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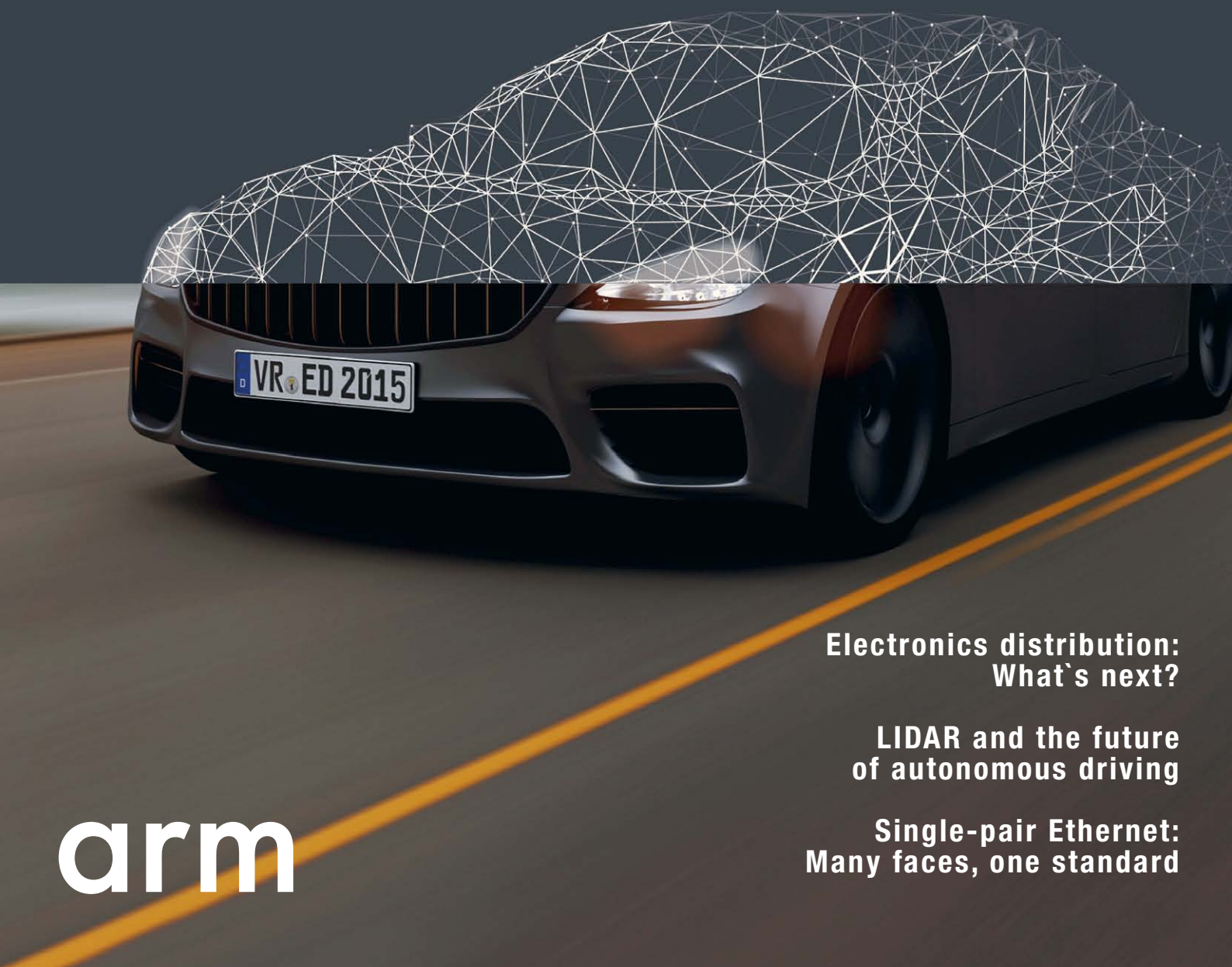
# Elektronik

11. February 2020

INTERNATIONAL

Machine learning in MCUs refine data at the source

# AI FOR IOT




**Electronics distribution: What`s next?**

**LIDAR and the future of autonomous driving**

**Single-pair Ethernet: Many faces, one standard**

arm

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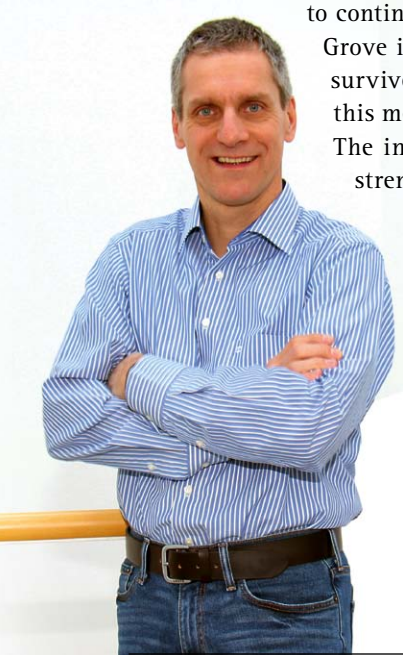
# SENTIMENT BETTER THAN NUMBERS

The German electrical and electronics industry has a mixed start to the new year 2020. New orders received by the key industry in November 2019 have slumped by almost 12 percent compared to the previous year 2018, as the ZVEI (German association of the electrical and electronics industry) economic barometer January 2020 has determined. Domestic orders fell by 15.3 %, and 8.9 % from abroad. The drop in incoming orders from January to November 2019 was less dramatic. It amounted to 3.4 %. However, this is no reason to sound the all-clear, as the decline in incoming orders accelerated until November.

Incoming orders naturally have a delayed effect on sales. In November 2019, the electrical engineering companies had to cope with a 4.6 % slump in sales compared to the previous year, with sales of €16.5 bn., whereby here too the domestic market weakened more than the international market. From January to November 2019, the sector generated sales of €175.2 bn., which corresponds to a still moderate 1.5 % drop in sales. Here too, the bottom has probably not yet been reached.

What is surprising, however, is that the business climate in the German electrical and electronics industry continued to improve in December 2019, reaching its highest level for half a year. Less surprising in view of the above figures is that the current assessment of the situation is lagging behind business expectations. Cautious optimism seems to be spreading for the future. 18 percent of companies rated their current economic situation as good, 63 percent as stable and 19 percent as poor. For the next six months, 22 percent expect business to pick up, 54 percent expect it to remain stable and 24 percent expect it to decline. Here the development at both ends of the scale seems to polarize into winners and losers, which is not a good sign for the entire electrical and electronics industry. It smells more like a selection process.

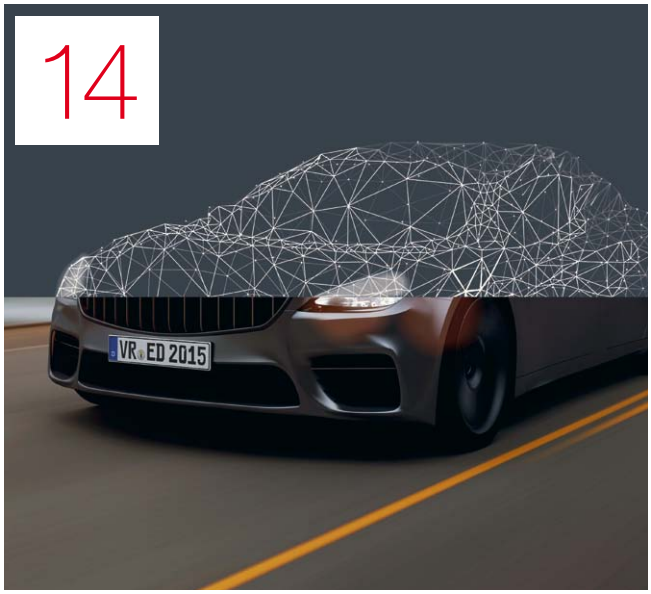
What can the industry do? It is only with new technical developments that new business areas typically open up. So it is important for the industry to continue to invest in research and development. Andy Grove is credited with the bon mot “only the paranoid survive”. Transferred to the German electrical industry, this means innovating to the max.

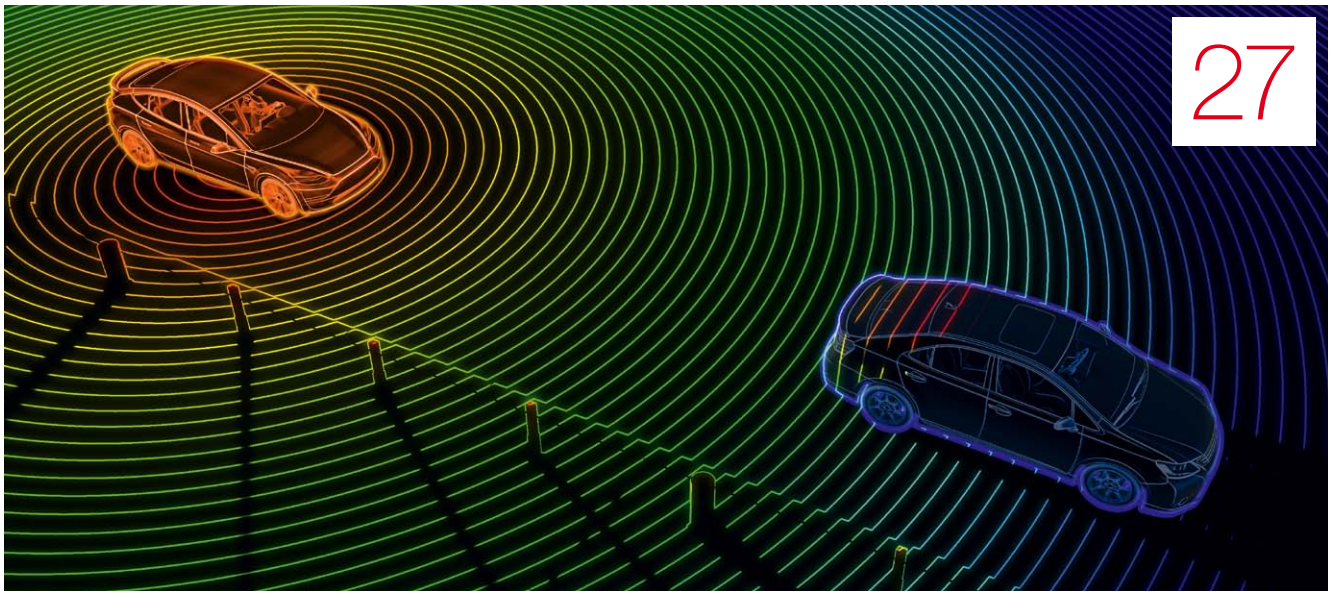


The industry must therefore maintain its innovative strength and best of all expand it, but not alone. Politics must set reasonable framework conditions, and society should let scientists and engineers contribute in solving the society‘s most pressing problems, such as global warming and an ageing population. Scientific progress is part of the solution and not part of the problem.

GERHARD STELZER

Editor-at-Large
Twitter: @GerhardStelzer
Mail: gstelzer@weka-fachmedien.de



## OPTOELECTRONICS



## CONNECTIVITY

ELECTRONICS DISTRIBUTION 2020

# WHAT'S NEXT?

Scarcity of components, slowdown in turnover and orders, constantly changing general conditions – a lot has been happening in the past year for electronics distribution. And what does it look like in 2020? What are the trends, what the major challenges? We asked around among stakeholders in the sector.

By Cornelia Meier

(photo: pichit | Shutterstock)

DIGI-KEY

# "CUSTOMERS NEED TO INTERACT WITH THE DISTRIBUTOR AND SUPPLIER AS ONE ENTITY"

DAVE DOHERTY

is the president and chief operating officer of Digi-Key Electronics, the leading global electronic components distributor. Under Dave's leadership, Digi-Key has expanded its global presence and exceeded the $2 billion mark in annual sales. Dave is a long-time veteran of Digi-Key and previously served as the vice president of global supplier and product operations. Prior to Digi-Key, Dave was vice president of marketing at Arrow Electronics. Dave holds a BSEE from Worcester Polytechnic Institute and an MBA from F.W. Olin Graduate School of Business at Babson College.

**What are the biggest supply chain challenges your customers face today? And how do you support your customers?**

Doherty: Micromanufacturing is allowing customers to provide greater end-customer segmentation and tailoring of their offerings, which has led to smaller production runs and a reduced ability to forecast end-customer acceptance and demand. This is occurring simultaneously to traditional distributors continuing to optimize their supply chain to a higher turns model. The convergence of these two forces has led to a heightened need for a high-service, inventory-rich model to support these realities. Digi-Key's model meets that need, built on high availability of new product introduction (NPI) and legacy products. High manufacturer minimum order quantities have allowed us to continue supporting low- to mid-volume customer production requirements.

**Do you see changes in the relationship between manufacturer and distributor? If so, which ones?**

Doherty: Relationships continue to evolve, but always with the goal of enhancing the customer experience. Digitalization and e-commerce strategies will continue to offer capabilities for suppliers and distributors. Customers still prefer the broad search and purchasing capabilities and high services available through distribution, while often relying on first-hand technical content for products identified from specific suppliers. Our mission is to make that process seamless by allowing the customer to interact with the distributor and supplier as one entity.

**Is there any news in your company regarding expansion, strategy or the like?**

Doherty: Digi-Key's new Product Distribution Center (PDC) will be the largest facility in the world committed to shipping custom, broken manufacturer pack quantities to meet our customers' exact requirements. The new facility will be complete by mid-2021. Digi-Key has also invested in numerous behind-the-scenes technology enhancements to maintain digital leadership. Customers will see evidence of these investments in an improved search experience, as well as a better personalization of Digi-Key's website. Digi-Key also offers the widest selection of component- and automation-level products to select from, including an enhanced Bill Of Materials (BOM) Manager, quoting and API tools.

GLYN

# "MARKETS ARE DEVELOPING AFTER THE HYPE"

THOMAS GERHARDT

is managing director of Glyn. He has played an active role in developing the company for 24 years. After studying information electronics and communications, he first gained experience in distribution at Spoerle (now Arrow).

**What do you see as decisive innovations and trends over the coming 12 months?**

Gerhardt: Well, the technology trends most spoken of at the moment are no doubt 5G, autonomous driving, electromobility, and artificial intelligence. Industry 4.0 or IoT may no longer be as topical as they once were, but they're being implemented. A large number of projects in these and collateral areas are already under way or due to start. Some of them also going into series. We tend to believe that there might be big returns right after all the hype. But the truth is that the markets develop and build up over long periods. In reality, things don't usually start picking up until the hype has long died down. In any case, the large number of topics give us a positive view of the future. The general trend to more electronics in all areas of our lives is bound to persist.

**What's the significance of environmental aspects for distribution?**

Gerhardt: There's a lot of room for thought, for differentiation. On the one hand, you can't compost electronic products, and there's still much potential in the current recycling chain. On the other hand, the majority of people would like to keep or even better their standard of living. Organizing that at the cost of less energy calls for more smart electronic solutions. And electronics also helps in the longterm transformation of mobility to electric engines, saving fossile resources. In that respect it makes a considerable contribution to protecting the environment accompanied by growing prosperity or economic vitality. As distributors we do our bit by covering much of our power need from our own solar installation. And by making the supply chain as efficient as possible through sophisticated software systems and logistic concepts.

ANDREAS MANGLER

studied physics at the Karlsruhe Institute for Technology before receiving a degree in electrical engineering from Karlsruhe University in 1988. He then commenced his career as an analog designer in applied research at IBP Pietzsch before going to Burr Brown/Texas Instruments. In 1995 he became head of marketing communication at Rutronik, holding a number of positions until appointed director of strategic marketing and communication in 2013.

RUTRONIK

# "WHAT'S LACKING IN EUROPE IS IMPULSE FOR GROWTH"

**How do you see the electronics market developing in 2020, in general and for distribution in particular?**

Mangler: Viewed worldwide after a retreating market in 2019, the forecast for 2020 is back up, as the figures from IC Insight also evidence. Here the Asian market is the driver; Europe is currently lacking impulse for growth. The distribution channel may serve many different market segments, but compensation of the slackening automotive market with its ecosystems is a challenge.

**Are the demands made of distributors changing? And if so, to what extent?**

Mangler: The distribution market is in a state of constant change. In the 20th century you had uniquely defined business models of distribution and thus clear spreading of roles. Today mixed and overlapping business models and numerous online services compete for the customer's attention. Rutronik closely watches the developments and continually matches its processes and services to offer the customer allround support.

**What are the biggest demands in the supply chain confronting your customers? And how do you support them in this?**
Mangler: Maximum service level for as little inventory as possible, efficient processes, low lockup of capital, and scaleable, batch-optimized procurement – that's the cut and thrust of how and where we operate. Given so many variables in the logistics chain it's essential to harmonize closely with the customer. Demands can only be jointly mastered through open, personal communication and commitment. Digital processes in procurement are an important building block of course.

MOUSER

# "THINGS HAVE BOTTOMED-OUT"

GRAHAM MAGGS

joined Mouser in 2010 and heads the EMEA marketing team, playing a major role in its development. He is responsible for supplier marketing, web marketing, advertising, public relations, media and events.

**How will the electronics market develop in 2020 in general and for distribution in particular?**
Maggs: We expect to see a slight upswing in 2020. The market has been pretty flat this year after, it has to be said, phenomenal growth in 2018. But we think things have bottomed-out and that 2020 should see modest growth. At Mouser, the only sector that is down is EMS, but we have to acknowledge that our performance in 2018 in this sector was heavily influenced by shortages, which now, largely, do not exist. Brexit and other potential ‚trade wars' of course have a knock-on effect, and we may well see specific shortages in some areas because of this. Yet because Mouser ships from the USA and because we deal in over 220 countries and regions worldwide, we like to think we have seen the issues before and have put in the appropriate contingency plans. One interesting development is that some semiconductor and component makers are looking to stop their authorised supply chain partners from selling to other distributors. This could cause significant disruption in the market if it becomes a trend followed by many major names.

**Do you see changes in the relationship between manufacturer and distributor? If so, which ones?**
Maggs: Yes (laughs). Every manufacturer treats its distribution network differently. At one end of the scale, some operate in true partnership with their distribution partners. In stark contrast, with others it almost seems like the manufacturer is in competition with their chosen distributors. eCommerce is a particularly tricky area, as many manufacturers offer eCommerce facilities on their websites, with eStores, and this can seem to be a challenge to distributors.

AVNET EMEA

# "AUTOMOTIVE AND INDUSTRIAL ARE GROWTH MARKETS FOR EUROPE"

GEORG STEINBERGER

is vice-president of marketing and communication at Avnet EMEA with many years of insight into the distribution sector. He is also chairman of the German association of components distributors (FBDi) and of the European equivalent DMASS.

**What innovations and trends do you think are decisive in the upcoming 12 months?**

Steinberger: What's set to shape 2020 is the widespread implementation of 5G, everything in and around IoT, and artificial intelligence. Not to forget edge computing, of which there's heated discussion.

**For which markets do you expect the most growth in 2020?**

Steinberger: These will continue to be smartphones and tablets. The automotive and industrial markets are very important for Europe, and here we expect a return to growth.

**Are the demands made of distributors changing? If so, in how far?**

Steinberger: Naturally they're changing, otherwise we'd have a standstill. Distributors are reacting faster and more effectively. Much is already and is continually being automated, like quoting and delivery. Standard processes are increasingly being automated and digitalized.

**What are the biggest demands in the supply chain confronting your customers today? And how do you support them?**

Steinberger: More exclusive contracts between distributors and producers lead to more dependence for all parties – single sourcing, price dependence and customer dependence. Whether that's competitive longterm remains to be seen.

RS COMPONENTS

# "DISTRIBUTORS MUST OFFER SOLUTIONS"

**What do you see as decisive innovations and trends in the upcoming 12 months?**

Lampert: Industrial IoT and thus Industry 4.0 are bearers of the next industrial revolution and will produce the major innovations in the next 12 months. The importance of predictive maintenance will increase for example, where systems can produce very accurate information on the condition of critical components. Preventive action based on this knowledge can then forestall a

JÜRGEN LAMPERT

has been with RS Components for more than 15 years, since 2018 as vice-president for Central Europe. He started his career in sales and subsequently held management positions in Germany and Central Europe.

costly standstill. This is where we want to support our customers by offering the right products and information.

**Are the demands made of distributors changing? And if so, to what extent?**

Lampert: We reckon that distributors will increasingly play the role of a provider of solutions. Web-based services will be important, going beyond a selection of products. So in future distributors must be more present in search machines, websites of manufacturers, online magazines, forums or communities, and offer free download design tools. The use of social networks changes the way of spreading information. The trend is to increased use of open-source offerings. Consequently we're also offering freely available tools through our DesignSpark ecosystem.

**Is there something new to report of in your company in the way of expansion, strategy and the like?**

Lampert: In June 2019 we announced expansion of the Bad Hersfeld distribution center. That's part of the strategy of a scaleable supply chain better oriented on the customer. The €65 million project will enlarge and further automate the distribution center. From the first day it'll operate with double the capacity. It's to be working fully within two years and with floor space of 35,000 square meters can serve customers in Germany and many other European markets.

CONRAD

# "FLEXIBILITY IS WHAT'S EXPECTED"

**In which markets do you expect the strongest growth in 2020?**

Fuchs: In discussions with our customers, we find that no matter what sector they are involved in, they are increasingly working with applications in and around the Internet of Things. We assume this development will continue in 2020, above all in predictive maintenance. In particular, there will be greater demand for products such as sensors, controllers, wireless modules and the test and measurement technology. We are expecting a strong development in the sector of electromobility, too.

**Is there a change in demands made of distributors? And to what extent?**

Fuchs: In our view demands will change increasingly where profit margin, availability, and timing are concerned. In terms of margin, more and more customers would like to buy at lower cost and/or higher discounts. However, not every manufacturer understands why a distributor should receive better terms. Good cooperation with both customer and manufacturers alike is essential. Where availability is concerned, especially in difficult times like the present, many try to reduce their stock little by little. From the distributor, in turn, customers expect much more flexibility and taking over the warehouse storage risks.

**Is there anything new to report from your company where expansion, strategy and the like are concerned?**

Fuchs: In 2020 we will continue to invest very much in our Conrad Connect platform. It enables linking of intelligent products and services with relatively little effort, and automating processes or operations. In the meantime many customers are using Conrad Connect for automated solutions in warehouses, offices or production halls. Additionally we're in the process of changing our business model, from a classic e-commerce provider to a marketplace for business customers. This change results from the fact that many of our customers have less and less time to spare and appreciate a platform on which they can order possibly as many different products as they need. For this purpose we continue to expand our marketplace, which started in May 2017 and currently comprises more than five million products. But from numerous conversations with customers, we know that personal support, a strong and competent field service and front office, support from the branches is still required.

STEFAN FUCHS

has been vice-president of online sales DACH at Conrad Electronic since September 2019, and is responsible for customer care and digitally managed customers. Prior to this he held the position of general manager of B2B Deutschland for five years.

REICHELT

# "2020 WILL BE A YEAR OF MAJOR CHANGES"

CHRISTIAN REINWALD

has been a member of the executive since January 2017 and heads product management and marketing at Reichelt Elektronik in Sande. He was previously responsible for mail ordering at ELV Elektronik in Leer, and held a number of management positions in international marketing and e-commerce at Farnell, Conrad and Quelle.

**How will the electronics market develop in 2020, generally and for distribution in particular?**
Reinwald: Even if recently there's often been talk of a recession, some indicators still point to further growth in the electronics market for 2020. What we can say for sure is that 2020 will be a year of major changes in the sector. With ever advancing digitalization and fundamental technology changes there's potential to create new possibilities for research and production. The expansion of 5G, for instance, is indispensable for further developments in autonomous driving and the smart factory. Ultimately that will also have its effect on the electronics market.

**In what markets do you expect most growth in 2020?**
Reinwald: Those are numerous and diverse. We see the biggest growth in components, household and security technology, and networks. There's also an especially promising forecast for development boards and embedded systems as well as lighting, test and measurement, and workshop supplies.

**What developments will we see on the end-markets?**
Reinwald: For 2020 we expect the creation of the 5G network, bringing along new possibilities for companies and end-users. We're convinced that developments in automation and robotics will take a giant step forwards. We expect machinery to become better and more efficient, and that robots will be able to undertake increasingly complex tasks. A further point is e-mobility.

**What are the biggest challenges in the supply chain facing your customers? And how can you support customers in this?**
Reinwald: Our customers expect us to deliver consistent quality by set schedules and at fair prices. They need security of planning so as not to endanger their continuum of manufacturing.
On the other hand, they need speedy delivery of very small quantities and innovative products for research and development projects in order to build prototypes and get these into production fast.
We're very well networked with partners and suppliers, and have maintained and promoted these relations for many years. Plus, our Information Technology and logistics systems are developed inhouse and perfectly match our high standard of efficiency as they can be adapted fast and flexibly.

FARNELL

# "WE'RE LOOKING TO A NEW GENERATION OF DEVELOPERS"

**On which markets do you expect the strongest growth in 2020?**
Ertl: The industrial sector looks highly promising, not least because of the really big potential presented by the use of sensors, artificial intelligence and automation in fabs and warehouses. Intelligence now supports entirely new areas, from asset tracking through to machine maintenance. The challenge facing the market is that this kind of technology wasn't in use before and companies don't have the right people to master it. As a result companies will have to engage electronics developers who are able to implement and operate the technology in sales or manufacturing capacities.

**Do the demands of distributors change? In what way?**
Ertl: In 2020 the demands stay high and will probably continue that way. A new generation of developers who have

grown up with personalization in the consumer sector now expect the same in the business sector. The online trend is present, real and irreversible. Farnell offers e-commerce solutions enabling a faster search for the right product. The depth and breadth of the product offering were expanded so that customers fast obtain all products they need.

Distributors must adjust to changing customer requirements to be able to respond flexibly to customer wishes. That not only means online possibilities and speedy delivery of products. Customers want inclusive support, whether online, personal or by phone, in their own language, plus extra services like re-reeling, date and lot codes.

**How is the electronics market going to develop in 2020, generally and for distribution in particular?**

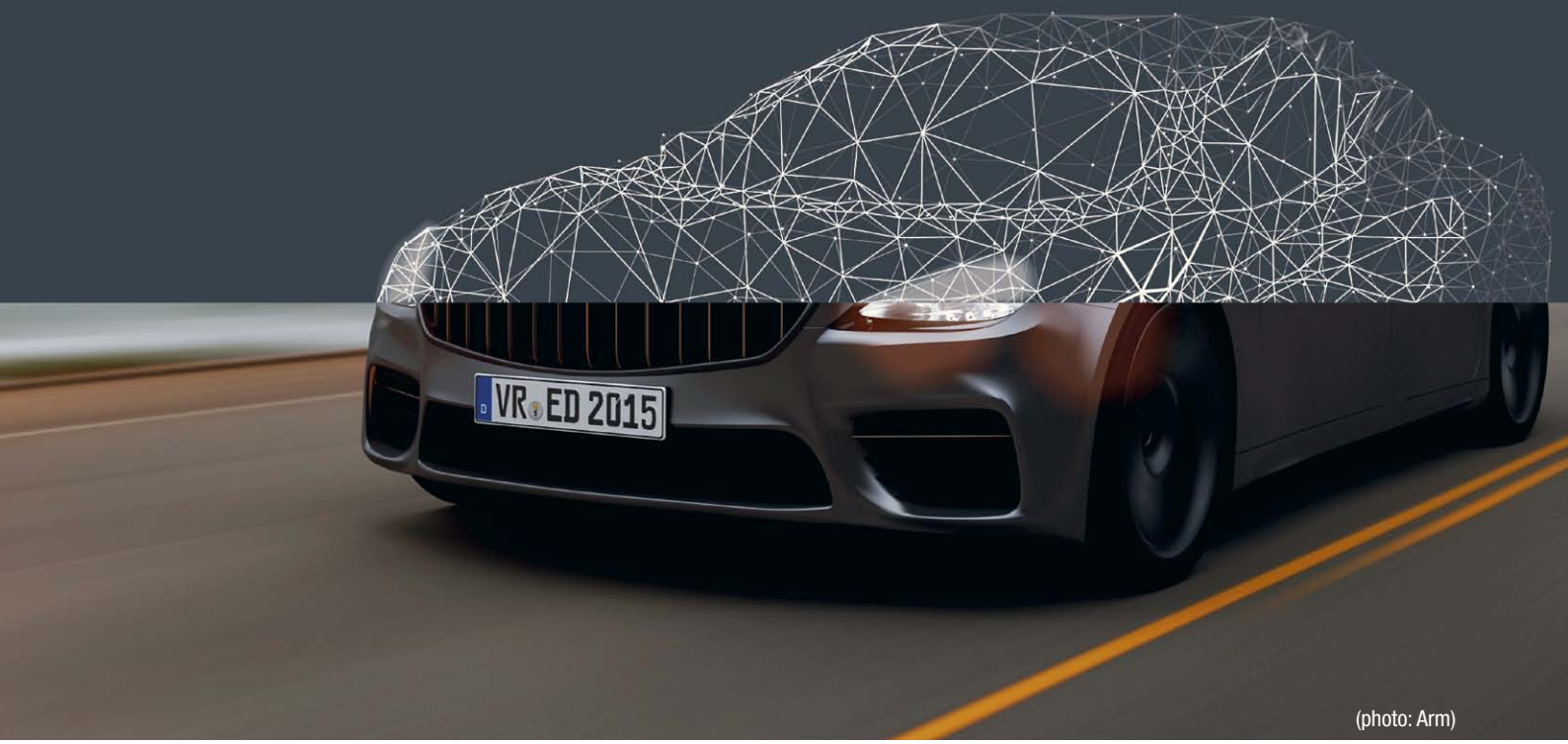
Ertl: 2019 was a year of political uncertainty and economic headwind. That will continue to affect distribution in 2020. Challenges in the automobile industry, like smaller demand, car-sharing, changed legal requirements, not least in connection with $CO_2$ emissions, and global trade wars, have contributed to a recession in this market segment. Despite the macroeconomic factors the electronics market continues to offer large potential. In development in particular we see demand for and interest in new technologies like artificial intelligence, and increased demand for IoT in the industrial sector. JL

SUSANNE ERTL

joined Farnell in 2010 and has held various positions in the sales organization, including front office, field service, telesales and customer service. Now as Director of Sales and Commercial Center DACH she is responsible for further developing Farnell's multichannel service and sales offering.

MACHINE LEARNING IN MCUs REFINE DATA AT THE SOURCE

# AI FOR IOT




(photo: Arm)

Data has often been described as ‚the new oil' because of its ability to fuel new economic growth. We can move that thought on, considering it also as the new water – because it's going to flow everywhere, bringing life to new business, services and technology. But like making oil and water fit for human use, data has to be captured as efficiently as possible, purified and refined. It must then be delivered to the right place at the right time. Enter the Internet of Artificially Intelligent Things, or AIoT; a new driver for data harvesting, processing and delivery, applying machine learning techniques to small, connected devices.

By Thomas Lorenser

The tech sector thrives on acronyms. Here's one that's fast-gaining traction: The AIoT. It represents an Internet of Things (IoT) enhanced by Artificial Intelligence (AI). This isn't technology marketers inventing a new term for the sake of it, it is the description of a new compute evolution where IoT devices are being rapidly supplemented with AI capabilities.
AI is a force multiplier for embedded and IoT deployments, driving advanced processing down into endpoint devices and enabling them to do far more. Gartner predicts that by 2022, more than 80% of IoT projects in the enterprise will include some form of AI; today this is figure is nearer 10%. There are many examples of endpoints employing AI already; notably smartphones running on-device capabilities such as facial recognition for handset unlock or categorizing photos. Voice recognition is also rapidly becoming a ‚classic' AI-driven feature, both for smart phones and smart speakers. For IoT to scale and for companies to take advantage of the enhanced insights and experiences offered by advanced AI, small IoT devices must become more capable of on-device processing, shifting compute closer to the source of data. The first generation of smart speakers typically used a high-performance application processor (such as an Arm Cortex-A CPU) to handle the wake word, then offload the speech processing to a data center.
Smart speaker technology has progressed to using a microcontroller processor (such as an Arm Cortex-M CPU) for the wake word, coupled with an applications processor for sending the speech to the cloud to process. Amazon, for example, recently announced their Alexa Voice Service (AVS) integration for AWS IoT Core, making it easier and more cost-effective for developers to add Alexa Built-in capabilities to small devices powered by Arm Cortex-M processors – however, the bulk of the processing is still done in the cloud. Smart speakers are almost entirely supplied by one of the ‚Big 5' tech companies, so they have the data center resources needed to support what could amount to many millions of requests per second from a global customer base.
Some companies are cutting the cord to the cloud even further, such as Snips, an Arm partner and member of its Innovator Program. Snips has developed voice recognition technology that runs at the endpoint, recognizing wake-words and a host of other commands locally on the device, using both microcontroller and application processors. Snips says there are many benefits from taking this AIoT processing approach – notably security, privacy and faster response times since there is less reliance on the cloud and gateway. Also, because an AIoT system doesn't rely on external connectivity, it is more resilient, easier and cheaper to scale.
In the future, technologies like Arm Helium, that bring an uplift in digital signal processing (DSP) and machine learning (ML) for future Cortex-M processors, will enable endpoint AI devices, such as smart speakers, with even more on-device processing capability and make it even simpler for software developers to implement.

Figure 1: Endpoints such as smart phones are using AI to change the way we interact with technology. (photo: Arm)

## DISTRIBUTION OF DATA PROCESSING FROM CLOUD TO ENDPOINT

While there are many, many companies deploying IoT, there is a strong underlying cohesiveness driven mainly by the Arm architecture, upon which most devices tend to be based. The AIoT will have the same characteristics, so as the ease of adding intelligence to IoT devices increases, we can expect competition in end products to rise in nearly every market. The nature of how the AIoT will work in practice is also in line with the much-needed distribution of computing. We already see more compute power moving from the datacentre into the network at the furthest edge where network gateways sit. Beyond that, we also see AI moving out into endpoint devices to improve decision-making latency and take cost out of the system. This new model will not replace the old one entirely, but will complement it by spreading computing process between cloud, edge and endpoint. This hybrid system will be far more sustainable in resilience terms, and in literal sustainability terms by reducing the energy footprint of our industry.

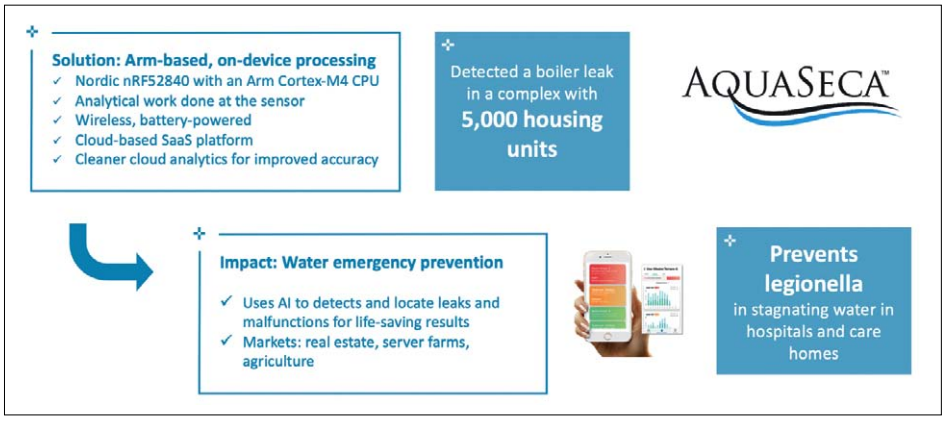



Figure 2: Aquaseca shows the impact an endpoint device using ML can be to help real-world issues. (photo: Arm)

AI and Machine Learning rely heavily on data, this is generally accepted. It is also generally believed that the processing power needed to handle that data is huge and, here, opinions start to diverge. Yes, it is indisputable that creating an AI model requires a large amount of data and an even larger amount of data processing, but once the model is created it can be deployed in endpoints with much more modest resources. This is the essential difference between training and inferencing. The former requires large amounts of processing power, often in the form of GPUs or HPCs running in racks found in data centers, but the latter is effectively code that can be deployed on almost any platform.

It is also important to understand how AI and Machine Learning differ; ML is a subset of AI and is most often deployed as a trained model that can infer, from data provided, what action to take. In most cases, and particularly in AIoT endpoints, there will be little or no reinforcement learning at this point; the inferencing will not get more (or less) accurate over time unless positive feedback is applied, which would subsequently change the model. This would typically require further training, which is not the scenario most associated with putting ML into small, low-power endpoints such as smart sensors and smart actuators.

By making this declaration, it becomes clearer how ML can be deployed in low power microcontrollers in small endpoints, and the benefits this can bring. It also highlights why those companies keen to deploy ML in endpoints will be more reliant on embedded technology providers to help them achieve that. This is a real opportunity for growth in the embedded sector, presented by creating an environment that supports ML in endpoints.

## REAL-WORLD EXAMPLES OF ML IN ENDPOINTS

Initial examples of how ML is making endpoints smarter and having a measurable impact on profitability and safety involve using AI to move from periodic maintenance to predictive maintenance. For example, EDGXL is an ultra-low-power inferencing technology developed by INFXL for deployment in resource-limited endpoints. The company took run-to-failure data from 21 sensors in a turbo propeller aircraft to train its EDGXL module. Based on a dataset of some 34,000 histories, gathered using sensors including temperature, pressure, RPM, fuel flow and fuel-air ratio, it was able to train the AI to predict a failure with 95% accuracy. Despite this, the model runs on a Cortex-M0 MCU, requires just 17kbyte of memory and consumes µWs of power.

AquaSeca has developed an Arm Cortex-M4 based vibration sensor that attaches to a water pipe to form a simple and low-cost method for detecting the relative flow of water. Any changes to the vibration signature would indicate cause for alarm, such as the faster flow caused by a leak, or the impeded flow caused by a blockage. The tell-tale vibrations that result from these kinds of faults can be detected by the sensor and the causes inferred using ML. The AIoT system can then alert the owner before the fault escalates, with a real-world impact of detecting a boiler leak in a housing complex of over 5,000 units and preventing legionella in stagnating water in hospitals and care homes. Today, the AquaSeca sensor sends its data to the cloud, but they plan to put all of the ML inference inside the sensor itself.


(photo: Arm)

Figure 3: Inferencing in security cameras will enable faster actions, by detecting the presence of an unknown person, identifying a package and inferring whether the person is delivering the package or potentially stealing it.

These and other examples like them illustrate how few resources ML really needs in an endpoint to deliver highly accurate predictive maintenance, but it is also being used to predict other things. For example, a smart sensor equipped with ML inferencing is being used to detect when a vulnerable person may have fallen or has been inactive for 'too long'. What constitutes a fall or long periods of inactivity is, of course, subjective, but through AI that subjectivity can be largely removed based on trend data used to train a model to recognise the pertinent signs.

A common theme with these examples is how movement in one form or another is being used to create datasets. Rather than absolute motion, the commonality here is relative movement and often something as simple as vibration. This is a form of movement that modern sensors are extremely adept at detecting and one of the most versatile forms of data gathering; vibrations convey more than just movement because the signatures can tell us much more.

## DEPLOYING ML IN ENDPOINT DEVICES

Conventional embedded software would normally be hand coded in a high-level language such as C, with a clear idea of the target architecture and its features. For example, while many MCUs are based on an Arm Cortex-M processor, different manufacturers implement vastly different peripherals, memory structures and other system resources. These variations would need to be understood by the developer and software development tools.

Conversely, an ML inferencing model starts life in a framework created specifically to support AI. Porting this model to an embedded platform must take into account the limited resources available, which is becoming less of a challenge thanks to the work being done to develop a strong tool flow that supports ML in MCUs.

Arm NN SDK is a good example of a simplified software development, an open source tool that runs on Linux and executes inference engines based on models that have already been trained. As such, it allows ML to be deployed on any architecture able to run Linux, such as Cortex-A processors. For deployment on Cortex-M MCUs, developers can move to CMSIS-NN. As part of the CMSIS framework, this software library of neural network kernels covers specific functions, as shown in the block diagram in Figure 4. These functions are supported by the CMSIS-NN library, with the help of the CMSIS-DSP library, to implement AI more efficiently in MCUs, as shown in Figure 5.

TensorFlow Lite is another framework gaining popularity in the embedded sector. This deep learning framework comprises tools designed to help port models created using TensorFlow to target architectures with fewer resources, such as MCUs. It achieves this through optimizing the models using a dedicated converter, for example taking 32-bit floating point numbers and turning them into 8-bit integers.

Part of the effort here involves creating tools that understand what the model is doing well enough to be able to prune parts of the network without impacting accuracy. This includes using the science of causality and counterfactuals, to discern what may have happened had the outcome of a previous stage been different, and then deciding if that would have made any difference to the eventual outcome.

Clearly the data science behind ML, particularly in endpoints, is quite intense and for this reason there are more tools and frameworks being developed. As an example, NXP has developed its eIQ (which stands for edge intelligence) software environment that integrates with CMSIS-NN, TensorFlow Lite, OpenCV (Computer Vision) and the Glow compiler. Like others now available, the approach taken by NXP with eIQ is to take a pre-trained model and modify it for easier or more optimized deployment on resource-constrained hardware platforms.

STMicroelectronics has recently introduced its own solution to helping engineers develop AI-empowered endpoints based on low power MCUs. The STM32 Neural Network Developer Toolbox, or STM32Cube.AI, also takes pre-trained neural networks and generates C code that can be directly deployed on the company's STM32 MCUs. It currently supports IDEs from Arm Keil MDK, IAR and System Workbench.

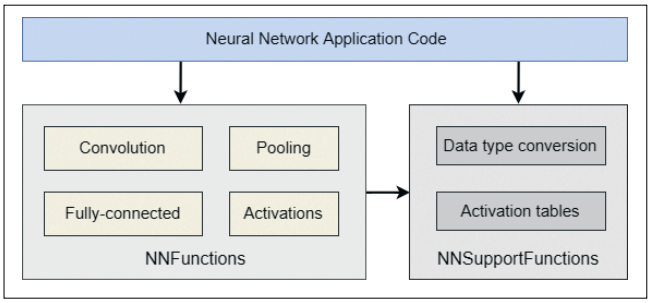



Figure 4: CMSIS-NN provides a library of functions for implementing AI and ML in Arm Cortex-M based MCUs. (photo: Arm)

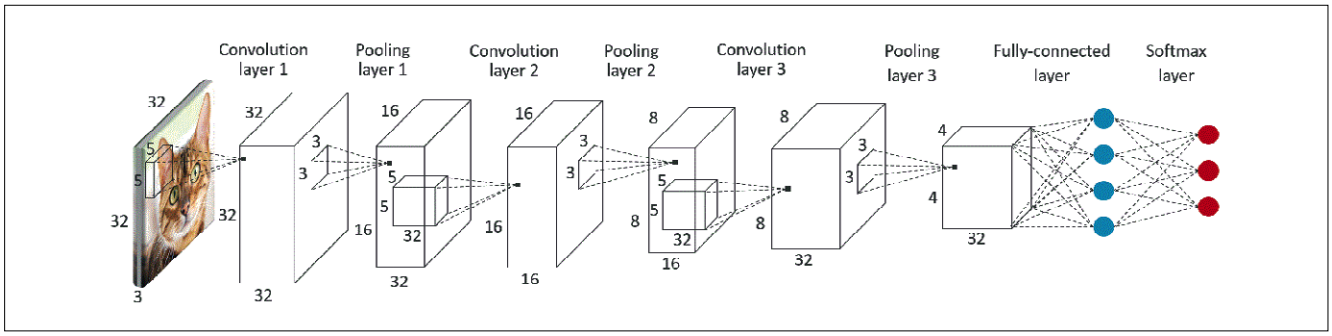



Figure 5: The many layers of a CNN, as implemented using CMSIS-NN. (photo: Arm)

## ONE SIZE (OF CODE) FITS ALL

The concept of taking a pre-trained model and optimizing it for target architectures with different levels of processing performance is gaining traction in the electronics market. There is a growing number of models available targeting the 'Three Vs' – Video, Voice and Vibration – as well as image recognition. By starting with a pre-trained model and passing it through subsequent levels of optimization, engineers can arrive at a deployable system much quicker.

Examples of this cross-platform approach to development are beginning to emerge throughout the industry, intended to simplify the developer's task of deploying code across potentially multiple architectures, including GPUs, CPUs, AI processors and FPGAs.

Arm is also a proponent of portable code, exemplified by CMSIS, its vendor-agnostic hardware abstraction layer for microcontrollers based on the Arm Cortex family. As outlined earlier, this now includes CMSIS-DSP and CMSIS-NN, two software libraries that are supporting many of the vendors' own code frameworks targeting AI and ML in endpoints, such as NXP's eIQ.

The efforts being made now to port neural networks and ML models to low-power MCUs, in order to empower AI directly in the endpoint, illustrate how important and enabling AI will be, taking the IoT to an entirely new level and allowing a new tier of end user to access the technology. But the efforts aren't going to stop with new software frameworks.

## THE NEXT STEPS IN AI PROCESSING

The market for AI processors is estimated by analyst Allied Market Research to exceed $90bn by 2025, which is a good indication of the amount of R&D currently going into developing new processor architectures better designed to run neural networks, accelerate AI training and execute ML models. Of course, as demonstrated, any processor can run AI to some extent, while those with DSP extensions will have an advantage over those that don't. However, while DSP instructions are beneficial, there are other types of vector processing instructions for compute architectures coming to the market that will provide even greater boosts to executing DSP and AI in endpoint devices.

This is illustrated by the introduction of Arm's Helium technology. Helium is part of the Armv8.1-M architecture and brings vector processing capabilities to the smallest devices, increasing the performance of signal processing functions by five times and delivering a 15x improvement in ML functions. Dr Dominic Binks, VP of Technology at Audio Analytics, has described Helium as changing the game. Audio Analytics already uses ML in its products running on Arm Cortex-M MCUs, but predicts that optimizing just a few selected routines for Helium would see more than a 50% reduction of execution time. With even more effort, this execution time will become even faster.

The key to deploying AI and ML is scalability, from the processor's resources to the number of heterogenous processors in one device, through to the ease of stitching multiple multi-core devices together in a single system. Only Arm is approaching this holistically to offer a full-scale selection of processing solutions.

Arm is also actively developing entirely new neural processing architectures and NPUs to address AI and ML requirements; the Arm Ethos-N Series currently features the Ethos-N77, Ethos-N57 and Ethos-N37. The N37 is aimed at smaller, most cost-sensitive endpoints but is able to deliver 1TOP/s in an area of just 1mm$^2$. Other examples of NPUs designed for low power and low cost are also in the development pipeline. This illustrates the commitment Arm is making to developing scalable platforms, in addition to the range of Arm CPUs available, that will continue to enable ML in the endpoint devices, and the many benefits this will have for a modern society. FR

**THOMAS LORENSER**

is director of new products in the Automotive and IoT Line of Business at Arm, leading a team responsible for the definition of Arm's roadmap for IoT and embedded applications. Thomas has 15 years of experience in various Product Management and Product Line Management roles in the semiconductor industry across many market segments, including mobile, tablets, notebooks and wearables. Prior to joining Arm, Thomas was Product Line Manager at Knowles Electronics and Product Manager at NXP and has extensive global experience from working with OEMs and silicon partners.

# AUTOMOTIVE ETHERNET CONGRESS

**February 12-13, 2020**

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## Wednesday, February 12, 2020

| | | |
|---|---|---|
| 08:55-09:00 | **Welcome** | Elektronik automotive |
| 09:00-09:30 | Keynote: **IVN Design Options for Tomorrows Architectures** | **Dr. Andreas Lock**, Robert Bosch |
| | **SESSION 1 / NETWORK & ARCHITECTURE** | |
| 09:30-10:00 | **Do we Really Need an All-IP Car?** | **Thomas Liebetrau, Tobias Islinger**; Infineon |
| 10:00-10:30 | **Meshing of the Networks: The Impact of Merging In-Vehicle Communications Networks to Support the Future Need for Adaptive Applications** | **Mike Potts**, Molex |
| 10:30-11:00 | COFFEE BREAK AND NETWORKING IN THE EXHIBITION | |
| 11:00-11:30 | **Early-stage Bottleneck Identification and Removal in TSN Networks** | **Dr. Hoai Hoang Bengtsson**, VOLVO; **Dr. Jörn Migge**, RealTime-at-Work; **Prof. Nicolas Navet**, University of Luxembourg |
| 11:30-12:00 | **Virtualizing Network Functions of the In-Vehicle Network** | **Dr. Christian Herber, Manfred Kunz**; NXP |
| | **SESSION 2 / LAYERS 3, 4** | |
| 12:00-12:30 | **TCP/IP and Other Higher-Layer Protocols via CAN** | **Holger Zeltwanger**, CAN in Automation |
| 12:30-14:00 | LUNCH BREAK AND NETWORKING IN THE EXHIBITION | |
| | **SESSION 3 / SECURITY & SAFETY** | |
| 14:00-14:30 | **Automotive Ethernet Fuzzing – Challenges and Best Practices** | **Ibrahim Memis**, Robert Bosch |
| 14:30-15:00 | **Ethernet Security, the Protocols and its Challenges** | **Dr. Karsten Schmidt**, AUDI; **Harald Zweck**, Infineon |
| 15:00-15:30 | **Experience and Lessons Learned from Firewall and Intrusion Detection System Development for Automotive Ethernet** | **Ramona Jung, Siddharth Shukla**; ESCRYPT |
| 15:30-16:00 | COFFEE BREAK AND NETWORKING IN THE EXHIBITION | |
| | **PARALLEL WORKSHOPS** | |
| 16:00-18:00 | Workshop 1: **Automotive Ethernet and Service-Oriented E/E Architectures** | **Alexander Mayr, Marcelino Varas**; Vector Informatik |
| 16:00-18:00 | Workshop 2: **From the Cloud to the Car – Use Cases** | **Michael Johnston, Dr. Rajeev Roy**; NXP |
| 16:00-18:00 | Workshop 3: **Automotive Ethernet Debugging, Compliance Testing and Switch Latency Measurements** | **Dr. Ernst Flemming, Dr. Nik Dimitrakopoulos**; Rohde&Schwarz |
| 16:00-18:00 | Workshop 4: **Automotive Ethernet Layer 1 to Layer 7 Test Automation** | **Darshan Mehta**, Tektronix |
| 16:00-18:00 | Workshop 5: **Security for Ethernet EE-Architecture** | **Ramona Jung, Siddharth Shukla**; ESCRYPT |
| 16:00-18:00 | Workshop 6: **Automotive Ethernet Switch Training** | **John Simon**, Intrepid |
| 18:00-20:00 | GET-TOGETHER AND NETWORKING IN THE EXHIBITION | |

## Thursday, February 13, 2020

| | | |
|---|---|---|
| 09:00-09:30 | Keynote: **Automotive Ethernet: Yesterday, Today, and Tomorrow** | **Natalie A. Wienckowski**, GM |
| | **SESSION 4 / VALIDATION & TEST** | |
| 09:30-10:00 | **Ensuring Security of Data Communication in an IVN and Comparing the Choice of Encryption Techniques** | **Avik Bhattacharya**, Keysight |
| 10:00-10:30 | **AVB/TSN Testing Strategy from Semiconductor up to ECU and System Level** | **Martin Heinzinger**, Ruetz System Solutions |
| 10:30-11:00 | COFFEE BREAK AND NETWORKING IN THE EXHIBITION | |
| | **SESSION 5 / LAYER 2** | |
| 11:00-11:30 | **When GATE's Misbehave for IEEE 802.1Qbv Implementation** | **Tanuman Bhaduri**, Keysight |
| 11:30-12:00 | **Achievable Accuracy of gPTP Synchronization over PCIe** | **Thorsten Hoffleit**, Renesas |
| 12:00-12:30 | **Choosing the Right TSN Tool(s) to Meet a Network's Bounded Latency Requirement** | **Don Pannell**, NXP |
| 12:30-14:00 | LUNCH BREAK AND NETWORKING IN THE EXHIBITION | |
| | **SESSION 6 / PHY** | |
| 14:00-14:30 | **Automotive Ethernet and SerDes Technologies – Friends or Foes?** | **Stefan Brunner, Claude Gauthier**; Automotive SerDes Alliance (ASA) |
| 14:30-15:00 | **Optical Multi-Gigabit Ethernet – on the Verge of Standardization and Implementation** | **Carlos Pardo**, KDPOF |
| 15:00-15:30 | COFFEE BREAK AND NETWORKING IN THE EXHIBITION | |
| 15:30-16:00 | **The Need for Asymmetrical Data Transmission – An Evolutionary Step for Automotive Ethernet?** | **Jürgen Röder**, Continental Automotive |
| 16:00-16:30 | **10BASE-T1S: The Solution for Introducing Ethernet to Low-Speed Network** | **Takashi Yasuda**, JASPAR (Toyota, Nissan, Honda and Mazda) |
| 16:30-16:45 | CLOSING | |

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SECURE AND RELIABLE WIRELESS NETWORKING

# THE IOT REVOLUTION FOR COMMERCIAL BUILDINGS

(photo: Shutterstock)

The IoT standard for wireless communication IP500 was developed to address the toughest demands in commercial buildings. With the EN pre-conformity, certified by the Association of Property Insurers (VdS), the IP500 standard positions itself in the wireless IoT market as a “hidden champion” for IoT applications for commercial buildings.

By Helmut Adamski and Witali Gisbrecht

With the recent successes of the IP500 Alliance [1] a new chapter in the IoT market for commercial buildings has started. Key manufacturers (global players) of security products started writing this chapter about ten years ago.

Just remember: At the time, other wireless IoT standards were trying to win over the IoT market. This has partly succeeded for the smart home market and is currently being tried in the wide area IoT market for smart city applications. Nevertheless, the gap between known wireless IoT systems for end users and the required standards in the commercial sector is enormous. Why? – Because technical challenges must work together in the overall picture of a wireless IoT platform. This means that different requirements must be supported by a wireless IoT platform at the same time; For example, a very low time delay (latency) in the IoT network and at the same time as a high data rate and transmission range, and this must be robust, secure and with a low energy budget for battery powered sensors. At first glance, this does not seem possible – but it is possible if the entire system is repeatedly coordinated between the application and the solution.

If a developer only wants to operate a certain IoT application, it is sufficient to concentrate on a few or maybe even one technical parameter, e.g. long range. However, if additional high data rates and low latency are required at the same time, other suitable wireless standards for this IoT application are not available as an IoT platform. Users experience this with other wireless IoT standards; they find themselves "caught" in a certain application when they want to implement new functions or expand the range of applications in the same IoT network.

## IP500 ALLIANCE

The IP500 Alliance started its activities as an interest group with well-known global manufacturers after the IEEE standard 802.15.4 (2006) was ratified in 2007. The goal was to define from the system perspective of the user, regulations and applications for the most robust IoT system for commercial buildings based on the IEEE and IPv6 standards, and to develop and establish them with partners.

In May 2010, the IP500 Alliance formed in the historic VDI house in Berlin as a registered association (e.V.) and started its work.

The previous work was essentially characterized by three phases:

➔ 2005–2009 collaboration on the IEEE 802.15.4 and IPv6 standards and formation of the IP500 specification.

➔ 2010–2013 Presentation of the first IP500 wireless modules (CNX100) in products.

➔ From 2014 expansion of the product portfolio up to EN pre-conformity by VdS.

Today, the IP500 standard has leading manufacturers as members with voting status. Only they are authorized, with one voice per manufacturer, to select the appropriate technologies (wireless, network and infrastructure) which has brought the IP500 standard to fruition.

The IP500 Alliance is represented worldwide in Japan, India, the USA and Colombia by representatives with local technical support. The headquarters of the IP500 Alliance is in Berlin.

Selected partners and global service companies (service providers) have been accepted as "None Voting Members" and form the technical backbone, as well as providing technical support to manufacturers and providing the delivery of IP500 wireless modules worldwide.

The IP500 Alliance has additionally established a certification process in order to guarantee interoperability of the various IP500 networked OEM products.

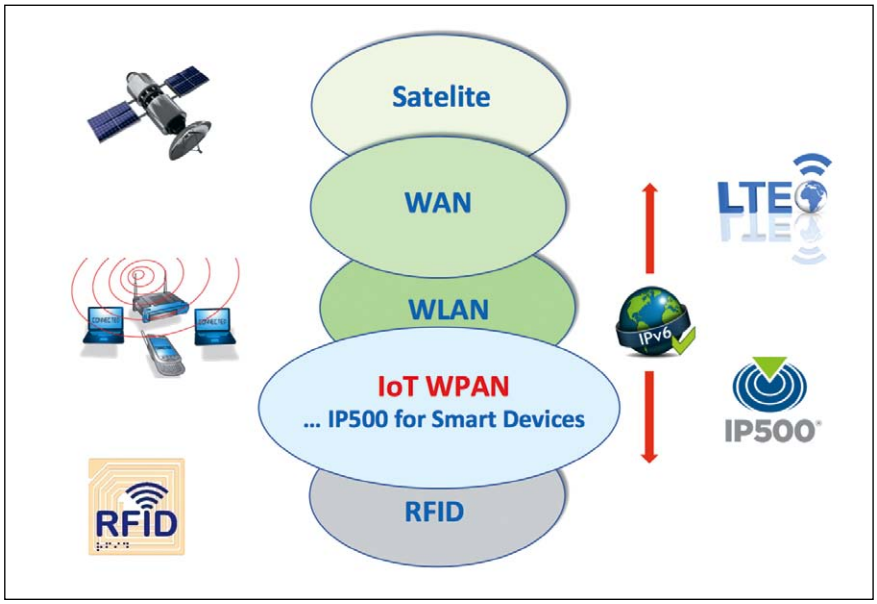



Figure 1. The IP500 Alliance wants to establish the IP500 standard as the dominant infrastructure for wireless IoT applications in commercial buildings. (image: IP500 Alliance)

## THE IOT REVOLUTION CAN BEGIN

Since the beginning, the aim of the IP500 Alliance was to establish a wireless IoT platform that can network all smart sensor applications in a building in one and the same infrastructure. Comparable to the WLAN standard, which has established itself as the wireless standard for IT applications (Figure 1).

If you consider all the applications in commercial buildings, the security applications in an IoT network are of supreme importance. This requires interoperability of all IP500 products, no matter which manufacturer makes such sensing / acting devices.

The IP500 Alliance has consistently implemented this idea over the years and has defined the "best-in-class" wireless technology in a clever constellation with the network layer and the IoT

infrastructure into the specifications of the IP500 standard. These specs were then implemented by partners in products that are available today, e.g. wireless modules (CNX200, Figure 2) and gateways (GW260).

## ENDURANCE AND STRONG PARTNERS PAY OFF

Through close cooperation with the certification bodies TÜV Rheinland and the Association of Property Insurers (VdS), the system view and important safety standards were kept in focus during the development of the IP500 standard. The result is now revolutionizing the IoT world, with maximum robustness, security, scalability and performance in wireless communication, in IoT network technology and its infrastructure.


Figure 2. The IP500 wireless module CNX200 contains a microcontroller for the IP500 network stack and also the antenna. It fulfills all requirements for worldwide certification – for Europe (RED), India, Japan, USA (FCC), etc. (photo: IP500 Alliance)

Unaffected by other existing wireless IoT standards, which were developed primarily through the bottom-up strategy of the IC and network manufacturers, the IP500 Alliance with its members and partners has created the wireless IoT platform IP500 from the system level point of view. The IP500 standard has been brought into line with the security standards that are decisive for the system level and has been approved by the relevant certification bodies, e.g. the VdS. As a result, the IP500 standard is unique worldwide today in that it is able to provide a wireless IoT standard as a platform that can simultaneously meet the highest performance demands in the IoT network and is pre-

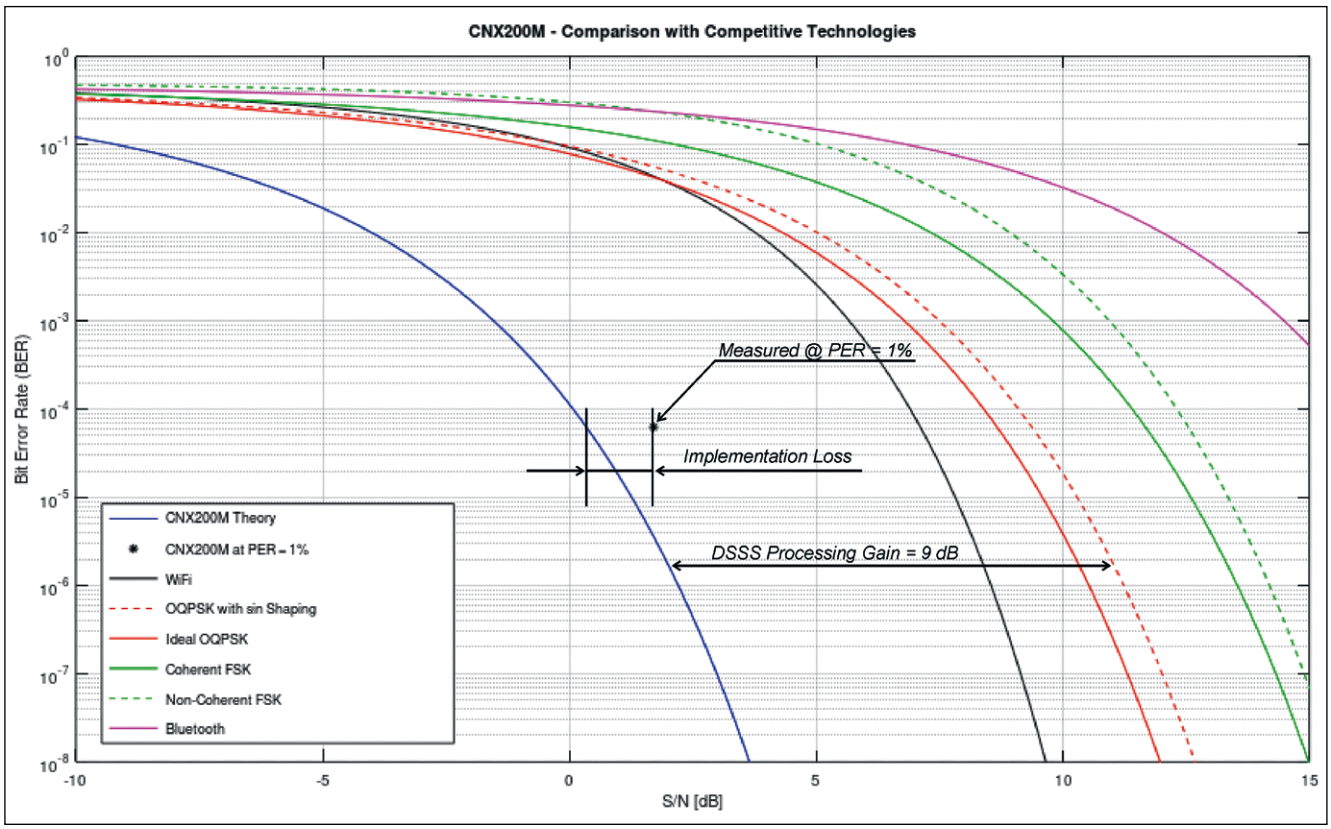



Figure 3. A comparison of the various wireless technologies shows that IP500 uses DNSS (Direct Spread Spectrum Sequence) — measured in the 2.4 GHz band and at 250 kbit/s — a process gain (processing gain) of 9 dB can realize and can work with a smaller signal-to-noise ratio (SNR). (image: IP500 Alliance)

compliant with European norms, e.g. EN 50131-5-3 [2].

## DEMANDS OF USERS AND STANDARDS FOR WIRELESS-BASED SECURITY APPLICATIONS

From the beginning of development, the requirements and standards for critical applications in a commercial building – access control, fire detectors, etc. – were given priority in the IP500 standard. At the same time, the best-in-class IoT technologies were correlated with these requirements and embedded in the IP500 specification. This top-down process, from a system perspective, has ensured that the IP500 standard is guaranteed to meet the requirements of target applications. The main driving factors of these applications in commercial buildings are:

➔ Highest robustness of wireless connection in the commercial and industrial environments.

➔ Maximum security in data transmission, including key management.

➔ Short response time (latency) between sensors, actuators and the infrastructure (gateways).

➔ High data rate with a long wireless range.

➔ Scalable and robust meshed network architecture (mesh topology).

➔ Energy and battery management.

➔ Interoperability between all OEM products.

➔ Redundant network topology including gateways with databases.

Most standardization committees for wireless IoT systems have started from the perspective of RF (radio frequency) transceiver ICs (integrated chip), that is, "bottom up". This means that the IC manufacturers have followed the IEEE 802.15.4 (x) standard and developed the corresponding IoT ICs, as have the network manufacturers and the software developers. However, the layers for bit transmission (PHY – Physical) and security (MAC – Media Access Control) are only roughly described in the IEEE standard – and they have no relation to the application and its requirements.

Developers and users must observe and also comply with the legal requirements regarding frequency usage in the respective countries. However, these rules pose enormous challenges for wireless IoT systems.

If you look at the 2.4 GHz range, for example, it is very busy, especially through streaming applications with Wi-Fi and Bluetooth. In comparison, the sub-GHz range only offers narrow channels and the usable frequency bands differ from region to region.

To meet these challenges, the IP500 Alliance has specified a dual-band process that offers high data rates in the 2.4 GHz band and a long range in the sub-GHz range.

Due to the asynchronous, meshed dual-band network, additional robustness and redundancy for the transmission of sensor data is achieved even in a very difficult environments. The data packets are cryptographically encrypted so that the IP500 standard combines performance and security in a wireless IoT network.

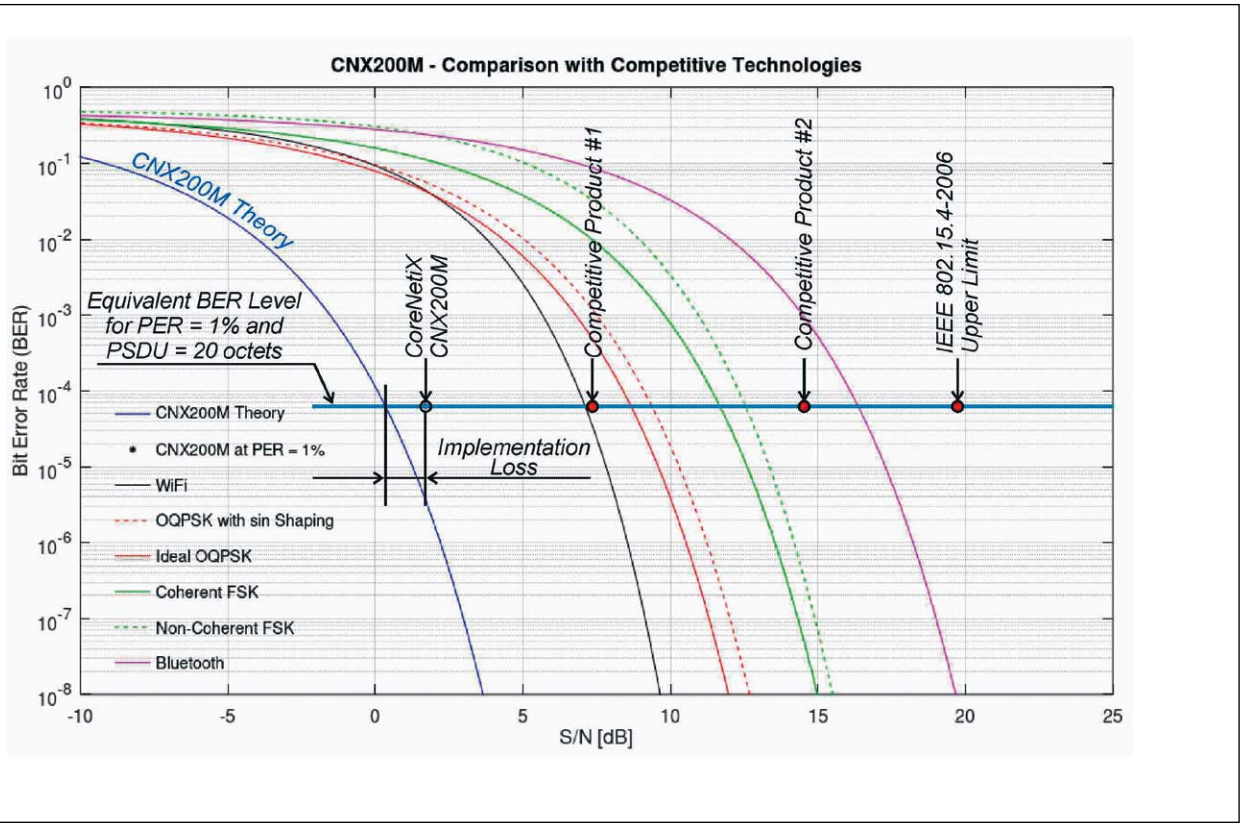



Figure 4. Comparison of the different wireless technologies – theoretical values and values of real implementations. The further left a technology, a product, can be placed on a horizontal, the better the signal-to-noise ratio. (image: IP500 Alliance)

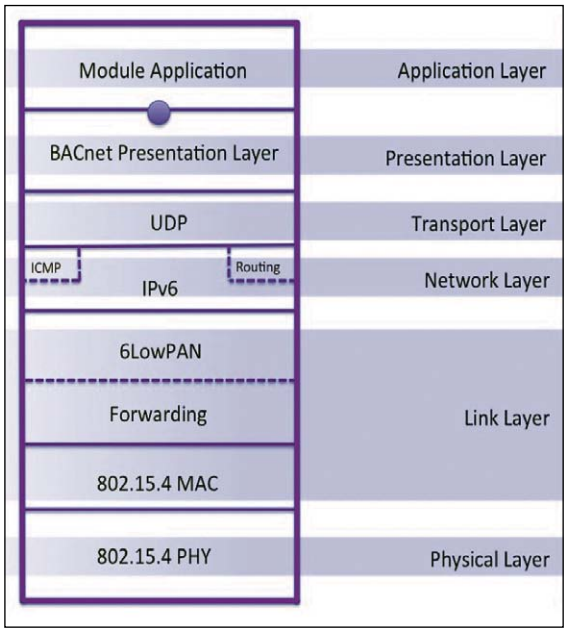



Figure 5. IP500 uses a finer subdivision of the data link layer than the previously known OSI model. (image: IP500 Alliance)

## PRE-COMPLIANCE WITH EUROPEAN STANDARDS

The VdS label is a seal of quality and is the most important quality indicator for those responsible for safety security systems when deciding, purchasing, integrating and installing security technology and security services – especially in commercial buildings. Organized in association with other European countries, the Association of Property Insurers is also recognized worldwide in its sphere of activity. A VdS certificate allows security-relevant systems to be approved after they have been checked for security, reliability and more. The aim is to use the tested techniques to reduce the risk of damage and ultimately to prevent damage prematurely. The technical hurdles are enormous in order to obtain a VdS certified product and system. If a manufacturer is interested in having a product certified with a wireless link, this manufacturer must make large investments in order to ultimately develop its proprietary wireless technology for safety-critical applications. As it is important that there is no interference with safety-related applications, this wireless technology still has to pass lengthy.

In years of cooperation with the VdS, the IP500 Alliance has successfully developed a robust and reliable wireless IoT standard in a first step of pre-conformity – according to EN 50131-5-3 [2] – for some important applications required to establish IoT platform. This pre-conformity allows the members of the IP500 Alliance tocertify their products, which are equipped with an IP500 wireless module (CNX200), without additional development effort and other pre-conformity testing for the VdS. This results in considerable time and cost savings for the manufacturer.

## WIRELESS TECHNOLOGY FOR THE HIGHEST DEMANDS

In order to meet all requirements to achieve conformity and interoperability, the members and partners of the IP500 Alliance have coordinated and developed the entire IP500 system at all three levels (layers). The three levels are:

➔ 1. Wireless transmission (PHY / MAC).

➔ 2. Network stack and application.

➔ 3. Protocol, infrastructure, gateway and database.

The first two levels – wireless transmission and network stack – are closely coordinated and essentially form a unit, as the example of true dual-band technology with mesh topology shows.

In this case, the PHY level provides both frequencies simultaneously and the network stack level automatically routes the data packets depending on the interference in one of the bands to the target node, a gateway or a terminal device.

## ADVANTAGES OF THE IP500 STANDARD ON THE WIRELESS LEVEL

Due to the requirements from the system level, OQPSK (Offset Quadrature Phase-Shift Keying) was chosen for modulation. The basis for this is the IEEE standard 802.15.4 (2006), which provides OQSPK for higher data rates in the 2.4 GHz band. Due to the system requirements of the security applications, the simultaneous use of both bands – Sub-GHz and 2.4 GHz – was specified in the IP500 standard. This created a very high level of robustness against interference.

Combined with the asynchronous meshing process of the network stack, the IP500-PHY and network stack can avoid different interferences – both in the case of interference on the frequency level and in the event of interference on the routing path.

The measurement results in Figures 3 and 4, measured in a real environment with high interference, as are typical for buildings, tunnels or metallic environments (aircraft and ships), provide an insight into the robustness of the IP500 standard compared to other wireless standards that are used worldwide.

It is advantageous to have a smaller signal-to-noise ratio (SNR) (position of the

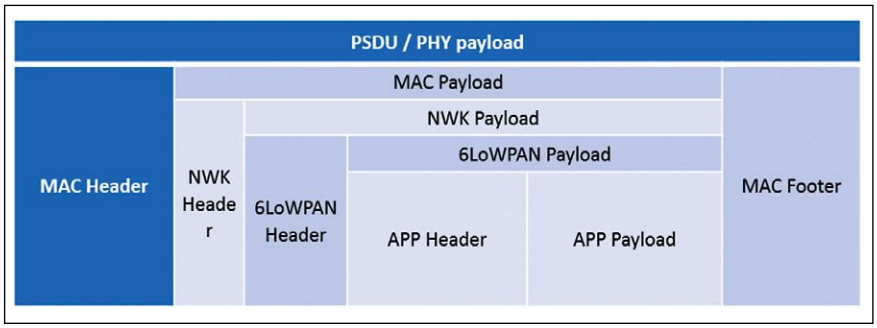



Figure 6. The application data is nested several times in packets in the higher levels of the IP500 protocol before it is sent out by wireless. (image: IP500 Alliance)

| MAC Header | | | | | MAC Payload | MAC Footer |
|---|---|---|---|---|---|---|
| Frame Control | Sequence Number | Destination PAN Identifier | Destination Address | Source Address | Nutzdaten | Prüfsumme |
| 2 Byte | 1 Byte | 2 Byte | 2 Byte | 2 Byte | variabel | 2 Byte |

Figure 7. IP500 uses the MAC frame of the IEEE 802.15.4 standard (2006). (Image: IP500 Alliance)

| NWK Header | | | | | | |
|---|---|---|---|---|---|---|
| Protocol ID | Header Length | Hop List | Payload Type | Payload Length | Sequence Number | CRC16 |
| 1 Byte | 1 Byte | 12 Byte | 1 Byte | 1 Byte | 4 Byte | 2 Byte |

Figure 8. The header of the network data packet for IP500 (NWK header) contains the information for the routing (hop list). (Image: IP500 Alliance)

| Hop List | | | | | | |
|---|---|---|---|---|---|---|
| Type | Length | Destination | Source | Hop 1 | Hop 2 | Hop 3 |
| 1 Byte | 1 Byte | 2 Byte | 2 Byte | 2 Byte | 2 Byte | 2 Byte |

Figure 9. The hop list specifies the routing of a wireless data packet through the IP500 network. It is generated by the source node by considering the shortest connection to the target node. (source: IP500 Alliance)

product further to the left in Figure 4) for several reasons:

➔ Higher link budget

Given the signal-to-noise ratio, the number of bits received incorrectly is reduced. For example: for SNR = 4 dB, the received messages from the IP500 wireless module CNX200M are error-free in practice.

A bit error rate BER = $10^{-6}$ means one bad bit per million received bits. In comparison, for the same SNR = 4 dB, the BER for Wi-Fi = 0.01, that is one bad bit per 100 bits received.

Under such conditions (SNR = 4 dB), wireless standards such as Wi-Fi, Bluetooth or LoRa cannot be used practically.

➔ Reduce energy consumption – reliable transmission requires less RF transmission power with a small SNR.

A closer look at the test results shows that the known wireless standards cannot be used extensively as a wireless IoT platform in a commercial or industrial environment, because lack of performance, robustness or security can

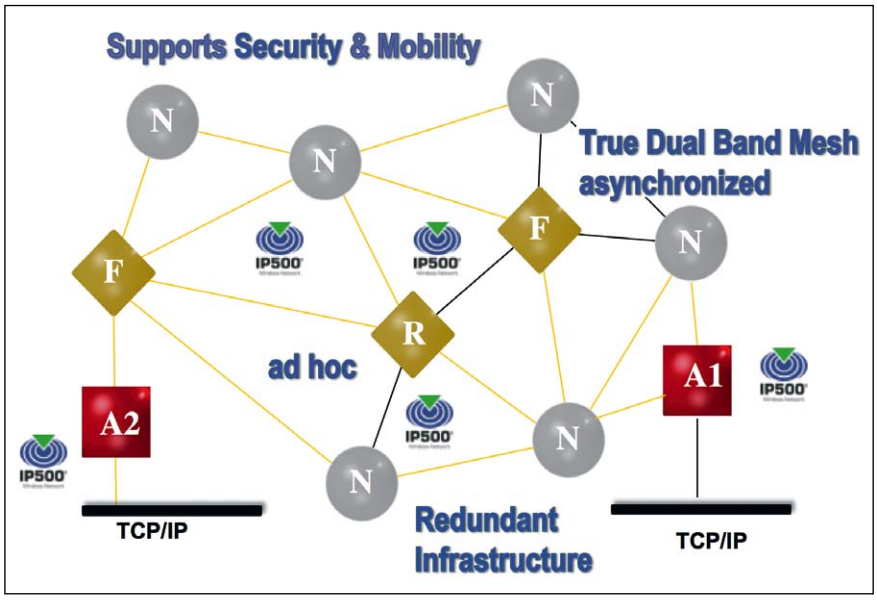



Figure 10: The IP500 network offers security, reliability and robustness through redundancy – with two gateways and operation in two independent frequency bands. (Image: IP500 Alliance)

significantly disrupt the IoT business processes.

## THE NETWORK LEVEL OF THE IP500 STANDARD

The construction of the IP500 network stack is responsible for the topology of the network, the scalability, the latency and the encryption of the data – and thus for the robustness and security in the entire IP500 network. Figure 5 shows the IP500 structure based on the well-known OSI model.

The asynchronous transmission method was selected in accordance with the IEEE 802.15.4 standard. Figure 6 shows the structure of a complete IP500 wireless data packet.

The main functions of the network are:

➔ Structure of the data packets (frames) and file headers (headers).

➔ Forwarding of the packets through the asynchronous mesh network using the routing table.

➔ Securing and encryption of data packets.

## ROUTING BY HOP LIST

The NWK header (Figure 8) defines the "Hop List", a given route through the network (Figure 9). The message from the application is organized in the packet and routed through the network according to the hop list – in dual band and via the switching nodes of the meshed network. The hop list delivers the next hop thanks to the asynchronous meshed network with minimal computing effort – an important skill that ensures low latency and low energy consumption of the individual network nodes (sensors). The node sending a message determines the hop list for the data packet from its routing table by forming the shortest route. This process offers the end user a self-healing, self-configuring mesh network with the lowest latency.

All messages of the IP500 application layer are sent in both directions between the nodes and the gateway, which is why each node and the gateway knows the route without any computing effort. Additionally the most recently received messages are also stored in the gateway. The use of alternative routes in the meshed network, together with the redundancy at the frequency level, ensures high reliability and low latency when interference occurs, which has been confirmed by VdS as the basis for preconformity with the European standards [2].

## SECURITY AND ENCRYPTION IN THE IP500 NETWORK

The calculation of the AES128 key for symmetrical encryption and decryption of the message is based on the sequence number of the message and a master key, which is carried out by an asymmetric ECDH method (Elliptic-curve Diffie-Hellman) between each individual node and the Gateway. End-to-end encryption ensures that the messages cannot be intercepted or forged by forwarding nodes. Using the AES128 key once for a single message increases the security of the IP500 network. HS

Literature

[1] IP500 Alliance, www.IP500alliance.org

[2] DIN EN 50131-5-3: 2017-09; VDE 0830-2-5-3: 2017-09: Alarm systems - Intrusion and hold-up systems - Part 5-3: Requirements for transmission devices, wireless frequency technologies use; German version EN 50131-5-3: 2017.

**HELMUT ADAMSKI**

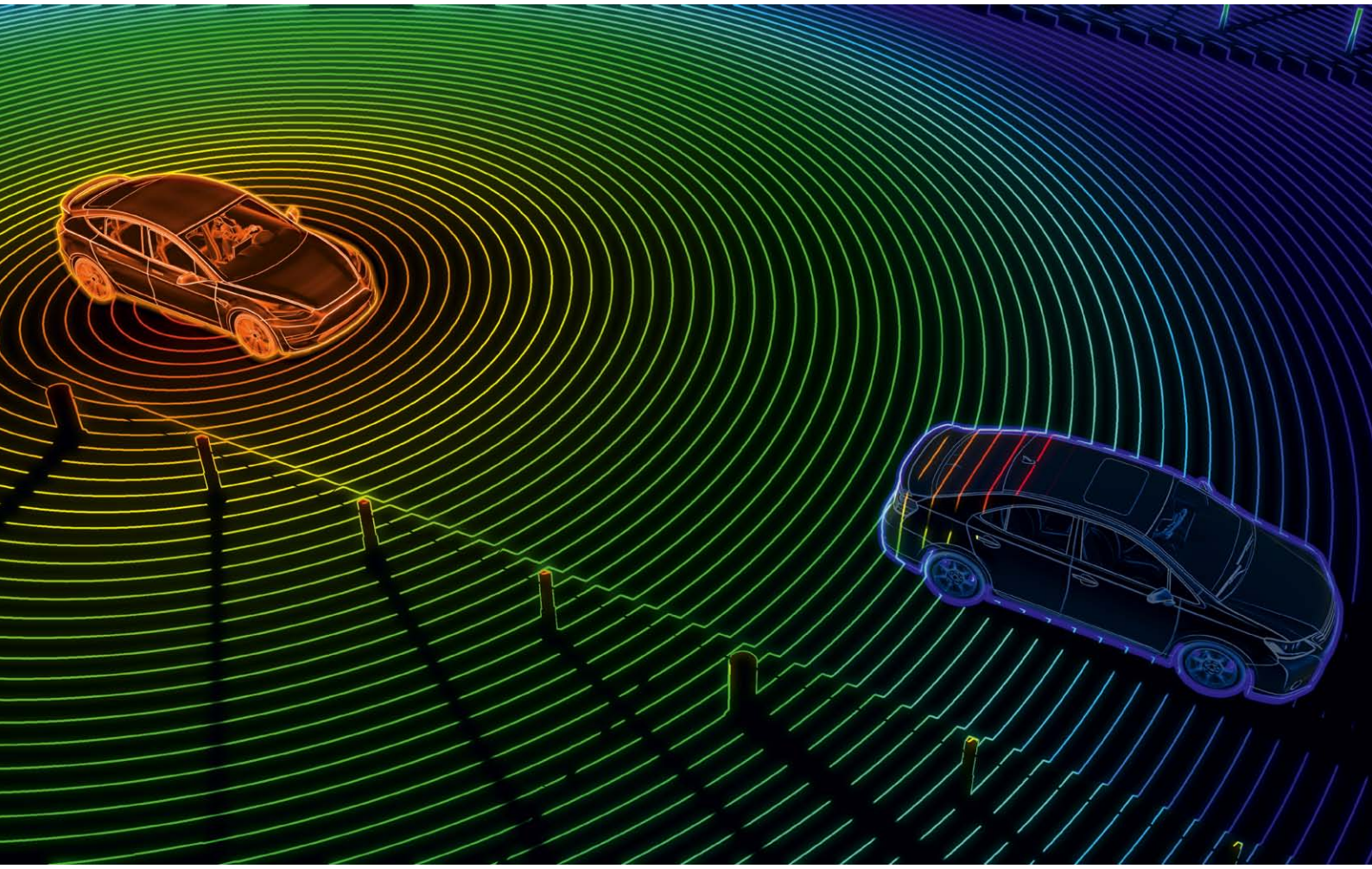
is an IoT pioneer and currently leads the IP500 Alliance e.V. as CEO and chairman. He has more than 25 years of experience in the high-tech industry, with a focus on IoT and IT network applications, radio ICs and security applications for buildings and premises. Adamski holds an engineering degree in electronics and attended Executive/MBA programs at the Institute of Excellence, San Diego, and Stanford University, California, USA.
**helmut.adamski@ip500alliance.org**

**WITALI GISBRECHT**

is a specialist in the development of embedded software for network stacks, security methods and gateway architectures. He graduated from the University of Paderborn in 2007 with a Bachelor of Science degree in Computer Science.

SENSORS OF THE NEXT GENERATION:

# LIDAR AND THE FUTURE OF AUTONOMOUS DRIVING



(Bild: temp-64GTX | Shutterstock)

Creating sensor topology for highly and fully autonomous vehicles is a major theme of the future for the automobile industry. Given its relevance for safety, LIDAR, extra to cameras and radar, is set to play a key role as a third essential sensor category.

By Robert Kempf

The right sensor topology for highly and fully autonomous vehicles is and will remain an exciting topic for discussion in the automobile industry. Harman believes that LIDAR technology will play a central role in the automotive future. LIDAR – light detection and ranging – uses light pulses from a laser source to scan the surroundings. This light-based sensor technology is crucial for solving current challenges in detecting the vehicle environment (Figure 1). However, LIDAR in its present form is too expensive for the mass market, costing as much as several thousand euros for high-resolution sensors. And also remains technically very complex and error-prone. The new solid-state LIDAR available from this year on will solve many of the ongoing problems of the technology. What is decisive for possible volume application in automated and autonomous vehicles is that some technical challenges still have to be overcome in the control unit architecture of vehicles.

## RADAR AND CAMERAS ARE NOT ENOUGH

Currently the automobile industry is still divided about the right way into the autonomous future of driving. In particular, the most suitable sensor configuration to ensure safety requirements for highly autonomous driving is a matter of discussion. Some manufacturers assume that cameras and radar systems are sufficient to enable automated driving. But with this opinion they are a minority in the industry.

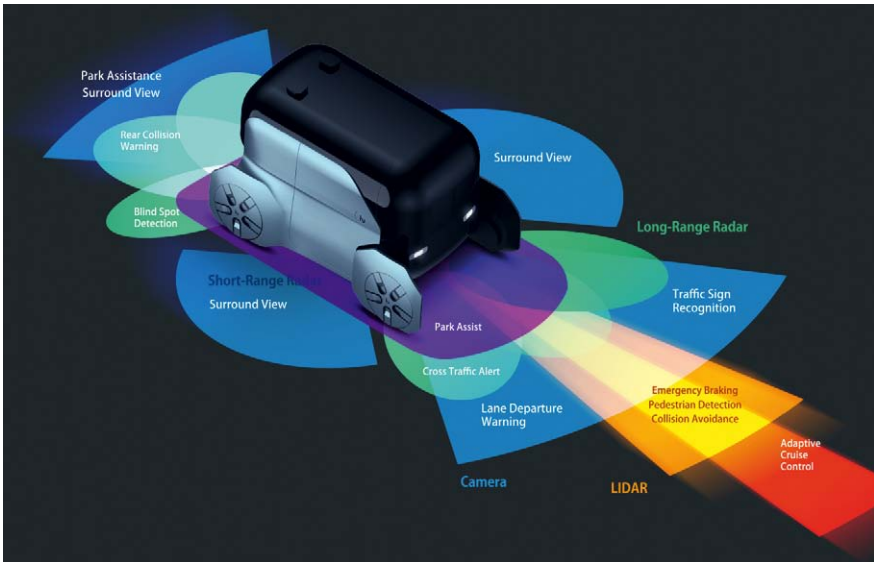



Figure 1. LIDAR: sensor topology and examples of application. (photo: Harman)

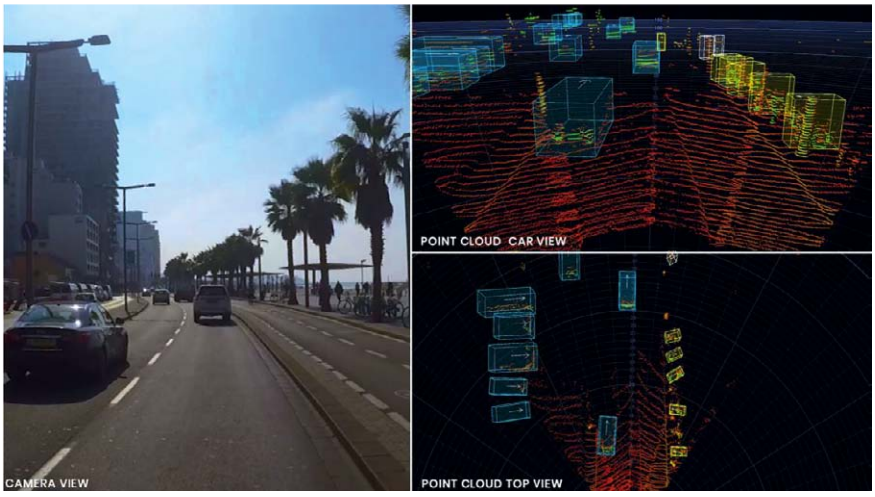



Figure 2. Point cloud display of real street view. (photo: Innoviz)

Although both sensor systems are extremely important facets of autonomous driving, they do have their shortcomings. The momentary automotive radar systems only deliver their information to an autonomous driving system selectively and with a small detection range. A further complication is that they can be disturbed by sensors of the same type, and sometimes even erroneously detect phantom objects.

## BEST POSSIBLE SECURITY ONLY WITH LIDAR

Cameras are dependent on light relations and illumination of the surroundings they capture. In addition, they are often not robust enough in difficult weather conditions such as rain, fog or snow to deliver the detailed information required for automated driving constantly and without error. Given these deficits, focusing on the two technologies falls short.

Harman, like most industry experts believes that, due to the shortcomings of radar and cameras, LIDAR is needed as a third sensor technology to ensure safe automated or autonomous driving in all environmental conditions. The current generation of high-resolution LIDAR sensors has high measurement resolution up to 0.1°x0.1° even at long distances and in 3D coverage. Due to its detailed detection, LIDAR provides a highly precise 3D image of the vehicle environment in the form of a 3D point cloud, which can be comprehensively processed by advanced driver assistance systems (ADAS) (Figure 2). LIDAR is also resistant to interference from sensors of the same type and, as an active illumination method, is entirely independent of daylight and ambient light levels.

Especially the long range of 150 m and more, detailed resolution as well as immunity to interference are weighty advantages of LIDAR systems compared to cameras and radar. Since none of the three types of sensor can cover all ambient conditions, the necessary requirements for diversity and redun-

dancy in ADAS for automated and autonomous driving can only be achieved by combining LIDAR, radar and cameras.

## KEY TECHNOLOGY LIDAR

In a number of future application scenarios LIDAR is also the undisputed key technology for detailed monitoring of surroundings. Examples are highway pilot systems for autonomous driving on an expressway at high speeds and the requirement to detect and classify smaller objects. This can only be reliably ensured by the LIDAR 3D point cloud.

But autonomous driving in a city center assisted by an urban pilot also demands the use of LIDAR due to the extremely complex and highly dynamic scenario, with numerous different road-users such as cars, cyclists or pedestrians in the overall driving environment. In addition to comprehensive detailed detection of all objects around a vehicle, LIDAR is especially important for the correct measurement of distance.

LIDAR alone can operate in all environments with the necessary system reliability and detection rate for objects, so this technology is also the basis for many future autonomous vehicles. In addition to cars and robotaxis, these include trucks and vehicles for construction and agriculture.

## THE FUTURE IS SOLID-STATE LIDAR

Until recently however there were some basic problems with LIDAR technology, delaying its widespread use. At the moment conventional LIDAR systems mainly use mechanically rotating components, making them susceptible to vibration and shock, or they have very limited resolution and range. Also, the more complex and larger a component is, the more difficult it is to guard against dust or moisture ingression. Achieving the wished robustness for use in the automobile industry, despite a relatively vulnerable construction, means that present LIDAR models must be quite large and solid. The result is high unit costs and a large space requirement at the same time.


Figure 3. InnovizOne — a solid-state LIDAR solution already available. (photo: Innoviz)

Since mechanical LIDAR variants either do not provide data of the driven environment in the required quality or are too large and expensive for the performance wanted, they are not yet suitable for mass use in autonomous vehicles of the next generation, despite all the advantages for future driving. Newly developed solid-state LIDAR technology now appears as a remedy. The new design does away with moving parts and thus avoids many of the drawbacks of mechanically rotating versions. Offering the same performance as current high-end mechanical variants, solid-state LIDAR is very much more efficient. There are fewer components so only a fraction of the space of current LIDAR models is required, and it can be up to 80 percent more cost-attractive. Despite a more compact design, solid-state LIDAR has longer range and, at 0.1°x0.1°, typically delivers higher resolution than current mechanically rotating versions. This means that small objects can now be detected over long distances.

SAE L3 (Society of Automotive Engineers Level 3) is the next level of automated driving set to be realized in the coming years. As a planning basis Harman has determined in this context that for the corresponding classic passenger cars with driver, a single forward-facing, high-resolution LIDAR with long range (50 to 200 m) is sufficient. Robotaxis on the other hand require substantially more recorded environmental data. So in addition to one long-range LIDAR at the front and one at the rear, they need two additional short-range LIDAR systems (less than 20 m) on each side of the vehicle. All future-proof LIDAR systems must achieve resolution of at least 0.1°x0.1°, a field of view of approximately 115° horizontally and 25° vertically. Plus a rate of 25 frames/s, while at the same time withstanding temperatures between –40 and +85°C.

> This high growth rate for LIDAR is based on expectations that manufacturers will increasingly equip their newly developed vehicles with enhanced ADAS functions to implement SAE L2+. This, in conjunction with the sharp decline in manufacturing costs due to higher unit volumes, will significantly boost growth in the forecast period 2018 to 2028.

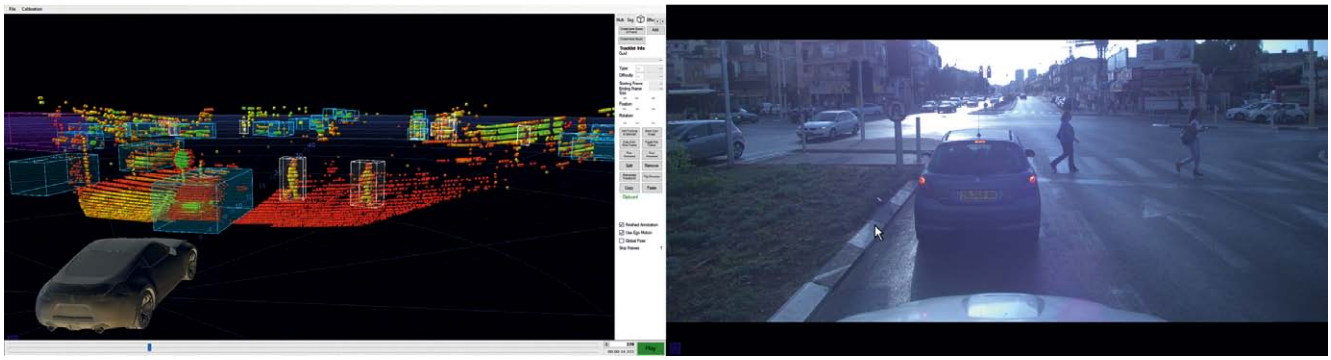


Figure 4. LIDAR display of point cloud and object detection. (photo: Innoviz)

## SOLID-STATE IS HERE AND NOW

Israeli manufacturer and Harman partner Innoviz offers with its MEMS-based solid-state LIDAR solution InnovizOne an example of a ready available LIDAR system that already meets future technical requirements (Figure 3). InnovizOne was developed especially for automobile manufacturers and providers of automated taxi and delivery services. The LIDAR sensor can be seamlessly integrated into system architectures, delivering high-resolution 3D point cloud up to a distance of 250 m, regardless of light and weather conditions. Combined with appropriate software the sensor enables excellent object detection, classification and tracking with high angular resolution. InnovizOne is certified according to ISO 26262, ISO 9001:2015, and IATF 16949 and will be used as the first solid-state LIDAR in the automobile industry in the first generation of autonomous BMW vehicles planned for 2021.

## CALL FOR POWERFUL CONTROL UNITS

The challenge for the use of LIDAR in everyday traffic of future automated and autonomous vehicles is to make appropriate use of the acquired sensor data by new, powerful ambient modeling algorithms. LIDAR provides the basis to create a classified 3D model of the driving environment. Evaluation of this 3D point cloud requires sophisticated algorithms to recognize and classify objects from a collection of points in space (Figure 4). To achieve the necessary quality of detection the self-driving vehicle requires powerful control units to process deep-learning algorithms and neural networks. For the comprehensive penetration of LIDAR solutions for SAE L3+ vehicles it is important that the hardware and software of different suppliers can be linked as well as to other sensors and ADAS solutions.
However, highly precise evaluation of LIDAR data by this approach is only part of the problem. To ensure a reliable high level of driving safety, the generated environmental model must also be considered in the context of the overall SAE L3+ system. For this purpose all available and relevant data sources from the different acquisition systems of the vehicle – camera, radar and LIDAR as well as external data from the cloud and V2X infrastructure – have to be combined in an optimal way to create a highly accurate image of the environment. For Harman sensor fusion is thus the key area for robust system development in the automated driving scenario.
The amount of data to be processed for this task places high demands on computing power. At present distributed control unit architectures are still mainly used in the vehicle in which sensor data processing takes place per sensor and the corresponding information is not brought together until object level, i.e. after detection and classification of recognized objects. For the much higher requirements of the future, centralized computer architectures are expected to prevail, allowing both parallel processing of the different sensor data and iterative processing of regions of interest in order to ensure a better detection rate (Figure 5). This architecture will already allow optimized processing and fusion for different sensors at the raw data level.

## BREAKTHROUGH FROM 2024

Although highly automated vehicles and robotaxis will appear on our roads later than predicted due to regulatory and technical obstacles, the race for the

### PERSPECTIVES FOR LIDAR

LIDAR is one of the three essential kinds of sensor, together with cameras and radar, forming an integral part of the autonomous driving future. Solid-state LIDAR technology in particular will reduce costs so significantly that its use will be possible in all future vehicle classes. Together with BMW the first generation of the new sensors is already planned for 2021 in small series. Significant volume with correspondingly optimized costs could then be available from 2024.
In addition to long-range LIDAR systems, short-range solutions are expected to become increasingly relevant. In particular, self-driving robotaxis and commercial vehicles are dependent on obtaining an accurate 360° image of their close surroundings at comparatively slow speeds below 50 km/h.
Analysts are convinced of the excellent future prospects for LIDAR. According to BIS Research's "Global Automotive Lidar Market - Analysis and Forecast, 2018-2028", the market for automotive light detection and ranging will grow from USD 353 million in 2017 to an estimated USD 8.32 billion in 2028.

future of autonomous driving is still in full swing. Harman expects an initial growth spurt for automated vehicles of autonomy category SAE L3 from 2021 onwards already, with larger fleets of robotaxis expected to enter the market in subsequent years. Such vehicles will initially be used with a limited operational design domain (ODD). Based on the data collected from these rapidly growing fleets, Harman expects that within a few years there will be major advances in environmental modeling and expansion of ODDs to SAE Level 5 systems. IH

Figure 5. Future sensor topology: 1 – central computer, 2 – allround cameras, 3 – external E-mirror cameras, 4 – internal E-mirror camera, 5 – passenger monitoring camera, 6 – driver monitoring camera, 7 – forward-looking camera, 8 – long-range LIDAR (LRL), 9 – short-range LIDAR (SRL), 10 – long-range radar (LRR), 11 – short-range radar (SRR), 12 – global satellite navigation system. (photo: Harman)

ROBERT KEMPF

is vice-president of strategy, portfolio and business development ADAS/automated driving of Harman International. He spent 20 years in a variety of global management positions and played a major role in the creation of new business divisions for mobile technology, cloud solutions and automotive. A focus has been identification of new technology and market trends and development of solutions and business models. A central aspect of his career has been innovation and growth through partnerships, in particular with leading Silicon Valley companies.

ELIV 2019 IN BONN

# IS GERMANY TRAILING?

(photo: oneinchpunch | Shutterstock)

In mid-October the who's who of automotive electronics gathered for the second time in Bonn/Germany to discuss challenges, solutions and problems at the international ELIV congress 2019. By Stefanie Eckardt

The automobile sector currently sees itself confronted with a process heading towards ecologically friendly, automated and networked vehicle concepts. "So our mission needs to be transformation", underscored Uwe Michael, head of Porsche E/E development and chairman of the ELIV program committee in his opening address (Figure 1). But no producer alone could achieve that because, besides climatic change, developments were also being influenced by trade conflicts, legislation and public opinion – far beyond the necessary technology. The automotive world was changing so fast, faster than it had done since the very introduction of the automobile. Above all, software would in future play a decisive role: "Software is the game changer – all customer functions in and around the automobile will benefit from software", emphasized Michael. Artificial intelligence, blockchain, cybersecurity, big data, autonomous systems or new business models would change and drive the industry permanently. 5G too was one of the things set to drive the sector. But "5G – and again Germany is trailing behind" was how Michael put it.

## DATA – THE NEW OIL

"Networked and automated driving takes software, software, software", underlined Dr Sigmar Haasis of Daimler in his keynote "AI – Transformation of the Automobile Industry" what the previous speaker Michael had already said. You need data, data, data. A realization that he shared with his listeners:

➔ Artificial intelligence is the game changer in the product development process.

➔ The focus must be data-driven organization: data is the new oil.

➔ Cultural change from "need to know" to "proud to share".

➔ Away from isolated AI application scenarios to an AI-based product development process.

Last but not least, one thing above all is important to remain competitive: "Invest in people because their know-how


Figure 1. Uwe Michael, E/E development head of Porsche and chairman of the ELIV program committee, stressed the need to actively implement a transformation process in the automobile industry. (photo: G. Stelzer | Elektronik automotive)

is THE key factor for successful business."

The second keynote came from Dr Christoph Grote (Figure 2) of BMW, directed at the topic "Beyond Software – Shaping Data Flow". Like the speakers before, Grote also concentrated on the subject of data, but emphasizing, "If I mix data the new oil with personal data, things start to get dangerous." He elucidated "We'll never earn money with the data of our customers. That would more than damage our image." Nevertheless, data was of exceptional importance for the automobile industry – if you used it correctly and shaped data flow the right way. Because the fast cycles of cloud-based approaches could profit to a large degree from data flow. What was important, as already mentioned, was how you went about working with personal data. The private sphere of the driver had to be guarded with no compromises. Plus, an industry-wide consensus on architecture played an important role, and ultimately a data market place was a key to success.

## "RANGE ANXIETY – THAT WAS YESTERDAY"

There was of course due focus on electromobility: electric vehicles from components, power electronics, batteries, power train development through to mobility concepts, then charging technology and infrastructure. Otmar Bitsche of Porsche stated that 800-V rapid charging was already reality on the Taycan (Figure 3). He furthered why 800-V technology was necessary, how Porsche had implemented the 800-V drive train (HV system, E-machine with DC/AC converter, HV battery), what possibilities of charging there were, and why the producer was involved in Ionity. The Taycan was a total product, as Bitsche emphasized, and he rounded off full of pride with: "The Porsche soul is now also electric."

After this mention of Ionity by Porsche, it was only logical that the enterprise itself stepped forward. And with no mean eloquence. "Range anxiety was yesterday" – with this statement Michael Hajesch, CEO of Ionity, welcomed listeners to his paper "Electromobility: a European Approach". Ionity was founded in September 2017 with five people based on the premise that carmakers would not sell vehicles if the infrastructure was missing. Its major sites are Munich and Oslo. "Our people in Oslo are already showing us what we can see here in Germany in three to four years", pointed Hajesch to Norway's pioneering role in Europe.

Still, the enterprise could be proud of its achievements to date. There were already 151 stations operating throughout Europe, 70 were currently being constructed, with a total of 400 stations planned by the end of 2020. What was important was that this was green power, and finding sources in Europe could be difficult, at least in the southern part. Turnover with these good 150 stations was 2 GWh. Did that sound a lot? No, as Hajesch explained: "By way of comparison, in China a provider is selling 5 GWh a day." But he was sure in his estimation that it was only a matter of time in Europe. Despite all the optimism – rapid charging was also a matter of interoperability, and that was where things needed to gain pace.

Autonomous driving and electromobility were just two topics at the enthralling event, spiced with papers on subjects like security, architecture, networking, data management. Next time round the event will take place from October 20–21, 2021 again in Bonn. ECK

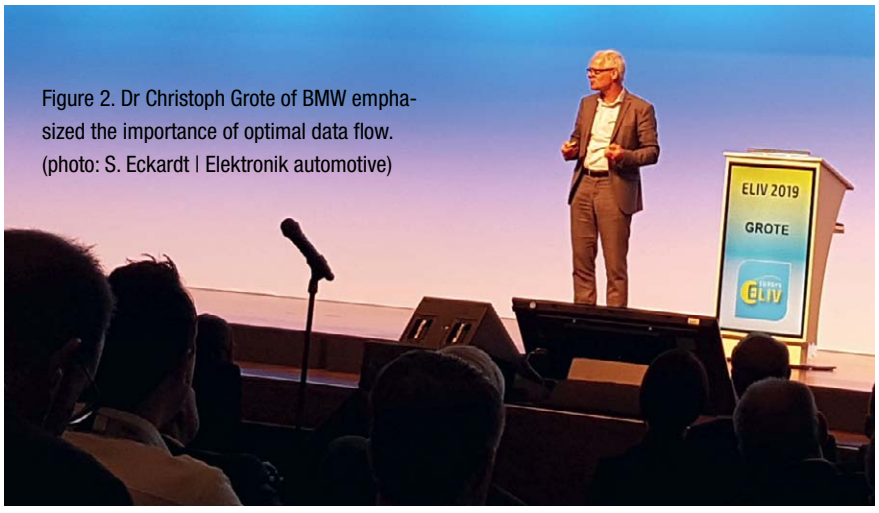
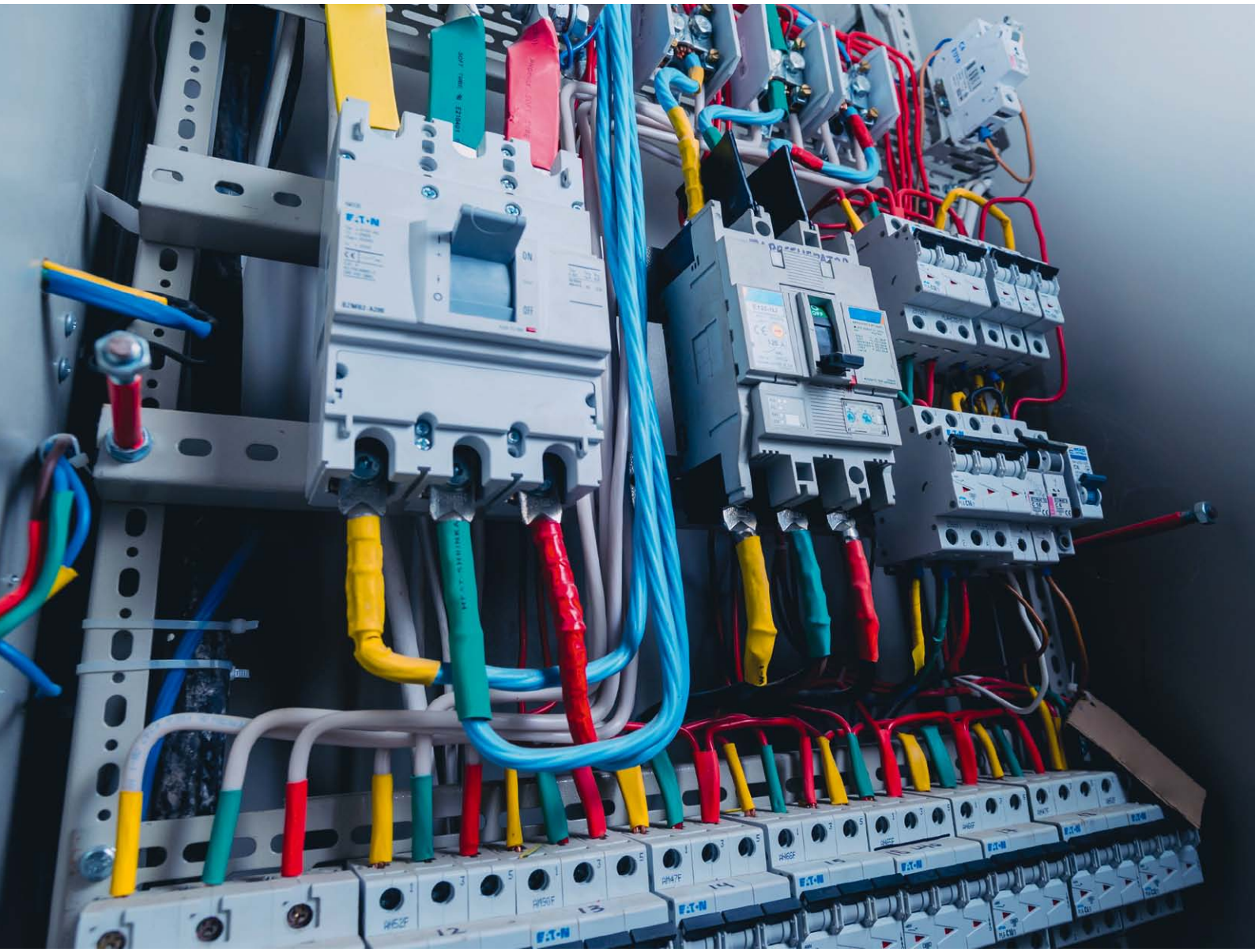



Figure 2. Dr Christoph Grote of BMW emphasized the importance of optimal data flow. (photo: S. Eckardt | Elektronik automotive)

Figure 3. The Porsche Taycan is the first purely electric sports car from the producer. (photo: S. Eckardt | Elektronik automotive)

PASSIVE RFID CIRCUITS FOR SENSORS:

# MONITORING CONTROL CABINETS



Control cabinets are monitored by regularly recording thermal images. Checking them continuously and automatically is possible by temperature sensors with a passive RFID tag. These meter directly on the conductor rail and send identifying data extra to measured readings.

By Dr. Andreas Weder

Predictive maintenance is a bonus if it receives data and there is a high degree of automation in how data is measured and captured. What it amounts to is permanently supervising the condition of machines or plant and optimizing maintenance based on the findings. For that purpose measured data must be identifiable and collected automatically. RFID sensors combine identification with the capture of measured data. Furthermore, they set up on an existing, tried and tested infrastructure.

## COMPONENTS OF AN RFID SYSTEM

RFID (radio-frequency identification) is a wireless technology enabling automatic identification of objects. For that reason it is often called an auto ID technology. The components of such a system consist of RFID tags, readers, and middleware to drive and read out the results. An RFID tag is frequently also called a transponder (a combination of transmitter and responder). Upon entry into the field of the reader, the tag reacts (responds) by automatically sending, i.e. transmitting, identification data. Data held in or stored by an RFID tag is read out by means of magnetic or electromagnetic waves.
This transponder consists of an integrated circuit and an antenna. The antenna is what primarily determines the size of a tag and is usually designed for different ambient conditions – underground, surrounding medium, installed situation. The aim is to optimize the reading distance or transmission. Basically, the reading range is greater the larger the antenna. Range is maximized by an integrated battery. Such systems are called active RFID. Passive systems draw the operating energy of the transponder solely from the field of the reader. The performance of a system will depend – extra to the antenna of the tag and battery support – on the selected frequency band. Reading distance, the influence of disturbing factors, and transmission are the major parameters affected by this (Table 1). Three frequency bands come into question:

➔ LF low frequency (125 kHz)
➔ HF high frequency (13.56 MHz)
➔ UHF ultra high frequency (868 or 915 MHz)

A complete system, extra to hardware components, also consists of software or the socalled middleware. This provides a connection between the hardware and higher-level software systems, like MES (manufacturing execution system), and ERP (enterprise resource planning), determines which data comes from which transponder, and reads this out by matching mechanisms. Hardware differs depending on the producer by frequency band, the protocols used, and interfaces. In practice there are a large number of different RFID components, which often makes system integration complex, and can lead to dependence on a single producer source.

| | 125 kHz (LF) | 13.56 MHz (HF) | 860–960 MHz (UHF) |
|---|---|---|---|
| Typical reading range | up to 1 m | up to 1.5 m | up to 10 m |
| Coupling | inductive | inductive | electromagnetic |
| Metal effect | mean | high | high |
| Water effect | none | low | high |
| Typical application | animal identification | access control | logistics and transportation |

Table 1. Features of RFID technology by frequency band.
(source: Fraunhofer IPMS)


Figure 1. Passive RFID temperature sensor on a screwed join in switchgear.
(photo: Fraunhofer IPMS)

## MEASURING CONDITION DATA BY RFID SENSORS

Information won by RFID can form a foundation for IoT and Industry 4.0 applications in many ways: the major aspect is the unique identification of objects like machines, components, equipment or tools. Enabling such objects to fulfill tasks as part of Industry 4.0, they must be able to communicate automatically.
A combination with sensor technology shows the way to further areas of Industry 4.0 application, especially a predictive maintenance scenario. Information can thus be expanded to data indicating a condition like temperature, humidity, shock and vibration, and so on. The operator thus obtains insight, deeper knowledge into the state of their equipment. Special RFID circuits can be connected to sensors. In this way it is possible, in addition to identification data, to determine and transfer the condition data of an object at the same time.

### RFID CIRCUITS FOR SENSORS

But conventional RFID transponder circuits do not allow the connection of sensors without more ado. Special circuits have to be created that support the standard RFID protocol on the one hand and that also provide interfaces for sensor elements or modules. Analog interfaces are suitable for connecting resistive, inductive, and capacitive sensors. Digital interfaces such as I²C or SPI very much simplify integration for the user and expand functionality. For example, in addition to generating measured values, other settings like different operating modes of a sensor can be varied.

### BATTERYLESS SENSORS

For passive systems the choice of sensors to be integrated should consider in particular the energy demand of a sensor, because the energy for measurement and transmission is drawn solely from the field of the reader. The bigger the

energy budget of a sensor, the smaller the possible distance between a reader and RFID tags. Extra to the existing infrastructure, an advantage of using RFID is that wireless and passive, i.e. batteryless sensors can be created and used in surroundings that are difficult of access or rough and tough. An application where both are the case is switchgear.

## MEASURING TEMPERATURE IN SWITCHGEAR

The state of switchgear cannot be determined alone by the parameter current. What says more is heating up of the conductor rails, especially at the screwed joins. Current flow may be the source of the heating up, but the development of heat in switchgear depends on a whole number of other factors such as ambient temperature, conditions of setting up and ventilation, and circulation inside the switchgear.
The insurers of switchgear recommend annual thermographic examination for early tracing of potential dangers and avoidance of production outages.
This process can nevertheless present drawbacks: switchgear is frequently located where it is very inaccessible. And precisely the screwed connections of interest are difficult to reach for thermographic measurement. Measurement is often made dangerously close to live parts because shutting down could falsify results. What is more, thermography is a single examination calling for a high degree of analytic experience to draw the right conclusions.
Passive sensor technology allows continuous monitoring, which is an advantage for this application. The Fraunhofer IPMS has developed a system that enables direct temperature measurement at different contact points of switchgear (Figure 1). This is not possible by cabled sensors. They could not be brought directly near the wanted point of measurement because of the high voltage on the conductor rails. Direct measurement uses RFID sensors operating in the UHF band. The condition monitoring system (Figure 2) allows permanent supervision of the contact points showing temperature, heatmap, and temperature over time.

## OPERATION IN METALLIC SURROUNDINGS

Passive UHF sensor technology presents special demands as regards arrangement and orientation of the RFID tags and the antennas of the reader. The electromagnetic field radi-


Figure 2. Several RFID temperature sensors interconnected to form a condition monitoring system, producing a live thermal image of the switchgear. (photo: Fraunhofer IPMS)

ated by the reader is not only reflected by the tags but by objects in the close vicinity. The reflected fields overlap the transmitted field of the reader, which can lead to attenuation, extinction or amplification of the field. That can often result in a chaotic pattern of reflections of differing intensity that can become almost incalculable. In metallic surroundings the effect is cumulative. As a consequence, there is not enough energy for the operation of individual RFID sensor tags, and gaps appear in the heatmap. To correct this, sensor positions have to be altered manually, and the configuration parameters adjusted, for example the number of sensor nodes and antennas, transmitted power, data rates, coding schemes, scheduling mechanisms.

The ideal solution to the problem is entirely electromagnetic simulation of all sensor nodes and their environment. But this is a time-consuming and compute-intensive process that is often in no relation to its usefulness. The Fraunhofer IPMS consequently uses a tool for self-optimizing constant operation of wireless sensor networks. This tool is based on fundamental knowledge and experience from the areas of high-frequency simulation and wireless communication, enabling simplified configuration and self-optimization of sensor nodes. In continuous operation too, reaction is possible to dynamic changes of operating state and ambient conditions, and reliable measured values are produced.

## DEVELOPMENT SUPPORT

In practice the requirements made of RFID sensor systems may vary entirely. Process demands, the physical environment, different application materials, the surrounding IT infrastructure – it can all affect the functionality and use of a system. Proof of concepts can be useful to verify the suitability of RFID as a basic technology for wireless sensors in different applications. Here the matching hardware for the ambient conditions and conditions of use is selected and tested in ambient conditions close to those of operation to determine whether the RFID technology performs well enough for the intended purpose.

The Fraunhofer IPMS also offers UHF evaluation kits for tests and demonstrations. These consist of a reader and different sensor transponders for random selection. Matching this there is middleware to read out and display measured values. MHA

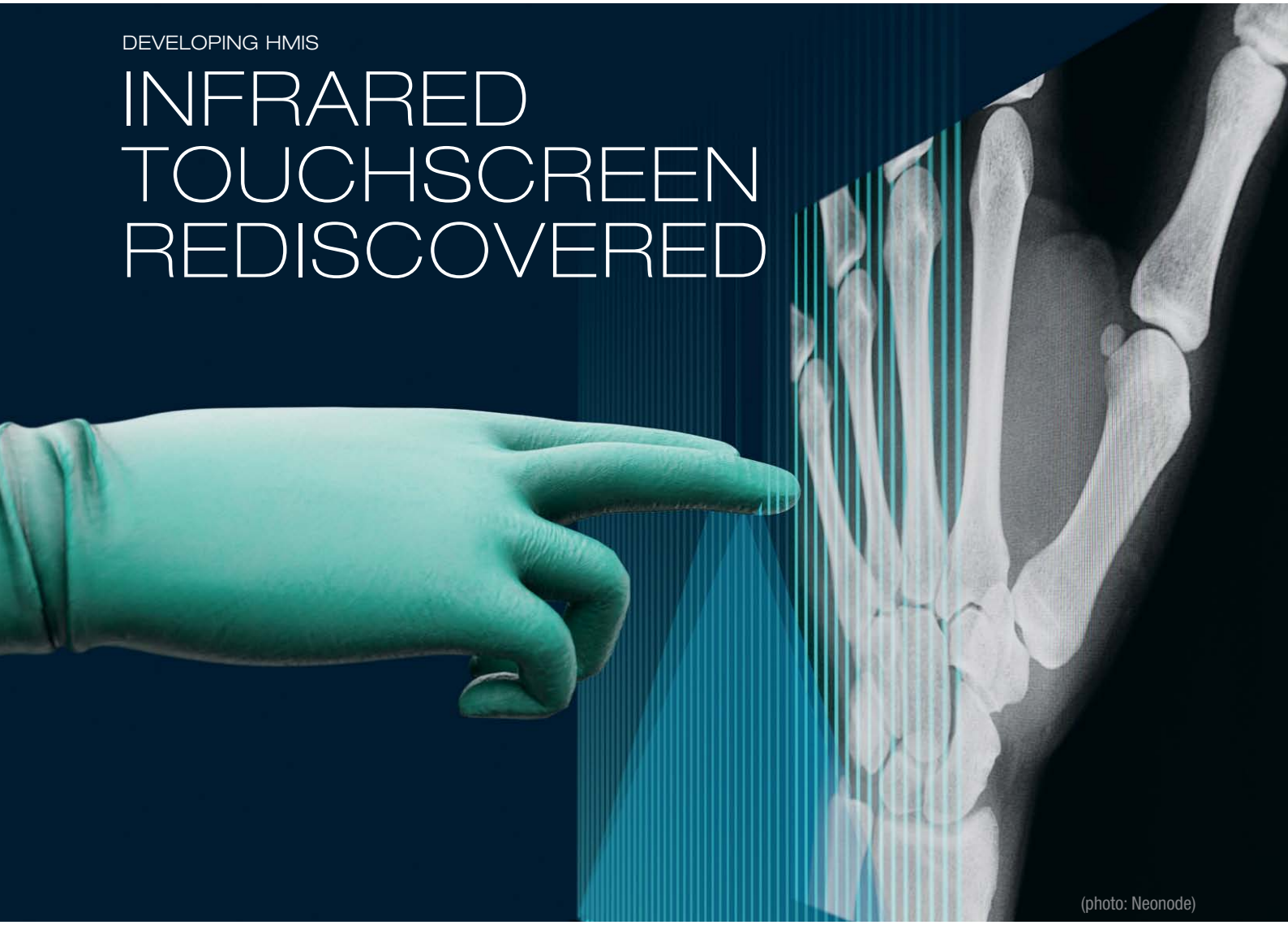
DR. ANDREAS WEDER

received a degree in communications engineering from the Technical University Dresden in 2006 and a doctorate for his work on wireless sensor networks in 2013. He joined Fraunhofer IPMS in 2006 where he has headed the module integration development group since 2016.

**andreas.weder@ipms.fraunhofer.de**

DEVELOPING HMIS

# INFRARED TOUCHSCREEN REDISCOVERED



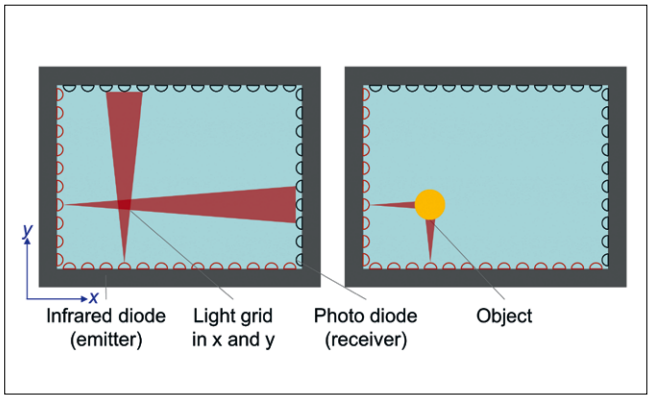
(photo: Neonode)

Infrared touchscreens are again becoming an alternative in HMI development. A modified approach does away with familiar drawbacks, like thick frames and restricted functionality in sunlight. Multitouch and gesture recognition are now possible in the meantime.

By Rudolf Sosnowsky

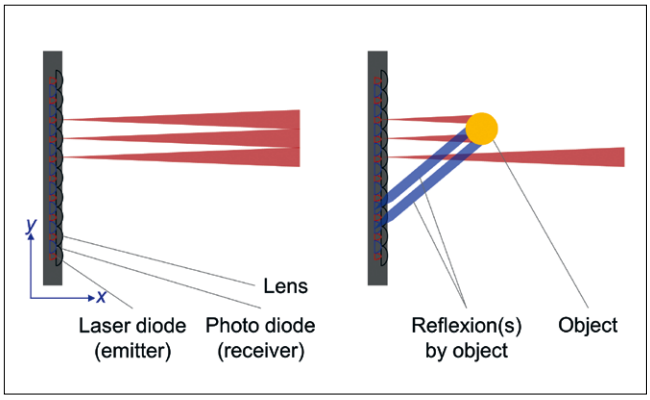
Infrared technology for touchscreens has a long history. The principle is simple: a light grid is mounted on the X and Y axes of a screen. If this light grid is interrupted, any penetrating object is detected and its position can be evaluated. This technology is simple and robust, and has the advantage of being separate from the display. It is used where displays are exposed to extreme environmental conditions, such as ambient temperature or vandalism. Examples are ticket vending machines and ATMs. There you can concentrate on protection of the display surface and make it meet requirements, e.g. mount a thick pane of protective glass that can be replaced in case of damage.

There are some disadvantages however. The diagonal increases the number of IR emitters and detector diodes as well as current consumption. Bright ambient light, such as direct sunlight at some times of the day, superimposes on the use-




(image: HY-Line Computer Components)

Figure 1. Functional principle of the infrared touchscreen.




(image: HY-Line Computer Components)

Figure 2. Functional principle of the zForce touchscreen.

ful signal and dazzles the photodiodes receiving the signal. Since the touchscreen is mounted behind the front panel, the display lies relatively deep in the housing, making the edge areas difficult to read when viewed at an oblique angle. A new approach in the now familiar technology avoids these disadvantages, offering a modern operating concept at the same time.

## INFRARED LASER WITH REFLECTION

The technology, known as zForce, places the transmitter and receiver side by side in a striped enclosure that only needs to be mounted on one side of the display. It does not evaluate the interruption of a light curtain but reflection of the emitted light by an object within sight. Recognition of multi-finger functions and gestures is done by the built-in controller. This technology offers several advantages over PCAP touchscreens; operation does not have to be carried out with a conductive object, and it is insensitive to electromagnetic fields and bright ambient light.

## SYSTEM INTEGRATION AND APPLICATIONS

With infrared touchscreens the sensor is connected to the housing, but not necessarily glued to the display. Figure 3 shows a cross-section through the construction. The display surface is located behind the front panel, touch sensor and protective glass far inside the device. To view the entire contents of the display, the user must stand in a straight line in front of the device. There are several options for integrating the zForce sensor. It can be mounted either flush with the housing or on the outside of the housing (Figure 4). Deposits such as dust and water above the display cannot impair its function. The display moves closer to the front of the device. For notebook users there are ready made strips that can be upgraded to a touchscreen notebook.
zForce technology is ideal for use in harsh indoor and outdoor environments where other touch principles fail. It can also be used to retrofit existing systems. The wide temperature range makes it easy to use in industrial environments. It can be operated with any object that reflects light, including protective gloves, credit cards and pens. Operation is no problem even with wet or dirty hands or long fingernails. The touch sensor is mounted outside the display, so this can be protected from environmental conditions without regard to the touch screen. The touch sensor is insensitive to electromagnetic interference, so it can be used in commercial vehicles, agricultural equipment and machines with large electric drives. The functional principle allows the display surface to be shielded against eavesdropping, and not to be disturbed by radiation in a sensitive environment. Of course, the protection also works inwards: the display opening as an entrance gate for electrical interference signals can be sealed. As a "smart sensor", e.g. on a worktop made of wood or stone, the sensor can also operate without a display. The costs scale well with the size of the screen, since in contrast to the IR touchscreen only one dimension has to be covered. Even this is not a must: with a selective touch area for example, the on-screen menu of a large screen in a lower corner can be operated without the touch sensor having to cover the entire width of the screen.

## CONFIGURATION AS PROXIMITY SENSOR

Depending on orientation of the laser, zForce can be used as a touchscreen, light barrier or proximity sensor. Figure 5 shows the differences. With alignment rotated by 90°, the

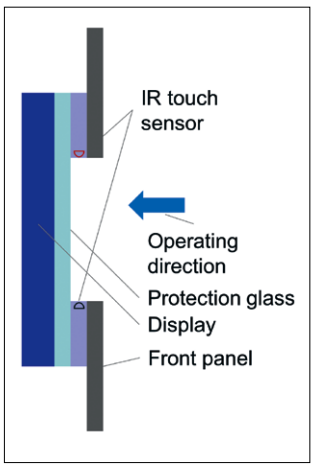
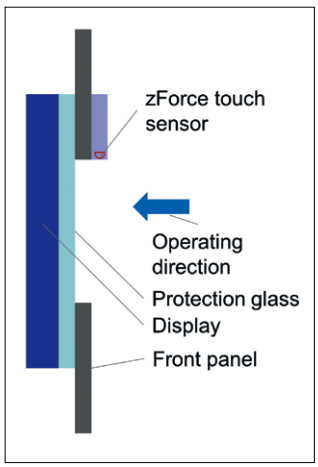



Figure 3. Cross-section of an infrared touchscreen system.




(image: HY-Line Computer Components)

Figure 4. Cross-section through a zForce touchscreen system.

sensor serves as a unidimensional user interface. In contrast to conventional proximity sensors, which evaluate the signal strength as an indicator for the position of an object, here the combination of transmitter and receiver signal determines the position of an object.

### TOUCHSCREEN WITHOUT TOUCH

While replacement of conventional touchscreens is obvious, zForce technology finds further areas of application. It is ideal for the monitors of imaging processes in medical technology. Image quality such as contrast, coating, antireflection coating and parallax are retained because the optical properties of the display surface are not affected. This is not the only advantage of not having to touch the surface with sterile gloves, but also in public places where elevators are called, vending machines operated and toilets flushed – germs have no chance to spread! Even in the food industry or a restaurant kitchen devices can be operated with dirty fingers without touching the surface and making the screen underneath unreadable.

Used as a light barrier the technology can detect the presence of (unwanted) objects and the system can take appropriate action. As a proximity sensor it can also be installed in moving objects to avoid collision with the surroundings such as in suction or mowing robots.

### SOFTWARE INTEGRATION

The built-in controller presents itself as a USB HID (human interface device), so it works straight away with the operating system of a corresponding host and replaces or complements the mouse functions as single or multi-touch. Alternatively, it provides information via I²C.

## COMPARISON WITH OTHER TOUCH TECHNOLOGIES

Compared to other technologies, zForce performs well. In particular the lack of coupling to the underlying display enables applications that cannot be implemented with other touchscreens. Figure 6 shows the sensor in side view.

### STURDINESS

The touch sensor itself is resistant to the usual chemicals used for cleaning or sterilisation in medical environments. Vandalism, usually directed against the display, is made ineffective there with a suitable windscreen. Since the functional principle is not based on electromagnetic fields but on “invisible” light, the sensor neither emits electromagnetic radiation nor is its function impaired by fields or interference pulses. Filters prevent the sensor from seeing ambient light from the sun or strong light sources. Service life is long regardless of the number of operations.

### ERGONOMICS

While the argument for PCAP is the flat, flush-fitting surface, the zForce sensor scores with its suitability for special applications. It offers multitouch functions with the recognition of several fingers and gestures, and can be operated with all media, be it thick gloves, credit cards or fingernails. This feature can also be exploited to enable non-contact operation in sterile areas or with dirty hands. In terms of special design, the touch sensor can also disappear completely into a surface and be used for hidden operation. Figure 7 compares the technologies.

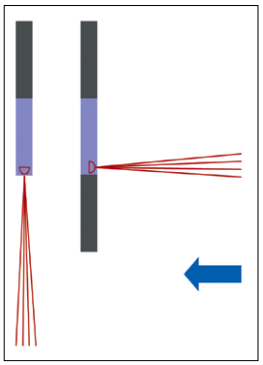


Figure 5. Use as light barrier (left) and proximity sensor (right).

(image: HY-Line Computer Components)

Figure 6. Sensor module from manufacturer Neonode, right opening for transmitter and receiver. (photo: Neonode)

| Technologie | Resistiv | PCAP | Infrarot | zForce |
|---|---|---|---|---|
| Diagonale | 24 Zoll | > 65 Zoll | 42 Zoll | 15,6 Zoll |
| Optik | – | + | ++ | ++ |
| Integration | + | o | + | ++ |
| Robustheit | - | ++ | ++ | ++ |
| Vielseitigkeit | o | + | o | + |

Table 1. Comparison of common touch technologies. (Source: Hy-Line)

## BOTTOM LINE

Although the majority of touchscreens today are based on the PCAP principle, there are applications for which it is less suitable. zForce technology offers the advantage of separate mounting; the display surface is not influenced by the touchscreen. This allows it to be designed according to other criteria: for rugged use, for operation with any object where actually touching the screen is not desired, or where image quality must not be influenced by an additional layer over the display. MHA

RUDOLF SOSNOWSKY

received a degree from Darmstadt University in electrical/electronic engineering. He first worked in the development of automotive electronics and in LCD manufacturing. He later moved on to Hy-Line Computer Components where he is engaged in the introduction of new technologies and selection of suppliers.

**r-sosnowsky@hy-line.de**

# IMPRINT


**EDITORIAL OFFICE**

**Contact:** Redaktion Elektronik,
Richard-Reitzner-Allee 2, 85540 Haar

**Assistance:**
Andrea Seidel, Silvia Langford
**Phone:** 089 25556-1332; fax: -1670
**Internet:** www.elektronik.de
**E-Mail:** redaktion@elektronik.de

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**Picture service:**
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Tel. 089 25556-1442,
mstephan@weka-fachmedien.de

**Technical department:**
JournalMedia GmbH,
Richard-Reitzner-Allee 4, 85540 Haar

**Printing:** L. N. Schaffrath, Marktweg 42–50, 47608 Geldern





**MEDIA CONSULTING**
**Contact:** Redaktion Elektronik,
Richard-Reitzner-Allee 2, 85540 Haar
**E-Mail:** media@elektronik.de
**Internet:** www.weka-fachmedien.de/media.html

**Sales Director:** Sonja Winkler
(-1383, swinkler@weka-fachmedien.de)

**International Account Manager:**
Konrad Nadler (+49 89 25556-1382,
knadler@weka-fachmedien.de)

**Media Consultants:**
**Nicole Müller**
(-1384, nmueller@weka-fachmedien.de),
**Konrad Nadler**
(-1382, knadler@weka-fachmedien.de),
**Bernhard Reinisch**
(-1381, breinisch@weka-fachmedien.de),
**Fax:** 089 25556-1670

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Fax 001 212 268 3355,
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**PUBLISHING HOUSE**
**Contact:** WEKA FACHMEDIEN GmbH
Richard-Reitzner-Allee 2, 85540 Haar
Phone: 089 25556-1000; fax: -1396
www.weka-fachmedien.de

**Sales manager:** Marc Schneider
(-1509, mschneider@weka-fachmedien.de)

**Production management:**
Marion Stephan (-1442)

**Publishing management:**
Matthäus Hose

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**Order and subscription service:**
WEKA FACHMEDIEN GmbH
c/o Zenit Pressevertrieb GmbH,
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70523 Stuttgart,
Phone: +49 (0)711 7252-210,
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**Bank account:** HypoVereinsbank
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# INDEX OF ADVERTISERS

SINGLE-PAIR ETHERNET

# MANY FACES, ONE STANDARD THROUGHOUT

(photo: Harting)

Industrial Ethernet over a single pair of wires, known as single-pair Ethernet (SPE), saves effort and costs. Several companies are cooperating to market SPE solutions. A comparison of current developments provides future users with information and an overview of standards, technical fundamentals and outlines the advantages over previous cabling modes.

By Jonas Diekmann and Matthias Fritsche

Generations of users have learnt that Fast Ethernet (10/100 Mbit/s) requires cabling with two wire pairs and Gigabit Ethernet requires four wire pairs. Together with knowledge of the different component categories for transmission rates from Cat. 5 to the new 8.1/8.2, this is the tool for planning, installing and operating data cables. In the new single-pair Ethernet (SPE) a technology is now entering the market that can also transmit these TCP/IP-based data streams over a single pair of wires.

This development requires new electronic components in future devices, such as PHYs, magnetic couplers and device sockets, but also the infrastructure of connectors and matching cables with only one twisted pair of copper wires. Especially in the field of connectors, several manufacturers of connection technology and infrastructure have presented solutions for the new standard in recent months. It is important to realize that SPE is not simply a new interface for familiar Ethernet connections but a new technology for which all components must be redefined. For end-to-end connection, different standards for interfaces, cables and a new transmission standard must be defined by standards committees. ISO/IEC JTC 1/SC 25/WG 3 plays a central role in standardization. Here, based on IEEE 802.3, the cabling standards of ISO/IEC 11801 are created and maintained (Figure 1). To this end there is a close exchange and intensive cooperation with IEEE 802.3 and committees for cabling components; this applies to IEC SC46C copper data cables and the associated IEC SC48B connectors.

## IEC 63171 – STANDARDIZATION OF SINGLE-PAIR ETHERNET CONNECTIVITY

The first draft SPE connector standard was submitted by Harting to IEC committee SC48B in 2016 and published as IEC 61076-3-125 up to the CD document. In 2017 Commscope submitted a further SPE mating face for standardization and the committee subsequently decided to create the IEC 63171 series of standards for all SPE connectors. Accordingly project team PT63171 was set up at SC48B and commissioned to create this new series of standards. Standards already in progress up to this point will be completed as self-contained documents and later integrated into the new series of standards in the context of revisions.

## STANDARD PROJECTS FOR SPE CONNECTOR FACES

➔ IEC 63171 – basic standard with all necessary specifications and test sequences (CD in preparation)
➔ IEC 63171-1 – SPE connector from CommScope based on LC locking for M1I1C1E1 applications (CDV available)
➔ IEC 63171-2 – SPE connector from Reichle & De-Massari for M1I1C1E1 applications (CD available)
➔ IEC 63171-3 – SPE connector from Siemon based on a pair of Tera connectors for M1I1C1E1 applications (NP available)
➔ IEC 63171-4 – SPE connector from BKS for M1I1C1E1 applications (NP available)

### GLOSSARY

➔ MICE – describes environmental conditions for installations and gives planners and users valuable information for the specification of technical equipment and cabling. Requirements are described for mechanical ruggedness (M), IPxx grade (I), chemical and climatic strength (C), and electromagnetic safety (E). In the widest sense, M1I1C1E1 describes an environment found in an office building, for example, and M3I3C3E3 an extreme environment as found in industry or outdoors.
➔ XT – is a common term for crosstalk, and the mutual influencing of adjacent wires in a cable.
➔ NEXT – denotes near-end crosstalk and is that part of crosstalk measured at the input end of the main signal, i.e. near to the point where the desired signal is fed into the cable.
➔ FEXT – denotes far-end crosstalk and is that part of crosstalk measured at the receiving end of the main signal, i.e. far from the point where the main signal is fed into the cable. An extra aspect here is cable attenuation, which reduces this disturbing factor. FEXT is thus usually lower than NEXT. But this needs to be seen in proper relation because FEXT tends to increase with frequency, and is appropriately less for low-loss cables as required for T1.

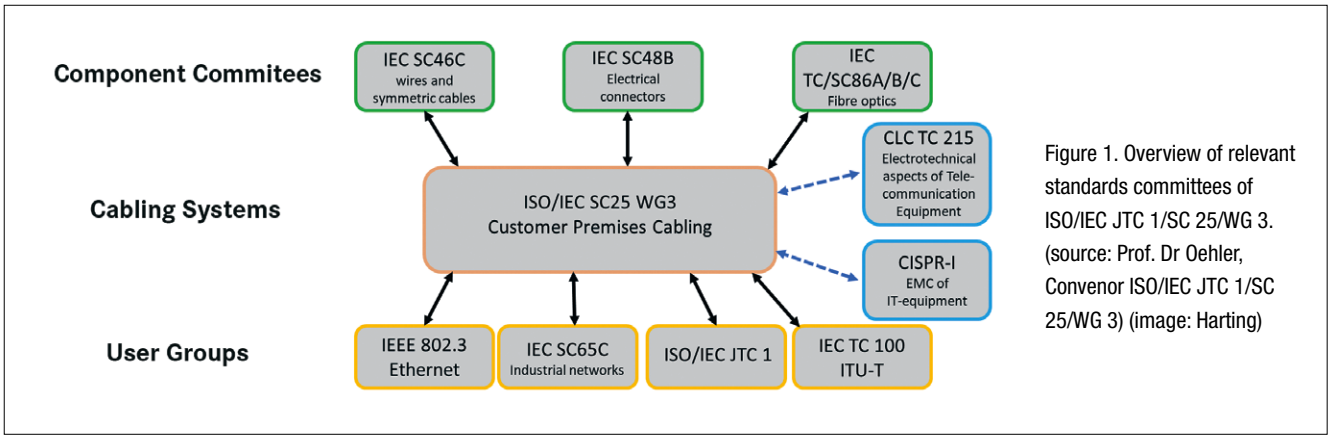



Figure 1. Overview of relevant standards committees of ISO/IEC JTC 1/SC 25/WG 3. (source: Prof. Dr Oehler, Convenor ISO/IEC JTC 1/SC 25/WG 3) (image: Harting)

➔ IEC 63171-5– SPE connector from Phoenix Contact based on the IEC 63171-2 connector face for M2I2C2E2 and M3I3C3E3 applications (CD available)
➔ IEC 63171-6 (formerly IEC 61076-3-125) – SPE connector from Harting, Hirose and TE Connectivity for M2I2C2E2 and M3I3C3E3 applications (CDV available, FDIS in preparation and final release in 2019)

IEC 63171-1 (LC style) and IEC 63171-6 (industrial style) are complete standard documents with all necessary specifications and test sequences. All standards commenced later refer to the basic IEC 63171 standard and only contain the different mechanical implementations.

## CABLING STANDARDS FOR SPE

SPE and standardized connectors are included in the current cabling standards. Internationally this applies above all to the series of standards for structured cabling according to ISO/IEC 11801:2017 and in a similar way to the European series of standards in CENELEC according to EN 50173, where SPE will first be included in Part 3 Industrial Cabling in the form of amendments. The central document for these is ISO/IEC 11801 TR9906 "Technical report: Balanced 1-pair cabling channels up to 600 MHz".
Implementation of SPE in the ISO/IEC 11801 documents is so important because only this standard describes the cabling channels with all necessary parameters (distance, number of connections, bandwidth and the complete set of transmission parameters including NEXT, FEXT, shielding properties, etc) in relation to the environment – MICE and that thus can be measured and verified even after installation.
Parallel to this, installation standards for industry as a basis for cabling automation solutions according to IEC 61918 (IEC SC65C) will be adapted accordingly. PI (with Profinet to IEC 61784-5-3) and ODVA (with Ethernet/IP to IEC 61784-5-2) will actively participate in further development and implementation of SPE standards.

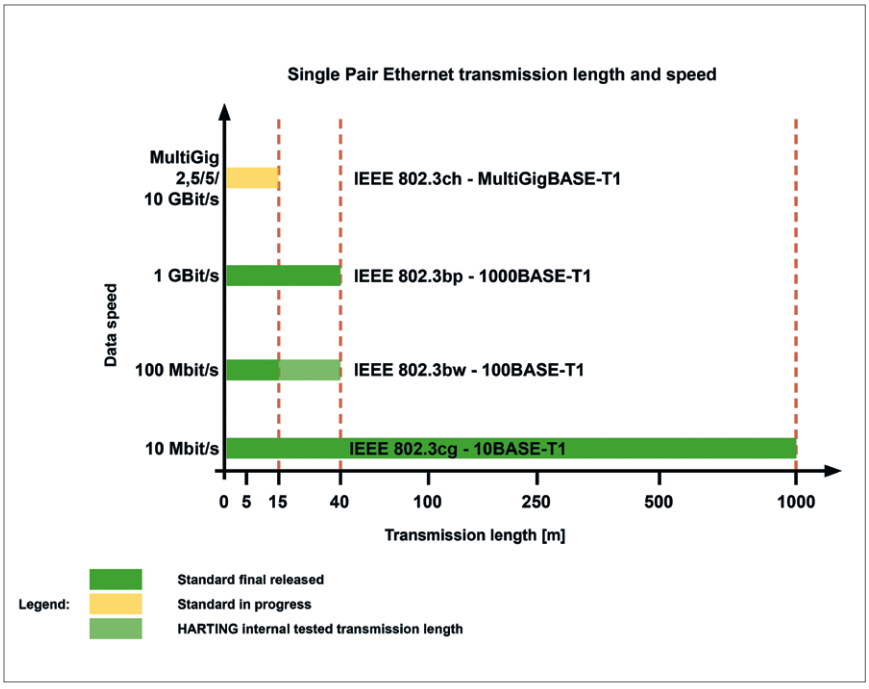



Figure 2. Range and transmission rate of current IEEE 802.3-SPE standards. (image: Harting)

In conjunction with the component standards for connectors and cables, all SPE users receive clear guidelines for the setup and testing of appropriate transmission links. For 1 Gbit/s SPE this cabling is initially limited to a range of 40 m, with ranges of 1000 m and more being realized for the 10-Mbit/s variant. Further papers on SPE cabling with relevance to the USA plus Canada and Mexico are being prepared at ANSI/TIA-568.5 and TIA TR42.7. In the TIA42 papers this is updated by addendum TIA-1005-A-3. The content of all these addenda is largely identical.
The standards provide the user with information on the structure of the cabling, the cabling components to be used to achieve the performance specifications and the limit values for testing the cabling. They are therefore the most important instrument for installing and commencing use of SPE cabling

systems. At the same time they ensure compatibility between devices and cabling by references to component standards. This compatibility is a basic requirement for the function of networks and connections based on SPE and thus the basis for IoT/IIoT. The use of other cabling components, such as those in ISO/IEC 11801-3 Amd. 1, is possible in principle, but then they no longer conform to the standard and carry the risk of incompatibility and sacrifices in functionality. For this reason, ISO/IEC JTC 1/SC 25/WG 3 and TIA 42 launched international selection processes at the beginning of 2018 to define uniform interfaces. The two selection processes were co-initiated by IEEE 802.3, which requested a recommendation for an SPE MDI (device interface) from ISO/IEC and TIA.
More than 20 national expert panels participated in this selection process. Two mating faces emerged as the result:
➔ for building cabling (M1I1C1E1) the mating face according to IEC 63171-1,
➔ for industrial and industry-related applications (M2I2C2E2 and M3I3C3E3) the mating face according to IEC 63171-6 (formerly IEC 61076-3-125).

The TIA 42 selection process confirmed the results of ISO/IEC and thus there is global agreement on SPE interfaces. The selected mating faces are now being incorporated in the respective international cabling standards. This is the prerequisite for large-scale use and thus for successful marketing of SPE technology with consistent compatibility of devices, cables and connectors in different fields of application, besides providing planning reliability for all market participants.

## TRANSMISSION UP TO 1000 M

The Ethernet technology of IEEE 802.3bp 1000BASE-T1 that is already available today delivers 1 Gbit/s transmission rate over one pair of copper wires. IEEE is

### OVERVIEW

➔ IEC 61156-x – standardization of single-pair Ethernet cables
IEC working group SC46C is currently concentrating on standardization of data cables in the following projects:
➔ IEC 61156-11 – SPE data cable up to 600 MHz bandwidth for fixed lay (final published)
➔ IEC 61156-12 – SPE data cable up to 600 MHz bandwidth for flexible lay (CD available)
➔ IEC 61156-13 – SPE data cable up to 20 MHz band width for fixed lay (CD available)
➔ IEC 61156-14 – SPE data cable up to 20 MHz bandwidth for flexible lay (planned)

currently working on a further standard for even higher data rates up to 10 Gbit/s (IEEE 802.3ch), required for high-resolution sensors and video transmission. In addition, a standard for only 10 Mbit/s (IEEE 802.3cg) is being created. This is also particularly relevant for many areas of industry as it allows transmission up to 1000 m and can therefore replace almost all field buses. Furthermore, in March 2019 another working group was set up to deal with transmission rates above 10 Gbit/s. Targets envisaged here are 25 Gbit/s and 50 Gbit/s. These high data rates are the basic technology for autonomous driving and new zoned computer architectures in vehicles (Figure 2).

| | 4-pair Ethernet cabling (MPE) | | Single-pair Ethernet (SPE) | |
|---|---|---|---|---|
| Data rate | Bandwidth (Cat.) | Transmission range | Bandwidth | Transmission range |
| 10 Mbit/s | 16 MHz (Cat. 3) | 100 m | 20 MHz | 1000 m |
| 100 Mbit/s | 100 MHz (Cat. 5) | 100 m | 166 MHz | 40 m |
| 1000 Mbit/s | 100 MHz (Cat. 5) | 100 m | 600 MHz | 40 m |
| 10 Gbit/s | 500 MHz (Cat. 6A) | 100 m | 4 – 5 GHz tbd. | 15 m |

Table 1. Comparison of SPE and MPE (values for shielded STP SPE cables). (source: Harting)

## DATA AND POWER SUPPLY

As with multi-pair cabling, there is a new remote power supply for SPE standard called PoDL (Power over Data Line), similar to Power over Ethernet (PoE). This combination of data and power through very small connectors and single-pair symmetric cables supports trends to miniaturization, higher data rate and modularization for more complex systems – all prerequisites for the rapid development of a market for SPE applications apart from vehicles too, in industry, smart cities and buildings.
SPE technology has thus already achieved the same performance as today's predominant multi-pair Ethernet (MPE), and within a very short time. The only limitation is the current range for 100 Mbit/s and Gigabit SPE (15 m and 40 m), resulting from the requirements of the main target group in the automotive industry.

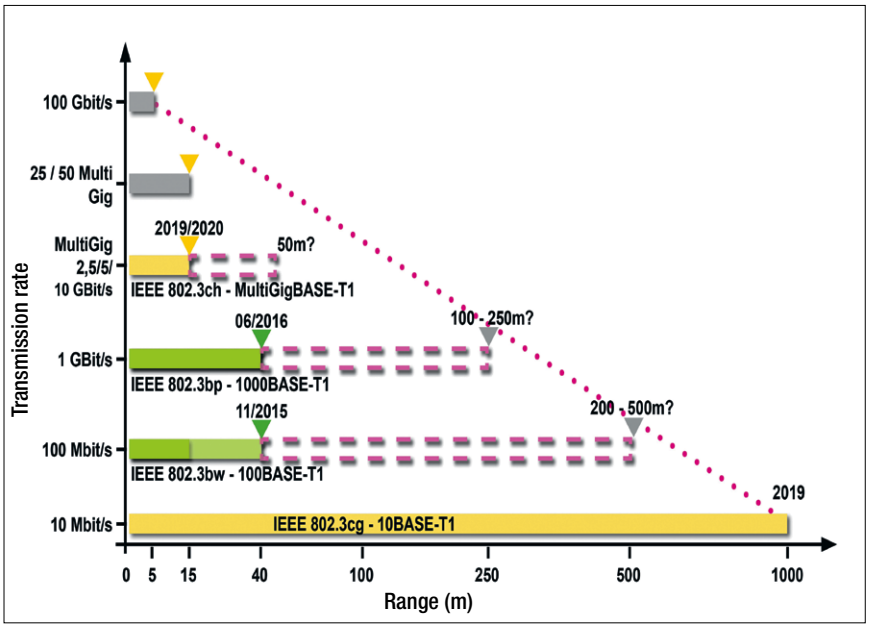



Figure 3. Range and transmission rate for future possible IEEE 802.3 SPE standards – extended reach. (image: Harting)

Experts believe that longer transmission is also achievable here. Figure 3 shows the lengths of transmission that are technically possible. However, for these extensions of the SPE standards to be tackled with IEEE 802.3, and in particular for the semiconductor industry to invest in development of the new chipsets, it is necessary to define the new applications and the market potential. This requires open cooperation between all interested parties for the extended SPE ranges.

## COMPARISON OF MPE (4-PAIR) AND SPE (SINGLE-PAIR)

Even though twisted wire pairs are needed for current 4-pair data cabling as well as for SPE, the requirements for cabling and connection technology in terms of transmission range with the currently available SPE transmission standards as well as the RF requirements, which is particularly evident in the necessary bandwidth, are quite different (Table 1).

## MIGRATION OF MPE FROM SPE (CABLE SHARING)

High data rates over one pair of wires: using 4-pair cabling for SPE by cable sharing sounds helpful. In special cases this is possible but not reasonable technically and economically. For one thing, SPE cabling requires more bandwidth compared to MPE, especially for crosstalk, and compared to MPE with 100 m transmission range, SPE has so far only had shorter transmission ranges of 40 m with 1000BASE-T1 for shielded cables. In this migration scenario, the user must therefore check the installed cabling line by line for SPE and usually replace it with higher classified cables. That also makes the economic sense of such concepts of use questionable. For example, to qualify installed Cat. 6A cabling for 1000BASE-T1, the transmission range must not exceed 40 m and the corresponding RF parameters must be qualified up to 600 MHz. Even if everything fits perfectly, 4 x 1 Gbit/s SPE can then be used for transmission, although these Cat. 6A cabling links can be used

today with 10 Gbit/s MPE. For these reasons, Harting sees the fields of application of SPE, especially in terms of industrial applications, elsewhere.

## FIELDS OF USE

In industrial applications Ethernet is represented throughout, from company headquarters to the shop floor. From here translators and gateways usually take over, establishing connection to field-bus systems. However, as more sophisticated and powerful sensors and actuators are appearing at field level, the need for Ethernet at field level is clear. Via SPE the large number of field devices can be supplied by Ethernet to save space and cut costs. That makes translators and gateways obsolete, makes every sensor IP-addressable and, with TSN, also deterministic: MPE up TO the field level and then with SPE directly INTO the field level. “From sensor to cloud” becomes a reality with SPE.

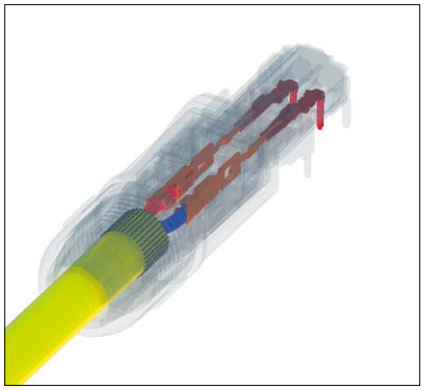


Figure 4. Symmetric structure of IEC 63171-6 connector face. (image: Harting)

## CONNECTOR FACE TO IEC 63171-6

Due to the higher bandwidth requirement mentioned above, RF demands of cables and connectivity increase, and a very symmetric connector design is necessary to reliably meet RF requirements. For this reason the contacts of the T1 industrial connector are arranged symmetrically in a fully enclosed shielded housing. This means that coupling capacitances and inductances of both conductors to the shielding or the PCB cancel each other out and differential data transmission is not disturbed.
Both contacts are also arranged parallel to the printed circuit board and next to each other. This means that the signal path in both conductor paths is identical and signal propagation time differences are avoided (Figure 4).

## COMPATIBILITY AND OUTLOOK

According to IEEE 802.3 standards, the greater ranges are only achieved with shielded transmission links. For this reason, and to ensure reliable transmission even in harsh industrial environments, a shielded design was consistently implemented. At the same time, the shielding plates also serve as a robust mechanical interlock for the IP20 version. The metal latching lever also eliminates the problem with the defective locking mechanism that is often criticized with RJ45. M8 and M12 circular connectors have established themselves in industrial applications. Accordingly the new SPE mating face has been integrated as a uniform “data container” in the M8 designs with screw, snap-in and push-pull locking. Furthermore, M12 designs with screw and push-pull locking are also standardized, in particular to accommodate the large cable cross-sections for the 1000 m 10BASE-T1L channel. This means that the same mating face is used in all designs so that IP20 connectors can also be connected to the IP65/67 interfaces for parameterization or testing. Use of the common M8/M12 designs ensures optimum market acceptance and at the same time reduces necessary investment costs since many suppliers have the corresponding housing designs available.
Use of identical socket and connector inserts (data containers) in all designs guarantees uniform technical characteristics in all series and creates favorable conditions for cost-efficient production through economies of scale. SPE interfaces according to IEC 63171-6 thus provide an internationally standardized mating face that supports future use of SPE in industrial applications. By using this standardized SPE data container, it is also possible to integrate the IEC 63171 mating face into numerous other designs, such as the connector system with internal M12 push-pull locking that is currently being developed as a new standards project, or other designs still to be developed. SD

**MATTHIAS FRITSCHE**

is a product manager and specialist on Ethernet connectivity at Harting, supporting the technology group on the latest trends and developments in industrial Ethernet communication. He is also a member of various committees promoting and shaping standards for users. The author has pursued the subject of single-pair Ethernet for a number of years already, seeing it as the future infrastructure for industrial networks.

**JONAS DIEKMANN**

is a technical editor in the Harting technology group, responsible for PR, press, marketing and content management for the electronics division. He has also been involved in the subject of SPE for several years, presenting it to customers and readers of magazine articles as the Gbit Ethernet foundation for the future.

STANDARDIZATION

# DNA FOR NETWORKS OF THE NEXT GENERATION

(photo: Shutterstock)

We can see today already that conventional Ethernet bus systems are unlikely to satisfy future demands of an industrial scenario. A new cabling standard is urgently needed.

By Carsten Nagel

At the Hannover Fair 2019 the companies Phoenix Contact, Weidmüller Interface, Reichle & De-Massari, Belden plus Fluke Networks founded a partnership for single-pair Ethernet (SPE) to create uniform standards for the new technology. The companies are developing and supporting the connector faces IEC 63171-2 and IEC 63171-5 jointly proposed for standardization.

## INTELLIGENT COMMUNICATION WITH SENSORS

Digital networking and modularity are penetrating industrial technologies to allow a high degree of flexibility in production. But on the last automation levels networking still often comes up against structural barriers. At the same time, given the increasing number of smart devices worldwide due to digitalization, the effort that goes into networking becomes more complex. Again and again, in an industrial system scenario, you find Ethernet as a field-bus alternative. The advantages of integrated networking through control as far as the IT world are considerable. Many obstacles like a defined reaction time were overcome and an industrial Ethernet thus created that satisfies the tough demands in a machine-oriented scenario. The migration of field-bus technology to Ethernet means that one is not only able to retrieve a status signal, but intelligent communication with sensors is also possible. Through the new technology and its new cabling structures it will be possible in future to reduce active components, utilizing a four-pair cabling infrastructure.

A single-pair Ethernet installation requires substantially less space, a special advantage for compact I/O interfaces. SPE only needs one pair instead of two or four pairs. The impetus for this development came from the automobile industry where onboard networks are implemented in this technology. In the meantime interest is growing in automation engineering too. The simple structure plus reduced weight, space need and installation effort are an attractive proposition for construction engineers.

Transmission rates of 10 Mbit/s over 1000 meters through to 1 Gbit/s are suitable for future Industry 4.0 applications. The SPE infrastructure is also an advantage in smart building networks, IoT applications, and other controller/actuator networks.

## CABLE SHARING

Extra to a purely single-pair cabling structure, it is also admissible to create a four-pair cabling structure to carry (share) four individual SPE channels. This is a bonus in industrial applications in particular, where you often find numerous sensors installed in the tightest space. Such bundled structures can only be implemented there with few other connection technologies.

Also worth special mention is that connection technologies IEC 63171-2 (IP20 environment) and IEC 63171-5 (IP67 environment) show the same connector face. A four-pair connection technology based on M12 extends the requirement for the connection technology in standardization for SPE, as also described in IEC 63171-5.

The same connector face means that you are able to combine connection technology in IP20 and IP67. This compatibility can be a particular advantage in field measurements. Existing cabling

Figure 1. The four-chamber system of the new connector concept enables cabling independent of application. (photo: Weidmüller)

systems in an IP67 environment can be measured to standard and qualified simply and fast with IP20 connectors. Direct four-pair measurement is possible, but single pairs in the four-pair system can also be measured.

Because of the higher requirement of connectors compared to category 8.2 according to ISO/IEC 11801-1:2017-12, the four-pair connection technologies according to IEC 63171-2 and IEC 63171-5 can be used independent of application. Areas such as data centers, offices, home and industry are imaginable. Connection technologies in the different environments IP20 and IP67 always have the same transmission characteristics.

The standards are currently being developed for thorough compatibility of devices, lines, and connectors. In IEEE 802.3 (Ethernet) the different SPE applications (100 Base-T1, 1000 Base-T1) were worked on and adopted in different project groups, that of the 10 Base-T1 application (IEEE 802.3cg) having been planned for September 2019.

In connection with the current status of the "IEEE P802.3cg/D2.2 Draft Standard for Ethernet Amendment: Physical Layer Specifications and Management Parameters for 10 Mb/s Operation and Associated Power Delivery over a Single Balanced Pair of Conductors" it should be emphasized that defined connection technologies (MDI) according to IEC 63171-1 and 61076-3-125 can but need not be used. Thus other connection technologies can also be used to set up a cabling structure. Especially as the MDI only describes the connection technology on the active component. User organizations like that of PROFINET (PNO) and the ODVA can define their connector faces based on current standardization.

To be able to implement cabling structures for single-pair Ethernet in future, further companies joined the SPE partnership. In addition to connector manufacturers Phoenix Contact, Reichle & De-Massari and Weidmüller, the new technology is supported by Belden for the cable environment, and Fluke Networks for field measurements. With this "round package" one is able to implement the cabling structure of the new technology allround and from different angles. The technology partnership develops components attuned to one another for single-pair Ethernet and sets new standards. The companies support the connector faces jointly put forward for standardization: IEC 63171-2 (office environment) and IEC 63171-5 (industrial environment).

## UNIFORM CONNECTOR FACE

Weidmüller is involved in the development of connectors compliant with IEC 63171-2 (office environment) and IEC 63171-5 (industrial environment). The standards define IP20 and IP65/67 connector faces for single-pair and four-pair data transmission in single-pair Ethernet applications. The focus is connectors for an industrial environment in IP20 and IP67, and here the establishment of a uniform and application-independent connector face. There are different approaches at present, with Weidmüller supporting a solution that sets up on ready established variants. First SPE connectors are now in development and running through appropriate test phases.

We can see today already that conventional Ethernet systems are unlikely to fulfill future demands for automation in an industrial scenario. Digitalization will mean an increase in the number of devices, and in data volume. And the growing number of smart devices worldwide will make networking more and more complex. Cabling as we have it today is no longer in time, in tune with the demands to be expected.

Industry needs a new infrastructure that can perform as well as possible with as few cables as possible. In concrete terms, the use of SPE in machines and plant will mean installation of smaller and lighter cable runs. Prices will drop because less material is needed. Single-pair Ethernet technology is the answer to the development – it is promised a huge future with wide adoption in industry. All promoted by simple structure and reduced weight, space requirement and installation effort. Simply said: single-pair Ethernet is currently a megatrend in industrial data transmission. SD

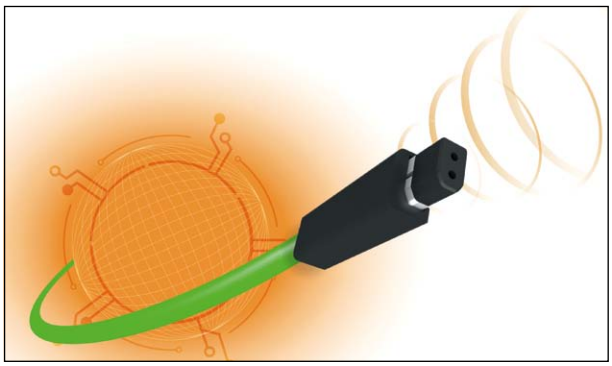


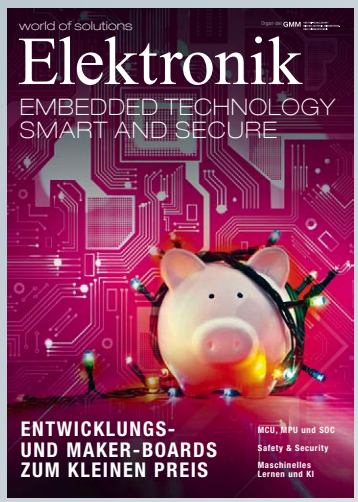
Figure 2. One out of four: future Ethernet cabling will be revolutionized by single-pair Ethernet. (photo: Weidmüller)

Figure 3. Reputable companies have joined forces to develop common components and standardize them for single-pair Ethernet. (photo: Weidmüller)

**CARSTEN NAGEL**

studied historical science and jurisprudence at Bielefeld University. Following PR consultancy at Weidmüller he was engaged in internal communication of the Weidmüller Group. Since 2017 Nagel has been responsible for external communication and technology communication of the company.

carsten.nagel@weidmueller.com

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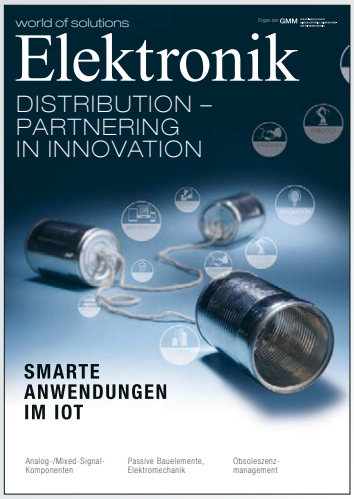


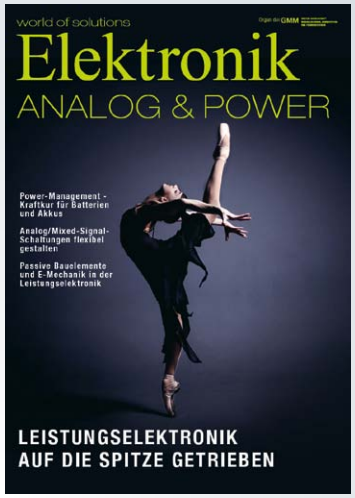


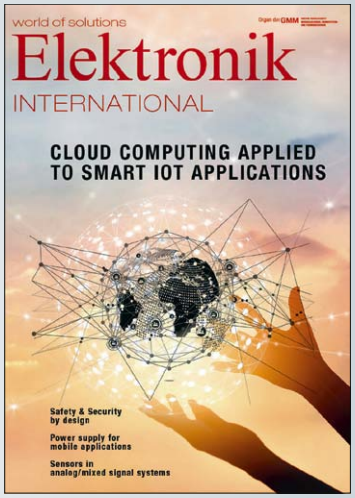



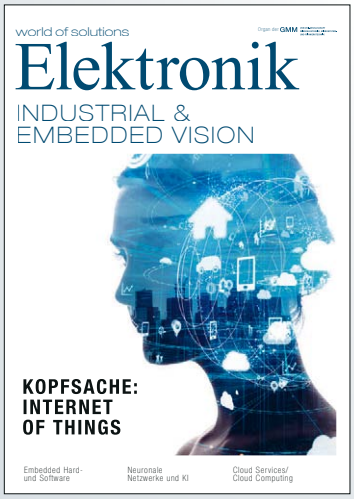


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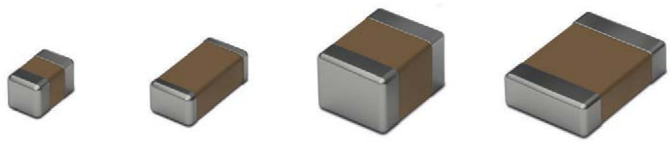

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