will affect them moment to moment in transit. After all, weather is the second largest cause of non-recurring congestion and accounts for a quarter of all delays.

According to the US Federal Highway Administration, nearly a billion hours are lost each year due to weather-related delays. Perhaps more importantly, weather can have a significant impact on people's lives and those of friends and family.

Last year, 7000 people were killed and more than 800,000 people were injured on US roads as a direct result of adverse weather conditions. One of the latest examples took place in April 2017 when eight people died in rain-soaked Houston after they drove into floodwaters or were caught inside their vehicles during a flash flood.

Even with the advent of satellite radio and in-car apps, delivery of weather guidance to drivers hasn't changed much since the first radio was installed in a vehicle 94 years ago. Drivers get very little actionable weather information, with the exception of the radio presenter providing occasional guidance during breaking weather events. There is definitely room for significant improvement in terms of providing real-time updates on weather affecting driving conditions.

Planning

Road weather has been a part of vehicle telematics platforms for some time. For example, nearly a decade ago, the industry saw the introduction of roadway weather information that is focused on identifying location-specific conditions based on a vehicle's current location. A version of this technology has been adapted for use in on-board entertainment or navigation systems in more than 30 automotive makes and models.

The basic information this kind of road weather technology typically features includes forecasts with watches and audible alerts that let drivers get the information without having to take their eyes off the road to view a display. Similar weather systems have been developed for use in several major automotive

manufacturers' vehicles.

As broadband and cellular service became more widely available, interest began to move from the one-way data streams to two-way, connected car applications. The proliferation of OEMs that are including 3G, 4G and proposed 5G wireless mobile technology services in vehicles only increases the availability of road weather safety features.

While improved data pathways are available now, vehicle designers are still trying to determine the best way to interface with newer navigation systems. Interest is high in providing drivers with information on what road conditions would be several days from now, or a kilometre ahead of them.

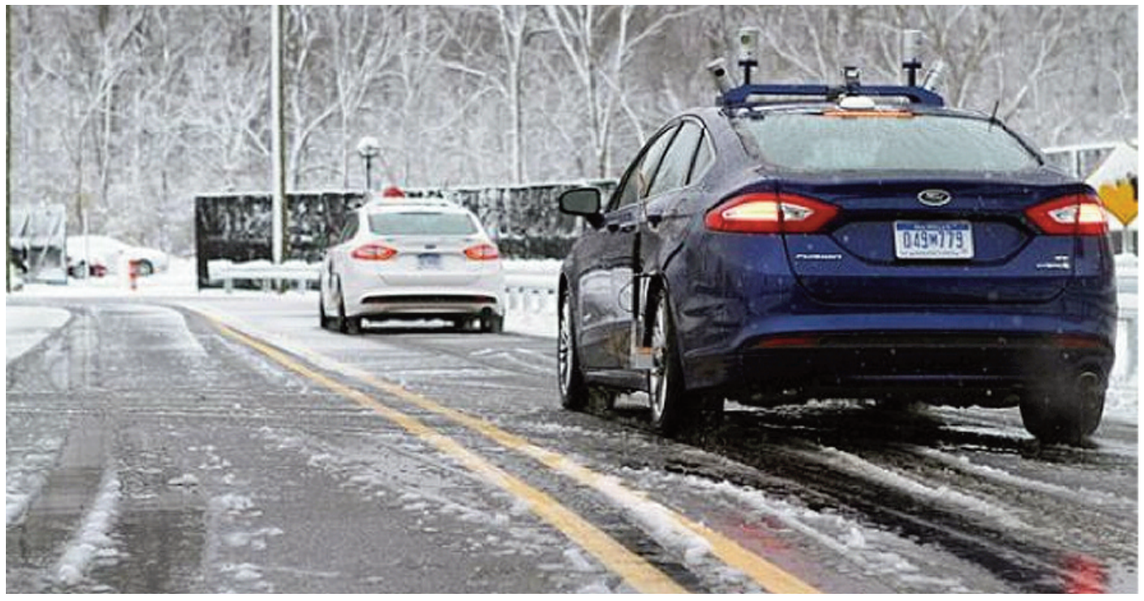
New telematics technology has emerged recently to meet this need, building off of existing weather telematics technology. These platforms use weather archives and offer real-time and archived traffic incident data. These technologies also typically include accurate forecasting of conditions that allow planning to avoid bad roads multiple days in advance. For example, one specific telematics technology has 72-hour forecast conditions and 0.8km resolution, which covers all atmospheric threats that affect vehicles, including winds, hail and heavy rain, as well as road surface conditions such as ice, snow and ponding.

Telematics also makes use of a land surface weather models that analyse conditions from at and below the surface, taking into consideration the surface type. These models also show temperature changes to provide information on whether the temperatures are warming up or cooling down such that ice might be forming.

The minute-by-minute updates enabled by this technology provide drivers with intelligence on what is down the road and what they are going to encounter. Availability of more pre-emptive data in advance will enable drivers to plan better and ultimately improve productivity. For example, if black ice is causing accidents and delays ahead, the driver can be alerted to its exact location and provided alternative routing.

Some of the newest telematics technologies feature easy access to their APIs allowing developers to integrate the service easily into navigation, routing and planning software, mobile apps, and in-vehicle deployments.

In the future, there will likely be multiple delivery methods for weather telematics based on the vehicle's price range. These will range from 4G systems, one-way narrow pipelines into a vehicle to two-way internet connected data connections. Wherever there is connectivity or radio broadcast, there will be a pathway for weather telematics.



Autonomous vehicles being tested in bad weather conditions

Autonomy

In addition to providing access to weather data for driving planning purposes, a robust weather telematics platform has a major role to play in the future of autonomous and/or smart vehicles. For example, the following smart-vehicle features are made safer with high-resolution weather data:

- **Lane-keep assist:** In the lane-keep assist function, the side-view cameras used to detect lanes are useless when roads are snow covered. Weather telematics can provide data to warn the driver and disengage the feature before entering snow-covered roads.
- **Electronic stability control:** ESC works great in slippery wet or icy conditions, but in heavy snow where vehicles get stuck the ESC system can make it very difficult to drive or get the vehicle out of deep snow. Weather telematics can alert drivers of heavy snow-covered roads and turn-off traction control in those conditions.
- **Adaptive cruise control:** During heavy precipitation, radars used to detect traffic just ahead or behind the car can suffer signal loss or attenuation, rendering the system nearly useless. Telematics data can be used to warn the driver of heavy precipitation just ahead so the ACC will disengage. Data on current road conditions can also be used to adjust the distance between cars and speed.
- **Collision warning system:** Radar used to sense objects just ahead is rendered nearly useless during heavy precipitation.



In-car navigation systems incorporate basic weather-forecasting information along with atmospheric conditions for better driver safety and improved decision making.



Better road condition intelligence and location specific alerting is available for implementation for advanced navigation units and the connected car

Telematics data can be used to warn the driver of heavy precipitation and the CWS will disengage. The data can also be used to adjust the CWS timing based on current road conditions.

Conclusion

Technology is available that constantly analyses all roadway conditions in the continental USA and provides location specific information and conditions. This technology can be easily integrated into a variety of telematics platforms to improve driver response time and increase safety. With the technology, drivers can keep their eyes on the road while receiving critical information on approaching conditions.



Glen Denny is president of Baron Services' enterprise division

Lighting software speeds design cycles

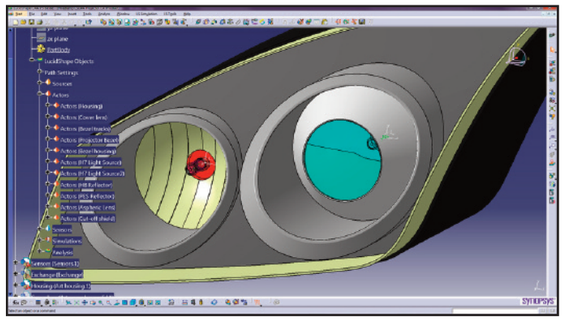
The latest releases of the LucidShape CAA v5 Based and LucidDrive software from Synopsys for automotive lighting analysis and simulation provide features to support faster design cycles, lower development costs and enhanced realism of headlight simulations.

LucidShape provides Catia-based optical simulations of automotive lighting products. The product's modelling and analysis of part-level models and product-level assemblies have been enhanced in this release with a surface sensor for high-accuracy analysis of illuminance and irradiance on curved surfaces.

The surface sensor lets designers analyse the illuminance and irradiance distributions as a false colour map directly in the LucidShape CAA part design view, adjust the scale and colour mapping, interactively measure the value at a specific location of the surface sensor, and export the simulation data to an Ascii file for additional analysis.

Tools have been added for light guide design and optimisation. The light guide module helps designers model and optimise automotive light guides and their extraction features faster and more flexibly. Designers can create, optimise and switch between multiple light guides in a part.

The Bézier Curve preview feature provides the ability to visualise Bézier curves prior to applying them to light guide extractors. Optimisation system types have been introduced so designers can set up and more easily optimise eight standard system configurations, including systems that have sources on both ends of the light guide that can be non-symmetric or symmetric.

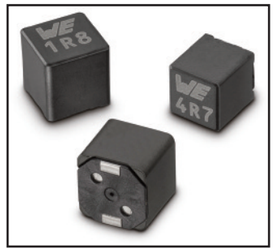


Additional usability improvements include the ability to save and return to optimisation states and create design tables.

With its GPU Trace capability, it takes advantage of graphics processing units to deliver simulation speed increases by orders of magnitude compared with multithreading capabilities. GPU Trace support has been added to the ray history sensor feature to speed analysis of signal lighting functions and reduce the number of design iterations needed to achieve lit appearance requirements and regulatory compliance.

LucidDrive lets designers simulate the performance of automotive headlamps when driving at night. It has seen resolution improvement for pixel light simulations, supporting high-resolution light distributions with the ability to specify a resampling threshold below 0.15˚ for improved visualisation of headlamp pixel light systems.

The vehicle detection feature has been enhanced to allow a higher frames-per-second rating with a larger number of vehicles in the driving simulation.



Current inductor

An AEC-Q-qualified high current inductor from Würth Elektronik uses a patented ferrite core design in the power choke with an air gap optimally centred to ensure a precisely defined saturation current.

The WE-CHSA can be used in temperatures from -55 to +150˚C.

The air gap enables saturation currents up to 54A. The magnetically shielded package assures a low stray field and the embedded solder pads provide coplanarity while allowing automatic optical inspection.

The rated current of the power choke extends to 28A. The product is available in package sizes of 8 by 8 by 9, 10 by 10 by 11 and 12 by 12 by 12mm.

For the rapid development phase, the complete series is available in a design kit.

It is suitable for applications such as in powertrain control devices, infotainment systems or high current applications for e-mobility.

Bidirectional buck-boost controller for redundant battery systems

A 98% efficient bidirectional buck-boost switching regulator controller that operates between two batteries that have the same voltage is suitable for redundancy in self-driving cars.

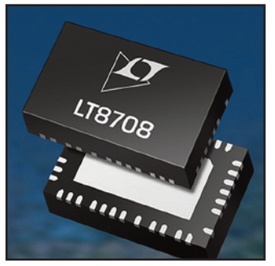
The Power by Linear LT8708/-1 from Analog Devices operates from an input voltage that can be above, below or equal to the output voltage, making it suitable for two each 12, 24 or 48V batteries commonly found in electric and hybrid vehicles. It operates between two batteries and prevents system shut-down should one of the batteries fail.

It can also be used in 48V/12V and 48V/24V dual battery systems.

The device operates with a single inductor over a 2.8 to 80V input and can produce an output from 1.3 to 80V, delivering up to several kilowatts of power depending on the choice of external components and number of phases. It simplifies bidirectional power conversion in battery-capacitor backup systems that need regulation of V_{out}, V_{in}, and/or I_{out}, I_{in}, both in forward or reverse direction. This device has six independent forms of regulation.

Used in parallel with the LT8708 to add power and phases, the LT8708-1 always operates as a slave to the master LT8708, can be clocked out-of-phase and has the capability to deliver as much power as the master. One or more slaves can be connected to a single master, proportionally increasing power and current capability of the system.

Another application is for an input voltage to power a load, where this same input voltage is used to power an LT8708/-1 circuit that charges a battery or bank of supercapacitors. When



the input voltage goes away, the load maintains power without disruption from the battery or supercaps by way of the LT8708's bidirectional capability.

Forward and reverse current can be monitored and limited for the input and output sides of the converter.

All four current limits – forward input, reverse input, forward output and reverse output – can be set independently using four resistors. In combination with the direction pin, the chip can be configured to process power from V_{in} to V_{out} or from V_{out} to V_{in}, suitable for automotive, solar, telecoms and battery-powered systems.

It comes in a 5 by 8mm QFN-40 package. Three temperature grades are available, with operation from -40 to +125˚C for the extended and industrial grades and a high temperature automotive range of -40 to +150˚C.

Leadless mosfets meet AEC-Q101

AEC-Q101-qualified mosfets from Nexperia are rated for use at up to +175˚C and are available in the AOI-compatible DFN2020 discrete flat no-leads package.

They measure 2 by 2mm, smaller and lighter than SOT223 and SO8-packages yet with comparable electrical and thermal performance.



The package's side-wettable flanks enable automatic optical inspection (AOI).

The parts can be used in under-the-bonnet applications, near the engine or gearbox, and suit medium-power automotive applications.

The devices extend the company's low and medium power mosfet portfolio. Six 40 and 60V devices are available with the higher temperature rating and automotive approval, each with $RDS_{(on)}$ between 20 and 40mΩ.

Box PC suits in-vehicle communications

A rugged box PC from MEN Mikro uses AMD's Ryzen V1000 APU for in-vehicle communications.

The BL72E is a robust box PC for rail and public transport markets particularly for on-board uses such as internet-on-board, positioning via GNSS, CCTV and recording, and passenger entertainment.

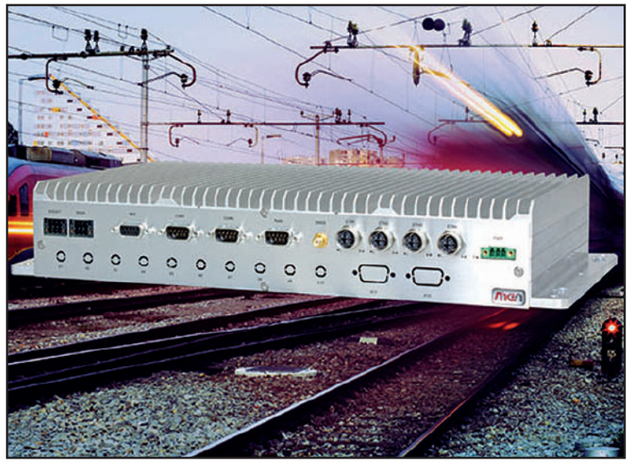
The fanless, maintenance-free box computer is based on the Ryzen V1000 APU family with a Radeon Vega 3D graphics engine. With up to four processor cores and virtualisation support, and up to 32Gbyte soldered-down DDR4 sdram, it can handle data intensive workloads.

To provide internet connection for passengers or locating the vehicle, wireless options include a GNSS positioning interface, two PCI Express Mini Card slots and two M.2 slots for implementing mobile service standards up to 4G LTE or WLAN IEEE 802.11.

Eight externally accessible micro-sim card slots are available. The box can also be delivered with a second IO board offering additional LTE modems, storage and IO.

A Sata HDD/SSD shuttle provides the storage capacity for entertainment servers or video surveillance systems, plus eMMC memory and an M.2 slot for PCIe based storage (NVMe).

It supports one DisplayPort interface with maximum 4K resolution. Other IO is available, including four Gigabit Ethernet, audio, two USB 3.0, RS232, RS422, RS485, Ibis, digital inputs and outputs. An MVB master or slave interface can optionally be implemented.



Mosfets cool on the double

Two 40V n-channel power mosfets from Toshiba use DSOP Advance (WF) packages with double-sided cooling capability.

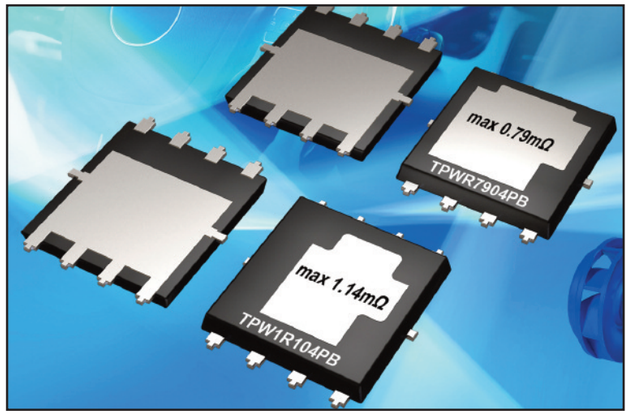
The TPWR7940PB is a 40V maximum 0.79mΩ mosfet in a (WF)L package, and the TPW-1R104PB is a 40V maximum 1.14mΩ mosfet in a (WF)M package. Both are based on the U-Mosix-H trench structure process and are AEC-Q101 qualified.

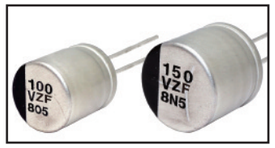
They target automotive applications such as electric power steering, load switches and electric pumps.

The (WF)M and (WF)L are 5 by 6mm packages with eight pins. They differ in their exposed surface area of the top metal plate. The top exposed area is about 8mm² in (WF)M and about 12mm² in (WF)L.

Measured in Toshiba's test environment, the maximum channel-to-top-plate thermal impedance is 1.5K/W for the TPW1R104PB and 0.93K/W for TPW-R7940PB. Their thermal performance is achieved by attaching the top exposed area to a heatsink such as a metal frame via an insulating layer.

The packages are footprint-compatible with an SOP Advance (WF) package that has no exposed top metal area. The (WF)M and (WF)L packages have a wettable flank terminal structure that enables automated optical inspection of solder joints on PCBs. This is important in automotive applications where verification of soldering quality is required.





Hybrid capacitor

A +150˚C conductive polymer hybrid capacitor in through-hole format from Panasonic suits automotive uses.

The ZF series is rated at 1000 hours at +150˚C, enabling devices to support powertrain and engine-mounted applications in the automotive sector. The hybrid capacitors are available in through-hole technology.

Hybrid capacitors suit high-endurance and high-performance applications that also require miniaturisation. The conductive polymer hybrid enables stable and low ESR across the temperature range of -55 to +150˚C.

Ripple currents in the order of 1A rms can be dealt with at peak voltage and temperature while maintaining ESR down to 20mΩ. The ripple current capability, as well as the lifetime of the capacitor, increases as temperature reduces.

A rated voltage from 25 to 63V DC and a capacitance from 30 to 270μF let the capacitors cater to both 12 and 48V systems.

They are RoHS and AECQ-200 compliant.

Buck DC-DC converters suit assisted driving

Automotive synchronous secondary buck DC-DC converters from Rohm have a high reliability and low power consumption in a compact form factor with a temperature range of -40 to +125˚C.

The BD9S products come in a leadless package with wettable flanks. This makes them suitable for applications such as radars, cameras and sensors that can be used for assisted driving.

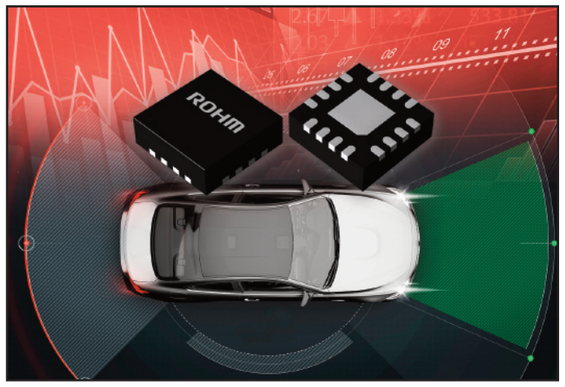
Each device is comprised of a compact, efficient automotive-grade power supply IC that includes an enable function to adjust the start-up time and a power-good output indication to improve system functional safety.

This line supports output currents from 0.6 to 4.0A. It is offered in 2 and 3mm² packages that deliver a power conversion efficiency of 90% at 3.6V input and 1.8V output.

Additionally, the current mode control ensures fast response to load transients and, combined with a fixed 2.2MHz switching frequency, it prevents interference in the AM band. This higher frequency allows use of smaller external components.

A dedicated light load mode improves efficiency in the lower current load region.

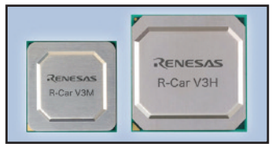
Applications include adas sensors, cameras and radars, and drive recorders.



Processor eases camera development

An integrated open image signal processor (ISP) can help develop automotive smart camera applications based on the Renesas R-Car V3M and V3H systems-on-chip (SoCs).

Integrating the ISP on the SoCs and leveraging MM Solutions' Auto CDK automotive camera development kit, the ISP helps automotive tier-ones simplify sensor calibration and tuning for camera applications, including front camera and surround view.



Part of the firm's Autonomy platform, it helps users tune and control their sensors to support human and machine vision. Integrating the ISP vision processing software onto the SoCs provides a camera-neutral approach, offering camera makers and tier-ones the flexibility to work with ECUs and sensors.

The open ISP supports sensor resolutions with high pixel processing capabilities for use in multiple camera use cases. The integrated ISP feature includes shading correction as well as local and global tone mapping.

Board edge connector

Yamaichi Electronics has extended its MXM family of automotive board edge connectors with a 314-pin variant.

Developed about six years ago, they were the first connectors for modules meeting the MXM and QSeven standards with 230 pins and a 0.5mm pitch. In 2013 a 230-pin high-speed version for applications to 5Gbit/s was launched.

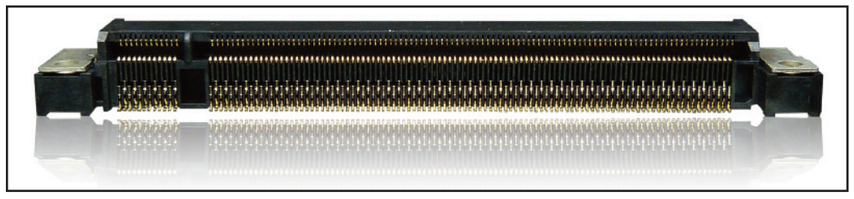
To meet the requirements of MXM 3.0, the 314-pin variant sits alongside the 230-pin high-speed version.

The contacts have the characteristics needed to ensure a stable contact force even when subject to vibrations and shock. The spring characteristic of the contacts also permits tolerance compensation and reliable data transmission if modules with dimensions close to the tolerance limits are used.

An added feature is the extended function of the module's side screw fitting. The tabs on the screw fitting can be folded out to facilitate insertion of the PCB. Following module assembly, the tabs are returned to their original positions and screwed from above to the module and the connector. Thus the module is securely fastened to withstand vibrations and shock.

The enlarged SMT tabs are used for the ground connection and for the SMT connection – along with the 314 contacts – to the motherboard.

The connector is available with a 0.1μm-thick gold plating in the contact area. It is packaged and delivered in tape and reel.



Chipset supports DSRC and C-V2X

A V2X chipset from Autotalks can support DSRC and C-V2X direct communications (PC5 protocol) at the highest security level. The chipset supports DSRC based on 802.11p and ITS-G5 standards and C-V2X based on 3GPP specifications.

While DSRC-based V2X is deployed in the USA, Europe and Japan, C-V2X is gaining momentum in other regions.

Delivering dual-mode functionality on existing automotive qualified AEC-Q100 grade two chipsets, while leveraging production grade software and maintaining the present API, can shorten time to market.

The PC5 part uses the 5.9GHz ITS spectrum for V2X and is cellular network agnostic; no cellular sim or coverage required, and it works without or with any 3G, 4G or 5G cellular modem.

Separating V2X from the cellular network access device can improve the cost-effectiveness of telematic control unit deployments. The separation of V2X from in-vehicle infotainment ensures that the purpose of the V2X system, which is giving drivers alerts of on-road dangers, is not compromised.

V2X isolation is combined with the firm's cyber security platform.



Rugged Ethernet connector

Suitable for armoured vehicles, a high-speed connector from Amphenol Socapex is a cat 6A, 10Gbit/s Ethernet device in a MIL-DTL-38999 series III derived shell.

The μCom series is a range of Ethernet connectors designed to meet the requirements of military trends such as miniaturisation, high speed and robustness for use in harsh environments.

The TVμCom-10Gb+ exceeds 10Gbit/s according to the IEEE 802.3an-2006, 10GbaseT standard, and the 38999 shell provides environmental resistance.

A reduced flange version is available for jam nut receptacles to reduce the panel footprint.

This connector is suitable for applications such as high definition and high-speed video, uncompressed real-time video over IP, 10Gbit/s Ethernet switches, vision systems for armoured vehicles, and high-speed mobile terminals such as for satellite reception stations and radios.

SBCs support Can FD protocol

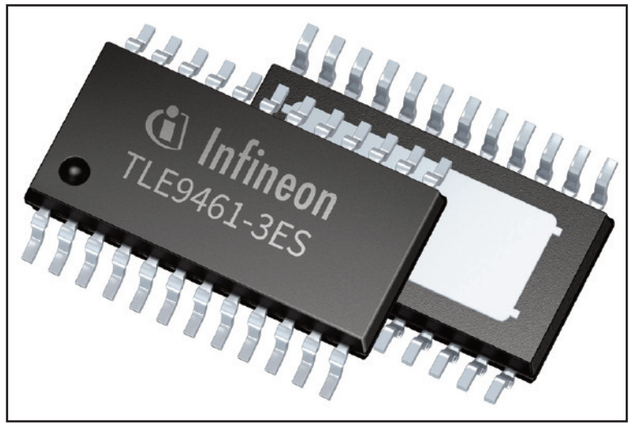
Two system basis chip (SBC) families – Lite and Mid-Range+ – from Infineon support the ISO Can FD protocol for communications at 5Mbit/s for automotive applications.

An SBC is the central supply of power and communications for microcontrollers within ECUs in cars. They are ICs that combine voltage supplies, Can and Lin communications bus interfaces, and supervision features. The combination of these three elements in one chip leads to lower costs and up to 80 per cent smaller footprint.

The Lite devices are the lower cost, entry level SBCs. They incorporate one Can transceiver to address applications such as in-cabin wireless charger, NOx sensor, gear shifter or light control units. The Mid-Range+ devices are more powerful with one Can and up to two Lin transceivers to support, for example, body control and gateway modules.

Today, the communications within the car and its connectivity to the outside world require an increased bandwidth and longer payload. For example, high-end front light applications such as matrix LED lighting require a large amount of data provided by camera systems and sensors to ensure a glare-free high beam.

With their optional partial networking feature, they reduce current consumption by putting the ECU in a sleep or stop mode when it is not needed. The Lite family



also has a charge pump to drive high side n-channel power mosfets. It can disconnect an external load during sleep mode to reduce quiescent current.

All devices include diagnostic and supervision features to support ECU functional safety concepts such as under-voltage monitoring, window watchdog with reset, fail-safe operating mode and fail-safe output. Moreover, with the Mid-Range+ family, external loads can be driven by four high-side switches.

They are scalable regarding the number of communications interfaces and are software compatible with other SBC families from the firm such as the DC-DC and Multi-Can power devices.

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