

N°42

AVNET ABACUS

# focus

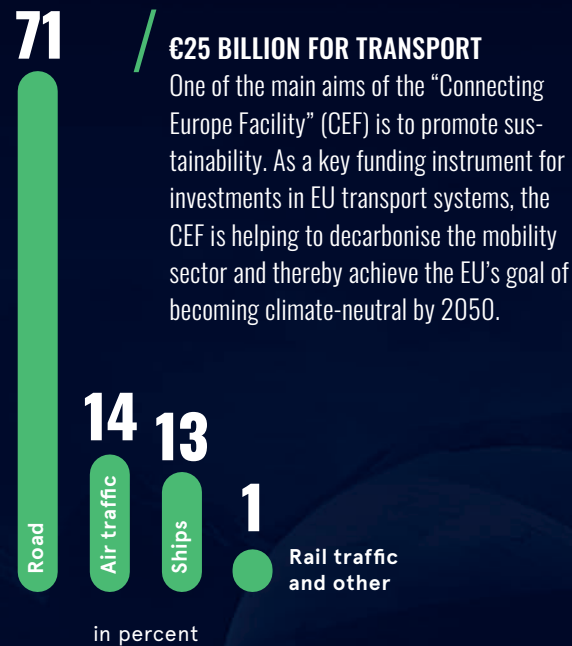
magazine



## SUSTAINABLE TRANSPORTATION

driven by innovative components and  
smart systems

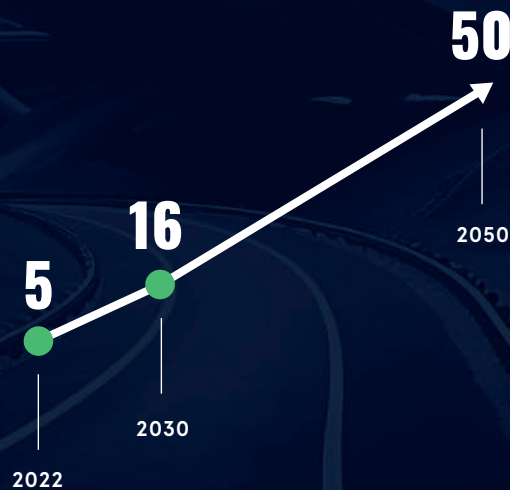
The “Fit for 55” legislative package from the EU: making the transport sector more sustainable



**100 %**  
 LOWER EMISSIONS from cars and light-duty commercial vehicles by 2035

**75 %**  
 LOWER EMISSIONS from shipping by 2050

More than 13.4 million cars and lorries in the EU run on alternative fuels. The percentage share is expected to increase tenfold by 2050.



Source: European Union

# MOVING TOWARDS A SUSTAINABLE WORLD OF TRANSPORT

In April 2023, the Council of the European Union adopted important legislation designed to achieve the EU’s climate goals for 2030. This legislation forms part of the “Fit for 55” package, which brings the EU’s measures in line with its undertaking to reduce net greenhouse gas emissions by at least 55 percent compared to 1990 levels by 2030 and become climate-neutral by 2050. For the transport sector in particular, the aim is to reduce greenhouse gas emissions (which currently account for more than a quarter of the EU’s emissions) by 90 percent. The rapid growth in sales of cars equipped with battery-electric or hybrid drive systems shows that it is consumers who are driving forward our efforts to create a more sustainable transport sector. However, private cars are just one part of the wider transport sector. Commercial vehicles, buses, and work machines used in the agriculture and construction industries, as well as vehicles for internal transportation tasks within industrial companies, are also increasingly being electrified. Even ships and planes can lower their emissions with electric drives.

Nevertheless, if we are to succeed in making the transport sector more sustainable, a range of technical challenges will need to be overcome in various areas. Examples include networking the electricity grid, charging infrastructure, and electric vehicles with one another, the use of innovative hybrid architectures in tractors or electric construction vehicles, and more efficient drive systems for railroads. What’s more, in order to master challenging off-road or industrial applications, we need plug connections, cables, passive components, and electromechanical parts (such as relays and contactors) that are able to withstand vibrations and fluctuating temperatures while also being protected against the ingress of water and chemicals. This issue of Focus Magazine contains a wealth of tips to help you select the right products for you and lots of useful information about the latest developments and trends. If you have any questions about specific topics, please do not hesitate to contact our Europe-wide team of application engineers, who will be pleased to advise you no matter how far along you are with your project. We hope you enjoy reading this issue! /

# ENABLE E-MOBILITY

THROUGH HIGH-VOLTAGE CONNECTIONS  
AND HIGH-POWER CHARGING

TE Connectivity (TE) has been leading the electrification charge since the beginning. We work with vehicle manufactures and tier-one supplier around the world to build high-voltage connectivity solutions that are the electrical foundation for safe and reliable zero-emission cars. Our charging inlet portfolio supports all common international interface variants, from AC for daily home charging, and high-powered DC charging available from public stations. They address the electrical engineering requirements of today's and tomorrow's EVs.

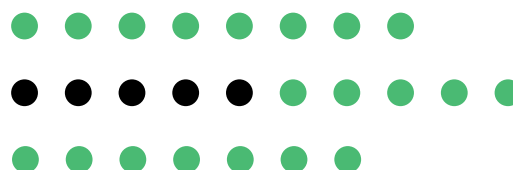



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“Europe is embracing the shift to zero-emission mobility. [...] The speed at which this change has happened over the past few years is remarkable.”

Frans Timmermans,  
Executive Vice-President for  
the European Green Deal





# ON THE WAY TO ZERO-EMISSION

A sustainable transport sector is a key building block in our efforts to create a greener future. Innovative components are ensuring that the drive systems required to achieve this are becoming increasingly efficient and affordable.

**T**ransportation, in other words, the task of moving people and goods from one place to another, is not just fundamental to ensuring our society works, it is also a key economic factor. In most countries, the transport sector directly contributes five to ten percent of gross domestic product (GDP) and is a prerequisite for successful social development and economic growth. However, current public debate has tended to focus on its negative side effects – for example, on the fact that the transportation of people and freight is predominantly reliant on fossil fuels. According to the International Energy Agency (IEA), this sector alone accounted for 37 percent of CO<sub>2</sub> emissions from all end-use sectors in 2021.

## ELECTRIFICATION IN THE SPOTLIGHT

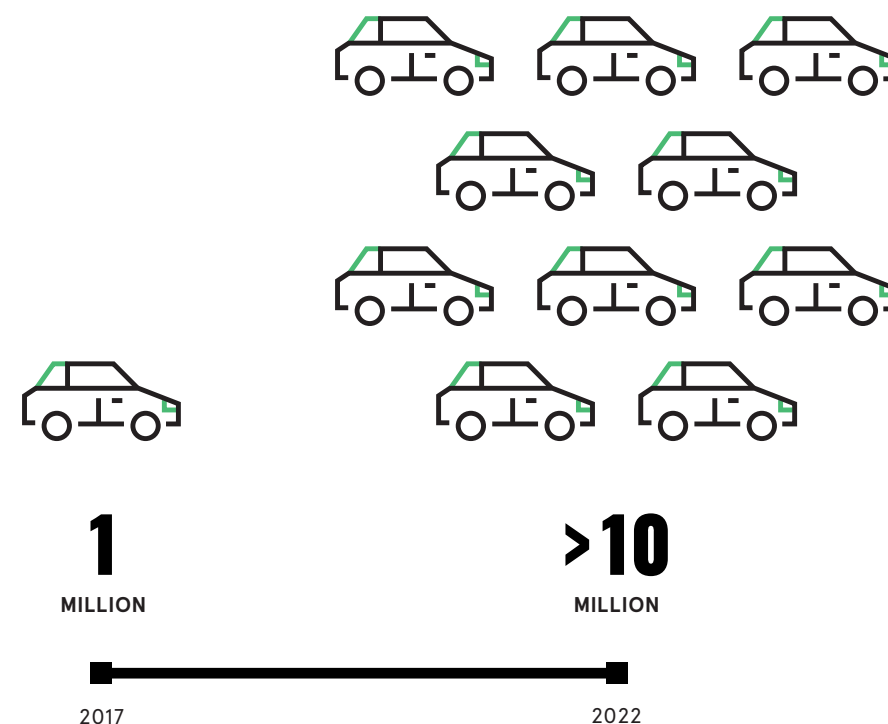
In response, politicians and industry have been promoting the use of alternative drive systems. As a result, global sales of electric cars rose from around 1 million to more than 10 million in just five years between 2017 and 2022. “Electric

vehicles are one of the driving forces in the new global energy economy that is rapidly emerging,” said IEA Executive Director Fatih Birol. “The internal combustion engine has gone unrivalled for over a century, but electric vehicles are changing the status quo. By 2030, they will avoid the need for at least 5 million barrels a day of oil. Cars are just the first wave: electric buses and trucks will follow soon.”

## THE INTERACTION BETWEEN COMPONENTS IS KEY

Although the spotlight is on electrification, alternative drive systems such as hydrogen technology and eFuels are also set to play a key role in improving sustainability, particularly in heavy-duty transport applications and the shipping industry. One thing they all have in common is that they impact a whole host of different components in the vehicle. One example is innovative batteries, which are themselves becoming much more sustainable thanks to their

## Global sales of electric cars



high energy density and the fact that the raw materials required to produce them are readily available. They can also be charged rapidly with increasingly higher currents. However, this does necessitate the use of cables and connectors that can withstand the high amperages involved and can safely transfer the power required for demanding applications, such as construction and agricultural machinery. New semiconductor materials such as silicon carbide and gallium nitride are opening the door to more powerful converters, which are also much more efficient thanks to new DC link capacitors. In addition, more and more sensors are now required to monitor the electrical systems. These sensors are becoming increasingly smaller and easier to integrate, which again helps to make the transport sector more sustainable. Another important factor is that electrification is going hand in hand with the wider digital transformation of our society. By networking vehicles with one another and their

surroundings, traffic jams can be prevented and emissions can be reduced. New antennas which combine several wireless technologies for these “Vehicle-to-X” solutions in a single component are also being developed.

## SUSTAINABILITY THROUGHOUT THE TRANSPORT SECTOR

All of these aspects need to dovetail with one another if we are to create drive systems that don’t just cut emissions, but also operate highly efficiently and require fewer raw materials. And that applies across the board – not just to cars, but also trains and planes. Frans Timmermans, Executive Vice-President for the European Green Deal, said: “To reach our climate and zero pollution goals, all parts of the transport sector have to actively contribute. By 2050, nearly all of the vehicles on our roads have to be zero-emission. Our climate legislation requires it, our cities demand it, and our manufacturers are gearing up for it.”

# HUB FOR SUSTAINABLE MOBILITY

**T**he way we get around is at a turning point. In the coming years and decades, the transformation of transportation will be far more profound than simply replacing fossil fuel-powered vehicles with electric ones. Successfully managing this transformation will require close collaboration between established automakers, startups, and cities. Digital Hub Mobility provides a platform for this kind of exchange. Kirstin Hegner, Managing Director of the Munich-based startup accelerator, talks about the challenges facing mobility and about projects that have already been successfully implemented.

## WHAT EXACTLY IS THE OBJECTIVE OF THE DIGITAL HUB MOBILITY?

**Kirstin Hegner:** The Digital Hub Mobility was initiated six years ago by the German Ministry of Economics and Climate Protection, and it was initiated to support digitalization and innovation in mobility, which is a highly complex sector. No single player can change things fundamentally alone. And that's why it is so important to have

a hub that brings all the right players together. We drive forward innovation for sustainable mobility in Germany and Europe by connecting the relevant players.

## AND HOW WILL YOU ACHIEVE THIS OBJECTIVE?

**K.H.:** Firstly, we connect the relevant mobility players. We do one benchmark trip every year to learn about mobility innovations in other places. And once a year we also do a symposium on relevant topics. Secondly, we implement collaborative, cutting-edge mobility projects. So we have a digital format where we build digital prototypes for certain kinds of problems that cities or companies come up with. But we also have a format called "citizen mobility," where we do urban experiments on sharing and mobility behavior. And then we also do multi-stakeholder co-innovation around green energy, where we put startups and companies together to work on new solutions. This way, we give visible impulses for companies, cities, and startups. >

A portrait of Kirstin Hegner, a woman with short brown hair, smiling. She is wearing a light blue herringbone blazer over a white collared shirt and a gold necklace. The background is a blurred outdoor setting.

“No single player  
can change things  
fundamentally  
alone.”

**Kirstin Hegner**  
Managing Director, Digital Hub Mobility

## SHENZHEN – BECOMING THE LEADING E-MOBILITY CITY

Shenzhen has more than 5,000 charging stations and over 80,000 charging points, covering different charging capacities and vehicle requirements. By the end of 2021, Shenzhen already had 20,000 electric buses, 24,000 electric cabs, and more than 60,000 private electric vehicles. Among private vehicles, there are more than 250,000 electric vehicles, accounting for a total share of 25 percent. This number is expected to increase to 750,000 by 2025, for a total vehicle population of about 1 million.



“The big game changer will be autonomous driving.”

### ARE THERE ANY EXAMPLES THAT COME TO MIND FROM CITIES YOU HAVE VISITED IN THE PAST?

**K.H.:** When we went to Shenzhen, our hotel was on a very busy street crossing. And I was so surprised how quiet it was because the vast majority of the cars were already electric. I experienced it there for the first time. This was also very interesting for the city and government officials who were with us. It was a real aha moment for them. Wow!

### HOW CAN WE MAKE MOBILITY SOLUTIONS MORE SUSTAINABLE? IS ELECTRIFICATION ENOUGH?

**K.H.:** No, electrification is not enough. Electric cars consume the same space as fossil fuel cars when parked in urban areas. Congestion is the same for electric vehicles as for others. Electrification only solves the problem of local emissions. But to make the whole system more efficient, we need to make better use of existing vehicle capacity. This includes having fewer vehicles sitting around unused for 23 hours a day. There is also another reason: our cities need to become more resilient to climate change, and to do that we need to make them much

greener to regulate the amount of heat absorbed by cities. But you need space for these plants. So reducing the number of parked cars is the first and most important measure to free up urban space and make our cities more climate resilient.

### WHAT TECHNOLOGIES DO YOU BELIEVE ARE ESSENTIAL FOR THE MOBILITY OF THE FUTURE?

**K.H.:** Basically all technologies that reduce the carbon footprint of mobility. But for me, autonomous driving will be the big game changer because it will drastically reduce operating costs in public transport. If autonomous driving becomes possible, then we will have a really efficient and attractive addition to public transport that will make a big difference. And thirdly, we need to combine energy generation from renewable sources with charging technology. So that's the whole issue of the smart grid, which is critical to decarbonizing e-mobility. The last point I want to mention, which I think is very important, is batteries that don't require rare earths.

### WHAT DO WE NEED TO DO TO MAKE INNOVATIONS POSSIBLE AND ENSURE THEIR SUCCESS?

**K.H.:** It is crucial that we support the companies that deliver the solutions we need. So we need

LISTEN TO THE IN-DEPTH INTERVIEW ON THE AVNET ABACUS PODCAST “THE TECHNOLOGY ADDICTS”.



to support startups. That's exactly what we do at UnternehmerTUM. We provide them with capital, we provide them with partners. We connect them with companies to help get their first projects off the ground. We help them find fellow entrepreneurs and support them on their way to success. And that, in my view, is one of the most important things we can do.

### SO ARE THERE ALREADY SOLUTIONS ON THE MARKET THAT HAVE BEEN CREATED WITH THE HELP OF THE DIGITAL HUB MOBILITY?

**K.H.:** There are many projects that we are proud of. There is our “Digital Product School,” for example. In the very first year, there was a team from BMW and Adidas that developed an incentive system for employees to cycle to work more often. What ultimately came out of that was a startup that helps companies provide a mobility budget for their employees. It is called Moovster, and it is alive and kicking. I also want to mention the collaboration we fostered between Charge X, a startup, and SAP, Germany's largest software company. The two are working together to build the SAP backend for electric charging. SAP's launch in this space has helped Charge X prepare to work with large companies. Whatever we want to create is a win-win situation. And in this case, it worked really well. //

# KEEPING AN EYE ON ALL PARAMETERS

Sensors provide the information required to effectively control systems and ensure they remain safe. The sensors themselves are becoming increasingly efficient, more precise, and easier to integrate.

Sensors have become an indispensable part of the networked and automated world we find ourselves in today. They are also key to providing the latest mobility offerings and technical solutions to ensure sustainable production and generate renewable energy. They are increasingly being used to improve the performance and efficiency of systems and plants, enhance safety, and save energy.

For example, (residual) current sensors are important elements in charging stations. Sensors installed in the drivetrain of an electric vehicle monitor temperature, pressure, position, the properties of fluids, fluid levels, gas concentrations, current, and speed. What's more, to ensure the vehicle battery performs at its best and remains safe, sensors also transmit critical parameters for the heat and energy management systems, regarding the condition of the battery, and to control and monitor humidity.

## MECHANICS AND ELECTRONICS IN ONE

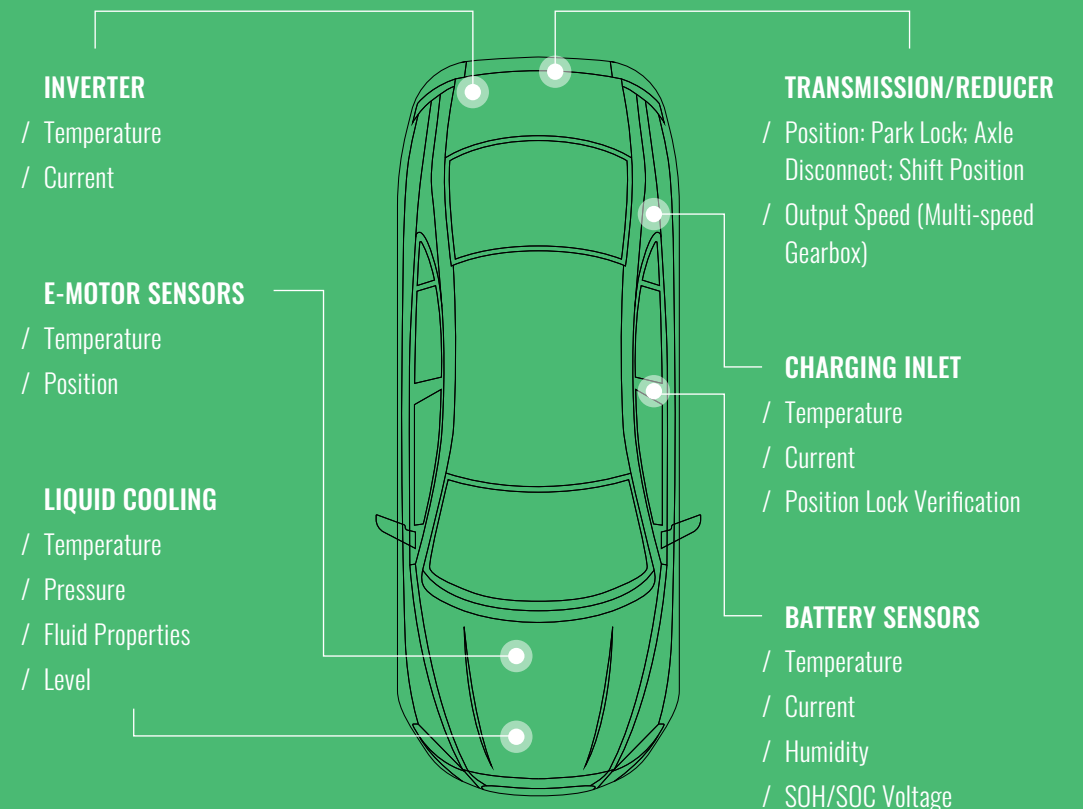
MEMS technology (MEMS = microelectromechanical systems) has opened the door to smaller and smaller sensors, and designs measuring just 1.5 by 1.5 millimeters can now easily be produced. But they can be made even smaller than that, as researchers at the Fraunhofer Institute

have used a micro-manufacturing process to generate three-dimensional functional microstructures at wafer level. These measure a few tens to hundreds of micrometers and can be used to build MEMS sensors. These offer a whole host of benefits – not only do they provide a robust design, long-term stability, and consistent quality, they are also highly accurate and less expensive, and they consume less energy.

## DIGITAL IS REPLACING ANALOG

At the same time, more and more analog sensors are being replaced with digital ones, in other words, with sensors that transmit a digital signal directly. They are incredibly small, consume much less power, and can be used for many different purposes. Their biggest advantage is the information that they transmit. Whereas analog sensors only send a milliamperere or voltage reading (which is converted into a measurement), a digital sensor can transmit much more than just the measurement itself – for example, the device status and calibration and adjustment data. Digital sensors can communicate directly with data loggers, and all communication with control systems or databases is also digital, meaning data transfers remain accurate.

## Example application for an EV drivetrain



Source: TE Connectivity

## WIRELESS SIGNAL TRANSMISSION

Another clear trend when it comes to sensor systems is the rapid growth in wireless sensors. They offer a number of advantages over wired sensors – for example, they can easily monitor measuring points that are far apart. The absence of wires means they are much faster and easier to integrate. Wireless sensors are crucial in areas such as smart grids in order to remotely monitor power cables and transformers. Here,

they are used to monitor the cable temperature and weather conditions. Various systems can be used for communication purposes, from Bluetooth and ZigBee to WLAN and cellular communication standards. As a result, it may be beneficial to obtain wireless sensors from service providers, as they can combine sensors and communication interfaces from different manufacturers into a single sensor module that is tailored to the application in question. //

# A CONVERTER FOR EVERY RAILROAD

A wide range of DC-to-DC converters are used on railroads. New power semiconductors increase their efficiency and help to make rail travel even better for the climate. And converters with ultra-wide input voltage make it possible to use them all around the world.

ELECTRICITY CONSUMPTION OF THE RAIL SECTOR WORLDWIDE

1.03

EJ in 2021

1.8

EJ in 2030

Source: IEA

COMPARISON

Gross electricity consumption in Germany (2021):

582

TWh

=

2.1

EJ

Source: German Association of Energy and Water Industries (BDEW)

There is hardly any means of transport more energy-efficient than rail. According to a study by the European Environment Agency (EEA), long-distance transport is responsible for less than a quarter of the carbon

emissions released by cars, and heavy goods transport comes in even lower by a factor of 5.7. As a result, railroad networks make a significant contribution to sustainability in the transport sector.

## DC-TO-DC CONVERTERS FOR INCREASED EFFICIENCY

Nevertheless, railroads still consume a lot of electricity. For this reason, work is being done around the world to further reduce their energy consumption. A key part of this is the traction systems. In this context, developing converters and inverters with lower power dissipation in the traction systems is crucial for reducing energy usage in rail transport and cutting carbon emissions. This is because a wide range of DC-to-DC converters are used in modern railroad systems to power monitoring and control units.

## NEW MATERIALS TO REPLACE SILICON

To increase their efficiency, new high-performance semiconductor devices and low-loss capacitors are required. Today, silicon carbide (SiC) and gallium nitride (GaN) are increasingly being used as materials for power semiconductors. Compared with the silicon-based semiconductors used previously, they enable higher switching speeds as well as lower inductances and capacitances, resulting in less leakage current and smaller component sizes.

## ONE FOR ALL SUPPLY VOLTAGES

One challenge in designing DC-to-DC converters for the global locomotive market is that the various rail systems are operated at different voltages. In most countries, such as Germany, the United States, France, and India, the internal control systems require a supply voltage of 24, 28, 36, 48, 72, 96, and 110 volts. DC-to-DC converters with an ultra-wide voltage input offer a solution that avoids having to design and manage a specific converter for each individual voltage level. They cover all possible voltages that will be used on board.

The converter manufacturers had to overcome two challenges to meet the requirements of EN 50155 – the internationally recognized standard for the design, manufacture, and testing of

electronic equipment installed in rolling stock. First, the DC power supply module must provide a stable supply to the back-end devices within the input voltage's fluctuation range. Specifically, pursuant to EN 50155, this means that the power supply units must operate stably in a voltage range of 0.7 to 1.25 times the supply voltage, in other words, from 16.8 to 137.5 volts. To satisfy the requirements of rail systems around the world with respect to power supply and certification, the input range of ultra-wide power modules needs to be 14 to 160 volts.

## SAFELY BRIDGING POWER FAILURES

There are huge demands on rail transport when it comes to reliability. In the event of a power supply failure, the back-end devices must still be able to store the current status data, allowing them to switch over to the emergency power supply in the proper manner. For this reason, the power module is combined with a capacitor that ensures the required power failure bridging. Therefore, EN 50155 has defined power supply voltage interruption classes, which are divided into S1, S2, and S3. If the converter keeps the output voltage stable when the input voltage drops to 0 volts and returns to normal after 10 milliseconds, it meets class S2. If the input voltage drops to 0 volts for up to 20 milliseconds and the output voltage remains stable, it meets class S3. The standard also provides "pass and fail" criteria, which are divided into four levels. Criteria A and B mean acceptable, while criteria C and D mean unacceptable. Here the system does not self-recover from the interruption.

State-of-the-art solutions combine the energy storage module with a module for automatic switching in the power failure bridging process dependent on the supply voltage. Additional energy pre-storage modules minimize capacitor volume and maximize energy storage, since reducing footprint and weight is also important in the railroad context. █





# SAMSUNG ELECTRO-MECHANICS – HIGH VOLTAGE MLCC FOR EV POWERTRAIN

Samsung Electro Mechanics Co. (SEMCO) is a global manufacturer of passive components for multiple industry sectors, established in 1973. SEMCO is an industry leader in material technology development, which is evident from its innovative MLCC product line (high capacitance and high voltage MLCC), which has made SEMCO the second biggest MLCC manufacturer worldwide. Typical applications include automotive, mobile devices, industrial applications, Smart Home, network technology, medical monitoring devices, white goods, and lighting.

## ABSTRACT

The global car market is going through a massive transition to electric vehicles. So far, internal combustion engine (ICE) vehicles have improved powertrains to cope with emission regulations. Emission regulations, convenience technologies and self-driving have driven electrification increases with automobiles. As the number of electronic units increased, the amount of power a vehicle consumes has also increased. Battery voltages have changed to deal with increased power consumption requirements, and they are associated with efficient power systems.

## VEHICLE ELECTRIFICATION AND BATTERY VOLTAGES

The battery voltage increase of the car is related to the trend of electrification. In order to understand the electrification trend, we must first look back on how the voltage of a car battery has changed. Before the mid-1950s, a vehicle's operating voltage was 6V. Since then, the engine displacements increased and required a large electric starter motor. The 12V system became standardized to meet the need for more electronic devices. Historically, cars only needed a small battery to crank the engine and turn on the radio. However, as the number of in-vehicle electronic devices has increased over time, so has the need for more power. To resolve this problem, discussions took place to increase the voltage from 12V to a higher voltage system capable of dealing with the additional power demand. In the 1990s, the 42V system was proposed, and in 2011, German carmakers made 48V the standard. Since then, hybrid cars and electric vehicles have begun to use higher voltages. Power (Watt) is voltage (V)\*current (A). When increasing power, it is more efficient to raise the voltage rather than the current.



When current is increased, thicker cables are required and connector pins must also be changed. Both have an impact on the hardware cost. This is the reason why battery voltages increased instead of current.

## HIGH VOLTAGE APPLICATION IN ELECTRIC CARS

The basic powertrain configuration of electric vehicles consists of a high voltage battery, inverter, and electric motor. EV powertrains use high voltage. The efficiency of an EV is linked to the efficiency of the DC/DC converter. Electric cars have various power conversion applications, such as LDC, OBC, and inverter. Various DC/DC converter topologies are being applied to integrate similar applications. For example, OBC (On-Board Charger) and LDC (Low-Voltage DC/DC Converter) are under development for the system integration which have an advantage of reducing components and saving spaces.

## HIGH VOLTAGE MLCC STRUCTURE FOR GUARANTEED RELIABILITY

How is the structure of high voltage MLCC different from that of general MLCC? Reliability should be guaranteed in high voltage environments. MLCC applied for high voltage applications are exposed to the risk of arc-over and a short-circuit can occur inside of the MLCC. Under high voltage, a strong electric field is formed around the MLCC, which ionizes the surrounding air. In particular, a strong electric field is concentrated on both terminals of the MLCC. If it exceeds the inception voltage of the ionized air, electrical arcs occurs, ultimately leading to a short-circuit inside the MLCC. The



structure that prevents this phenomenon is a shield pattern inside the MLCC.

Floating design is a design that lowers the short-circuit risk when MLCC crack occurs, but it is also useful for high-voltage products. The floating structure distributes voltage so the voltage inside the MLCC is only half of the voltage applied to the end terminals. For example, when 1000V is applied to both ends of the MLCC, if the floating design is used only 500V is applied to the MLCC dielectric layer, which is half of 1000V. It is definitely an advantage from the perspective of reliability because the electric field applied between dielectric layers decreases. Voltage along with temperature are key factors to determine MLCC lifetime.

SEMCO high voltage MLCC guarantees reliability in high voltage applications. You can find additional information and details about SEMCO line-up on their Website. /



**SAMSUNG**

**SAMSUNG  
ELECTRO-MECHANICS**



**ELECTRIFICATION OF COMMERCIAL AND INDUSTRIAL VEHICLES**

**A GREENER WAY TO STORE ENERGY**



TE Connectivity (TE)

**POWERTUBE HIGH VOLTAGE CONNECTOR**

MODULAR AND SCALABLE HIGH VOLTAGE CONNECTOR SERIES

Designing for an electrified future requires laying the right foundations now. In the industrial and commercial transportation market, this means vital components of a vehicle must withstand years of service in the elements without failing, and so must the systems that connect them together. That's exactly where TE Connectivity's (TE) new PowerTube connectors can enable your hybrid and electric vehicle designs.

The PowerTube connector series is built to handle large electrical loads (up to 580 A continuous current and 1000 V) and multiple wire sizes between 35 mm<sup>2</sup> to 150 mm<sup>2</sup>. These modular and scalable connectors are manufactured to adapt to your designs and hold up to intense environmental demands.



**The energy transition means we are now using an ever-increasing number of batteries. Ensuring they are sustainable has, therefore, become an important consideration. New legislation from the European Union is intended to reduce the ecological and social impact of batteries across all phases of their life cycle.**

**A**ccording to the World Economic Forum, global demand for batteries is estimated to increase 14-fold by 2030, reaching an energy storage capacity of around 2,600 GWh. One of the main reasons for this is the energy transition, along with the associated e-mobility solutions and the need to store fluctuating supplies of renewable energy. There is also a general trend towards the use of more efficient electric drive systems.

In most cases, it is the energy and power density provided by the latest generation of battery technologies which makes these an attractive proposition, such as in construction machinery, or for the mobile robots that are increasingly being used in the logistics sector (AGV/AMR), for landscape conservation, and in the agricultural industry.

**STATE OF THE ART**

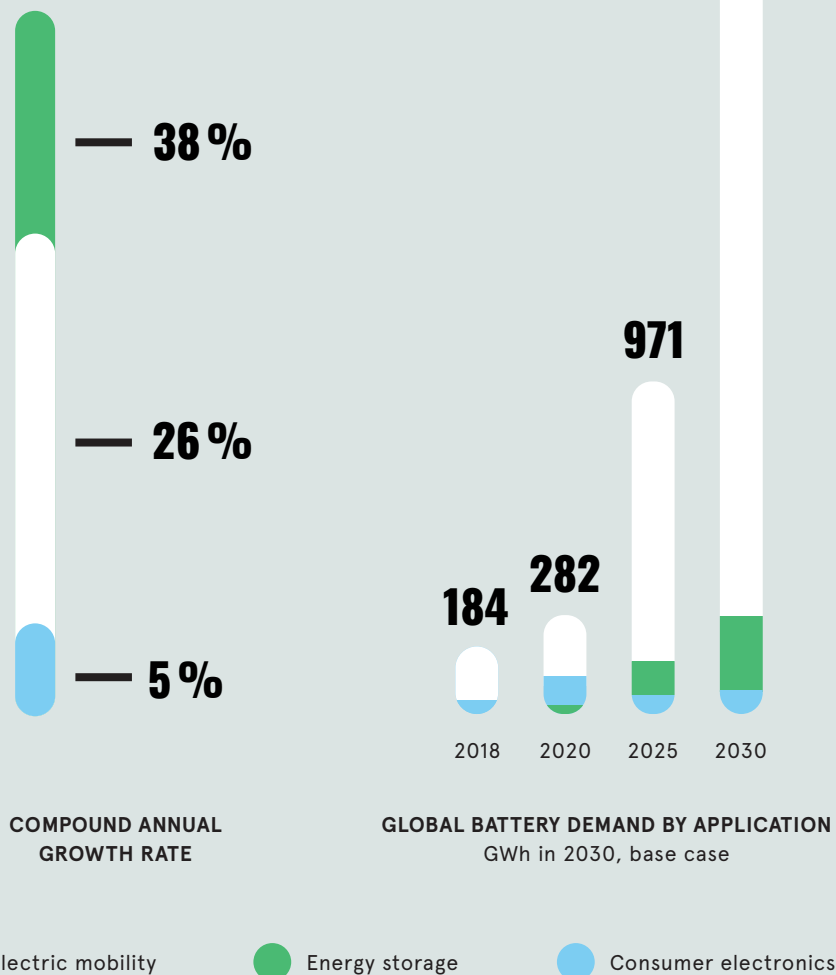
Lithium-ion batteries in particular (NMC – nickel-manganese-cobalt) have become widespread in recent years. They are often superior to traditional lead batteries in virtually all technical respects – service life, number of charging cycles, charging time, and weight – and are often also a better financial proposition. Nowadays, lead batteries are only the preferred option for starter batteries and uninterruptible power supplies, as they can provide a lot of power for a few seconds at a very low cost. Analysts are expecting lithium iron phosphate batteries (LiFePO<sub>4</sub> or LFP) to

## Evolution of battery demand by application area

THE DEMAND FOR BATTERIES IS ESTIMATED TO INCREASE

# 14-fold

by 2030



Source: World Economic Forum

experience strong growth in the next few years – an average of around 15 percent annually by 2030 according to Research Nester. Although LFP batteries are a less attractive proposition than NMC batteries in terms of energy density, compared to lead batteries they can still store a lot of energy at a low weight or volume, they enable faster charging, and still offer a very long service life. What's more, the batteries can be charged to a state of charge of 100 percent without causing the battery to age faster. They have excellent thermal and chemical stability, which makes the batteries even safer.

### NEW EU REGULATIONS

Rare earth elements and minerals are required to produce lithium-ion batteries (NMC), but mining them poses challenges for our environment and wider society. It is also difficult to recycle these materials, particularly lithium, meaning they usually end up being thrown out with the trash once the batteries reach the end of their useful life. To prevent this, in December 2022 the EU decided on new regulations governing the design, production, and waste treatment of batteries. They apply to all types of batteries sold in the EU: portable batteries, SLI batteries (supplying power for starting, lighting, or ignition of vehicles), light means of transport (LMT) batteries providing power for vehicles such as electric scooters and bikes, electric vehicle batteries, and industrial batteries. There are also plans to state the carbon footprint of batteries, for instance for electric vehicles, LMT batteries, and rechargeable industrial batteries with a capacity of more than 2 kWh, which means they will need to bear a corresponding label. Furthermore, three-and-a-half years after the legislation comes into force, portable batteries must be designed such that consumers can easily replace them themselves. Avnet Abacus offers a wide range of certified battery modules, including scalable battery systems, making it simple for our customers to meet these requirements.

### THE MEASURES FORESEEN IN THE EU'S NEW BATTERY LEGISLATION INCLUDE:

- / Collection targets of 45 % by 2023, 63 % by 2027, and 73 % by 2030 have been set for portable batteries; for LMT batteries the targets are 51 % by 2028 and 61 % by 2031
- / Minimum levels of recovered cobalt (16%), lead (85%), lithium (6%), and nickel (6%) from manufacturing and consumer waste must be reused in new batteries
- / All waste LMT, EV, SLI, and industrial batteries must be collected, free of charge for end users, regardless of their nature, chemical composition, condition, brand, or origin
- / By December 31, 2030, the commission will assess whether to phase out the use of non-rechargeable portable batteries of general use

### SUSTAINABLE ALTERNATIVES

Sustainability is increasingly becoming a key factor in the development of new battery types. Researchers are currently focussing on sodium-ion batteries in particular. Chinese car manufacturers are already starting to install this type of battery in their electric cars. The major advantage of sodium-ion batteries is that the raw materials required to produce them can be obtained much more easily and with significantly less environmental damage. Compared to lithium, sodium is also much more readily available and costs a lot less. However, its energy density is lower than LiFePO4 batteries by around another 20 percent. For this reason, sodium-ion batteries are mainly suited to applications where weight or size are not decisive criteria, such as in electric vehicles with a lower range for use in cities, or for energy storage purposes in the electricity grid. /



# THE CHALLENGE OF CHARGING – CONNECTING THE EV

**Founded in 1976, Samtec is a different kind of connector manufacturer. Its goal is to provide the best service in the industry, delivering cutting-edge connectivity solutions with a dedicated customer focus.**

The transportation sector is undergoing rapid change, and electrification is critical to the future of mobility. While many electric vehicles (EVs) can now travel 400 km or more, charging stations are still few and far between, creating a significant barrier to their adoption. The demands of consumers are driving developments

in lithium-ion (Li-ion) batteries, and governments are investing in fast charging stations to make electric power a realistic alternative to gasoline. The same Li-ion battery technology is revolutionizing other areas of the automotive industry, from commercial vehicles to construction equipment.

## NEW WAYS TO USE CARS

While electric power is important, new technology will also change how we use vehicles. The future of mobility will be delivered by autonomous electric vehicles, employing the latest connectivity and artificial intelligence. This has created Transport as a Service (TaaS) which allows users to purchase individual journeys rather than vehicles.

TaaS is not limited to traditional cars. In today's cities, the use of cars is often limited. Instead, commuters rely on public transport and will use TaaS to obtain the mobility they need for the last kilometer. This is the name given to the last part of any journey from the bus stop or subway station to the final destination.

## INTO THE CITY

In cities, this mobility is being provided by electric scooters and bicycles, often known as e-scooters and e-bikes. Delivering pollution-free, accessible, and convenient travel for commuters, e-bikes are typically found at fixed charging stands in key locations.

E-mobility is taking advantage of the improved Li-ion battery technology that has emerged from the automotive industry. It offers compact size, moderate weight, and energy capacity for the city environment. However, although these vehicles are intended for short urban journeys, their design must provide the same level of safety as more conventional electric vehicles. Li-ion batteries have limitations. They work best in conditions that their human users would find comfortable, and extreme temperatures adversely affect their performance. In addition, damage to the structure of the battery can lead to fire, which in Li-ion batteries results in a dramatic event called thermal runaway.

## CONNECTORS FOR FAST CHARGING

Care must also be taken when the battery is connected for charging. Li-ion batteries are made up of cells. A damaged cell cannot accept the same energy as its neighbors, and so EVs use battery management systems (BMS) to ensure that the battery pack is charged safely. E-bikes and e-scooters provided by city mobility schemes will use similar robust BMS, but some cheaper examples may not, which places the user at risk. There are other risks associated with extreme temperatures. The connectors used for fast charging and the currents they carry can become hot enough to injure unprotected skin. Connector manufacturers need to create solutions that can deliver high currents in fast charging stations while maintaining safe operations for users.

Concerns over the environmental impact of fossil fuels have seen the rapid growth of electric vehicles. The adoption of new e-mobility solutions using TaaS will be powered by lithium-ion batteries. However, Li-ion battery packs have their own limitations, and so it is vital to use robust and reliable battery management solutions to provide reliability and safety. The connectors and cabling required to support these technologies must be just as reliable. /

# SAFE AND RELIABLE CONNECTIONS FOR OFF-HIGHWAY VEHICLES



**Electric motors aren't just on trend for road cars; electrification is also becoming more widespread in off-highway applications. High charging currents and harsh environmental conditions place particular demands on the connection technology – and the trend towards increasingly smaller designs means new solutions are required.**

It is not just road traffic that needs to reduce its CO<sub>2</sub> emissions – more and more electric vehicles are also being developed for what is known as the “off-highway” sector. While this

mainly relates to construction machinery, electric drive systems are also being promoted for the agricultural industry, municipal machinery, and mining and materials handling equipment.

The major challenge in designing electric work machines is determining a simple way to charge their batteries on demand while still enabling the vehicles to remain in ongoing deployment. Direct current rapid charging solutions provide the answer to this problem. For example, they enable a state-of-the-art, eight-tonne compact excavator equipped with a CCS2 interface (CCS = Combined Charging System) to be fully charged in just 45 minutes at a charging capacity of 150 kilowatts, freeing up a further six hours of work time.

## HIGH CURRENTS MEAN HIGH REQUIREMENTS

However, the use of high-voltage cables also places high demands on the electrical, mechanical, thermal, and chemical properties and on the cable materials used. The contacting system must be able to cope with currents of up to 400 amperes. Future contacts will even have a current rating of more than 800 amperes and will enable a direct high-current connection to the electronics in the drivetrain, such as converters or power electronics.

What's more, the plugs and cables also need to withstand the harsh conditions encountered by off-highway vehicles, such as strong vibrations, weather conditions, and mechanical stress.

## CUSTOM ASSEMBLY

The way in which the associated plug connections are assembled influences the machine design, installation, and safe operation. For instance, cables designed for higher currents enable smaller cross-sections. This also means smaller bend radii and a lower weight, and thus greater flexibility and easier handling – important factors when you don't have much installation

space. Correct installation is also made easier if you have the right plug shape: should it be straight or angled? And which protection class is required – is IP67 sufficient or do you need IP69k after all?

The service providers and distributors operating in this market can provide tailored solutions that factor in all of these questions. The more manufacturers of single components they have access to, the more effectively the connection technology can be adapted to the application in question.

## MORE AUTOMATION, LESS SPACE

Alongside electric drive systems, automation is another big trend that is shaping the world of connection technology. As a result of automation, the number of electric components found in work machines has risen constantly. Manufacturers need to find solutions with smaller, lighter components without impairing performance. In response, connection technology providers are coming up with increasingly smaller designs, such as plug connector systems

designed specifically for areas where space is at a premium. In some cases, it is possible to reduce the crimp length by up to 50 percent and use significantly less installation space.

Tailored solutions are required to successfully master the trends of electrification and automation in off-highway applications. Many different factors need to be taken into account when selecting suitable cables and plugs. While this may require a bit of time and effort initially, the results are definitely worth it, as customized connection technology not only ensures that the machines operate safely and reliably, it can also simplify the production process. //

## OFF-HIGHWAY ELECTRIC VEHICLE MARKET

15.7

BILLION US DOLLARS  
in 2021



168.7

BILLION US DOLLARS  
in 2031

This corresponds to average annual growth of **26.7** percent

Source: Allied Market Research



# SUPPORTING THE CONNECTIONS FOR SUSTAINABLE TRANSPORTATION

**Worldwide, companies are increasing their focus on sustainability, particularly in the transportation industry. As a result, there has been a significant increase in the development of new technologies in the field of electrification over the past ten years in order to manage the increasing demand for electric or hybrid vehicles (EV/HEV) and to support sustainable transportation. Alongside this, the EV charging infrastructure has significantly expanded.**

## CONNECTORS

Connectors play a crucial role in sustainable transportation by enabling the internal connections within the electronics systems of electric and hybrid vehicles and the charging devices. They are used to create a reliable and efficient connection, which is essential for the proper functioning of modern automotive and charging systems.

Modern electric and hybrid vehicles are equipped with numerous sensors and actuators to monitor and control various functions. Connectors can facilitate the connection of these sensors and actuators. For the infotainment systems many connectors are used to internally connect displays, cameras, global positioning system (GPS) modules, multimedia, heating,

ventilation, air conditioning (HVAC) displays and in particular EV chargers. Connectors used in the automotive industry must meet strict requirements for reliability, durability, and environmental resistance. They should be able to withstand various environmental factors such as temperature changes, moisture, vibration, etc. Another trend is production efficiency, which is helping to make electric and hybrid vehicles more cost-efficient and affordable for consumers and, thus, increasing the number of sustainable vehicles on the road. Manufacturers are continually trying to optimize their manufacturing processes and resources to achieve higher levels of productivity, cost effectiveness, and quality in production. Improving production efficiency is crucial for companies to remain competitive, to meet market demand, and generate higher profits. A key aspect is improving the workflow, reducing waste, and optimizing processes using automation and robotics. More and more integration of robotics in the production line can increase efficiency and precision. Robots can perform repetitive tasks with high accuracy, which results in reduced production time and minimizes human errors. Flexible printed circuit (FPC) or flat flexible cable (FFC) connectors are commonly used in electric/hybrid vehicle infotainment systems, displays, light detection and ranging systems (LiDAR), cameras, driver monitoring systems, and in particular EV chargers.

The connectors help to improve design flexibility, productivity, and efficiency in production processes by saving space on the board, reducing FPC/FFC assembly time, and enhancing signal integrity. Furthermore, these connectors are reliable and durable, and absorb mechanical stress and vibrations. They are lightweight, thus contributing to fuel efficiencies and improved vehicle performance.

FPC/FFC connectors come in various different designs, and it is essential to select the right one to ensure a secure connection. The specific connection mechanism used depends on the design of the connector and the application it serves. The most common connection mechanisms seen in the market are zero insertion

force (ZIF) connectors, which require no force when inserting the FPC/FFC into the connector, and connectors with rotating locks (flip-lock) especially for EV chargers.

As well as the above, there is also a unique technique available: the Hirose One Action FH connector.

## ONE ACTION FH

The One Action FH connector has several benefits compared to the conventional connection processes of (1) opening the lock, (2) inserting the FPC/FFC, and then (3) closing the lock. The connection is made by simply inserting the FPC/FFC into the One Action FH connector. There is no need to touch the lock when connecting, which prevents lock damage. Locking is performed at the same time as the FPC/FFC insertion, which prevents incomplete mating. Having larger tapers on each side helps with inserting the FPC/FFC either manually or by robot. This can decrease the risk of misalignment significantly. The connector has visual openings in the lock, so it can be detected if the insertion is incorrect.

All of these benefits help to reduce the number of operation steps, thus decreasing the work time by one third. The One Action FH is fully compliant with RoHS and REACH environmental regulations, and together with the vast range of features and benefits, the One Action FH provides an excellent connection solution for EV chargers to support sustainable transportation. ▮

# EFFICIENT PROTECTION FOR MODE 3 CHARGING STATIONS

The relatively new IEC 62955 standard stipulates that all three phases need to be switched off in order to provide residual current protection on Mode 3 charging systems. New solutions enable this to be done using just one relay, which can be installed directly on the circuit board in order to save space.

There were around 7.4 million zero-emission cars on European roads in 2022, and ACEA (the European Automobile Manufacturers' Association) expects this figure to reach 12.5 million by 2023. According to ChargeUp Europe, most of these electric vehicles – around 75 percent – are charged either at home or at work.

## CHARGING IN MODE 3

Charging stations that provide charging mode 3 ("Mode 3") are the backbone of the charging infrastructure required for this. They offer normal to fast charging speeds (between 3.7 and 22 kilowatts) and run in a three-phase system with 32 amperes at 380 volts alternating current. To ensure they operate safely, a safety feature is built into the overall installation along with a residual current protective device. The IEC 62955:2018 standard, valid since 2019, covers equipment for residual current protection in charging devices for electric vehicles. When it comes to Mode 3 charging stations, it prescribes the use of effective measures to protect against DC residual currents, in other words, it stipulates the use of RCDs (residual current protective devices). This protective device must switch off all phases, including the neutral conductor.

## PROTECTED BY A RELAY

A relay can be used as the protective switchgear, provided that it detects DC residual currents and isolates at no more than six milliamperes. For safety reasons, the main relay should be designed as a N/O contact to ensure the power supply to the vehicle is interrupted if the charger fails. Low contact resistances are important in order to minimize losses, and the holding currents for the N/O contact relay must be low in order to guarantee the overall efficiency of the charging station.

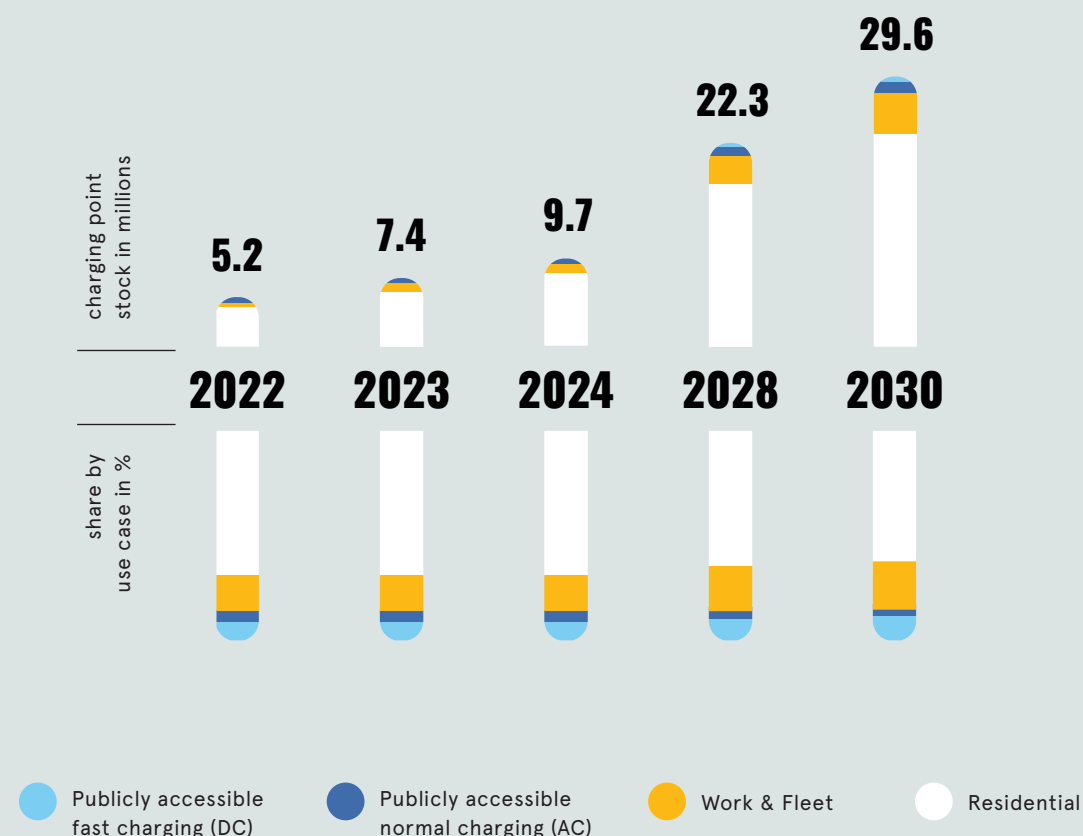
## INSTALLED DIRECTLY ON THE CIRCUIT BOARD

In the interests of optimizing efficiency, size, and costs, relays that are mounted on circuit boards are advantageous as this avoids the additional material and assembly costs associated with separate switchgear. They also make the design more reliable as there is no need for connection lines between the board base and relay.

## PROTECTION FOR THREE-PHASE SYSTEMS

Circuit board relays that can be used as the main switching element in three-phase systems are a relatively new development. While the use of circuit board relays has so far been

Forecasted share of installed charging capacity in EU-27



Source: ChargeUp Europe State of the Industry 2022 / P3 analysis

restricted to applications with relatively low voltages, the market now also offers highly efficient 40-ampere relays for three-phase systems. These enable all of the switching functions required for a Mode 3 charging station or wallbox to be integrated on the circuit board – which not only saves a lot of space, but also means major cost savings.

IEC 62955-compliant circuit board relays offer significant opportunities for both AC and DC charging stations. They help designers to create charging systems that can handle higher voltages and power outputs while also meeting increasingly stricter efficiency demands. As such, they also help to further expand the urgently needed charging infrastructure for electric vehicles. //

# STAYING COOL AT HIGH FREQUENCIES

The switching frequency used by SiC and GaN semiconductors places high demands on the DC link capacitors in converters. However, the latest generation of materials is able to withstand the high operating temperatures that arise, while also reducing the equivalent series resistance and parasitic inductance.

**S**emiconductor devices based on wide-band-gap materials are increasingly being used for the power electronics in automotive applications. WBG semiconductors enable power converters to operate at higher voltages, temperatures, and frequencies, which significantly increases both the efficiency level and power density and makes the electric drive much more efficient.

## HIGH SWITCHING FREQUENCY PLACES ADDITIONAL LOADS ON CAPACITORS

However, devices based on silicon carbide (SiC) or gallium nitride (GaN) use a high switching frequency, meaning DC link capacitors with particularly low self-inductance and a high resistance to ripple currents are required. Moreover, the slew rate at the output of a SiC half bridge may be much higher than on a silicon component, with SiC power stages reaching a  $dV/dt$  of 30 to 50 kilovolts per microsecond. This places an additional load on the capacitors.

## THINGS HEAT UP CLOSE TO WBG SEMICONDUCTORS

To cope with these high switching frequencies, film capacitors are being used more and more as DC link capacitors as they can withstand high ripple currents. However, in order to keep the lines as short as possible and thus minimize the parasitic inductance, the capacitors need to be placed very close to the WBG modules. The problem with this is that WBG semiconductors are operated at high junction temperatures, which means the DC link capacitors also heat up. However, the temperature limit for conventional film capacitors with a dielectric made from biaxially oriented polypropylene (BOPP) is just 105 degrees Celsius.

## SPECIAL WBG DC LINK CAPACITORS

New types of capacitors designed specifically for the DC link of WBG converters are being developed, enabling them to be positioned closer to the fast-switching power semiconductors

than was previously possible without the use of cooling. Depending on the specific manufacturer, they are either based on PLZT ceramic (lead lanthanum zirconate titanate) or use robust base metal electrodes (BME). They all reduce ripple currents thanks to a lower equivalent series resistance (ESR) and can withstand high operating temperatures ranging from 125 to 150 degrees Celsius.

## FREE UP EVEN MORE SPACE

In some cases these DC link capacitors are also available as an SMD variant. Their small size means they can be placed even closer to the fast-switching power semiconductors, minimizing the inductance of the supply line. In addition, the parasitic inductance ESL (equivalent series inductance L) – which is particularly disruptive at high frequencies – is very low. The combination of short lines (meaning low inductance) and the very low self-inductance of the capacitors prevents large overvoltage spikes when

switching off the current at the semiconductor modules. This generally means there is no need for snubber capacitors, simplifying the overall system design and saving extra space. //

## TESTED STRESS RESISTANCE

When choosing suitable DC link capacitors in automotive applications, take care to ensure that the components are certified to AEC-Q200. This is the global standard from the Automotive Electronics Council governing the stress resistance of passive electronic components.







# A WORLD WHERE EVERYTHING COMMUNICATES WITH EVERYTHING ELSE

In future, vehicles will be able to communicate with other road users and the infrastructure around them, improving safety and reducing emissions. Special antennas ensure that the necessary wireless technology blends harmoniously into the vehicle's design while minimizing development work.

**A**ccording to forecasts from McKinsey, one in every four cars in the European Union – more than 70 million vehicles in total – could be equipped with an electric drive system by 2030. As a result, the demand for electrical power is also set to increase, which poses a challenge in terms of ensuring the power grid remains stable.

## CARS AS POWERBANKS

However, electric cars have the potential to not just consume power, they can also play an important role in the power grid. As soon as they become capable of bidirectional charging, they will also be able to feed power back into the grid if they are not being driven at the time. The technology that makes this possible is called V2G or "Vehicle-to-Grid," which enables the grid/charging station and the vehicle to communicate with one another.

## OVERARCHING COMMUNICATION

V2G is just one part of a much larger world of networking. "Vehicle-to-Everything" (V2X)

encompasses all technologies where the vehicle communicates with others, for example other vehicles (Vehicle2Vehicle), the infrastructure (Vehicle2Infrastructure), and pedestrians (Vehicle2Pedestrian).

As a result, the vehicles are able to exchange traffic data and information about road hazards in real time, which helps to reduce accidents. V2X is also a key element of autonomous driving. What's more, exchanging information with other road users and the infrastructure helps to prevent traffic jams and enables more energy-efficient routes to be planned, saving fuel and reducing CO<sub>2</sub> emissions.

## A WEALTH OF WIRELESS TECHNOLOGIES

V2X uses different communications technologies, in some cases at the same time: High-Precision GNSS (Global Navigation Satellite System), WiFi-based DSRC (Dedicated Short Range Communication), or Cellular V2X which uses cellular telephony. UWB is a relatively new development. >

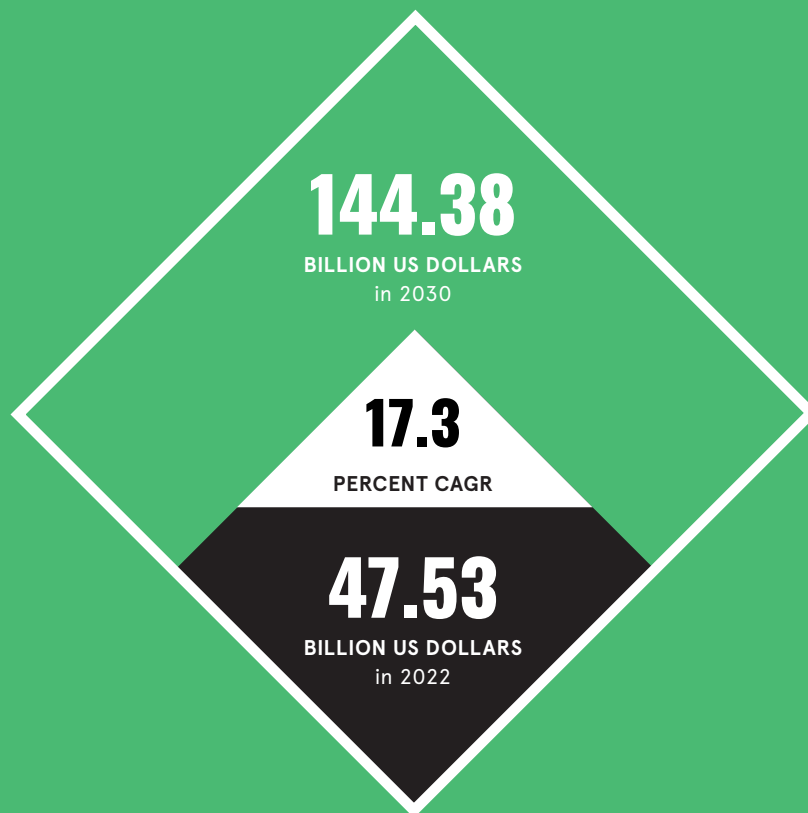


This technology (Ultra Wideband) was originally used for indoor positioning purposes. It enables the distance between devices to be calculated and is accurate to just a few centimeters. The Car Connectivity Consortium is currently developing specifications based on UWB for use as digital keys in phone-as-a-key applications. However, in future UWB could also be used to identify pedestrians and cyclists, for automated parking maneuvers in multi-storey car parks, or when positioning vehicles on wireless charging stations.

### SPECIAL V2X ANTENNAS

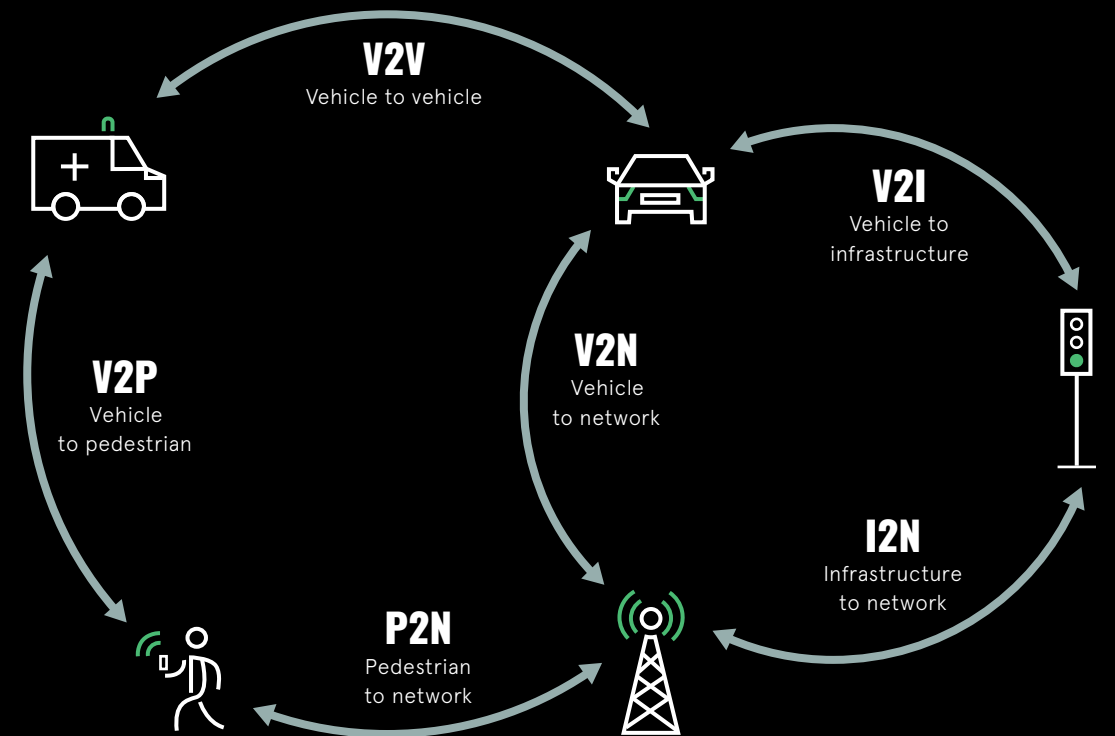
Of course, V2X needs corresponding antennas so that the vehicle can connect to all other networks. Designing these V2X antennas is a challenging task due to the complex environment in vehicles, the trend for invisible antenna solutions where possible, and the need for omnidirectional coverage. Additionally, no car designer wants to spoil the look of their vehicle with a mess of antennas for all the different wireless standards. That's why there are specially designed V2X antenna modules which combine a

### Global V2X market volume



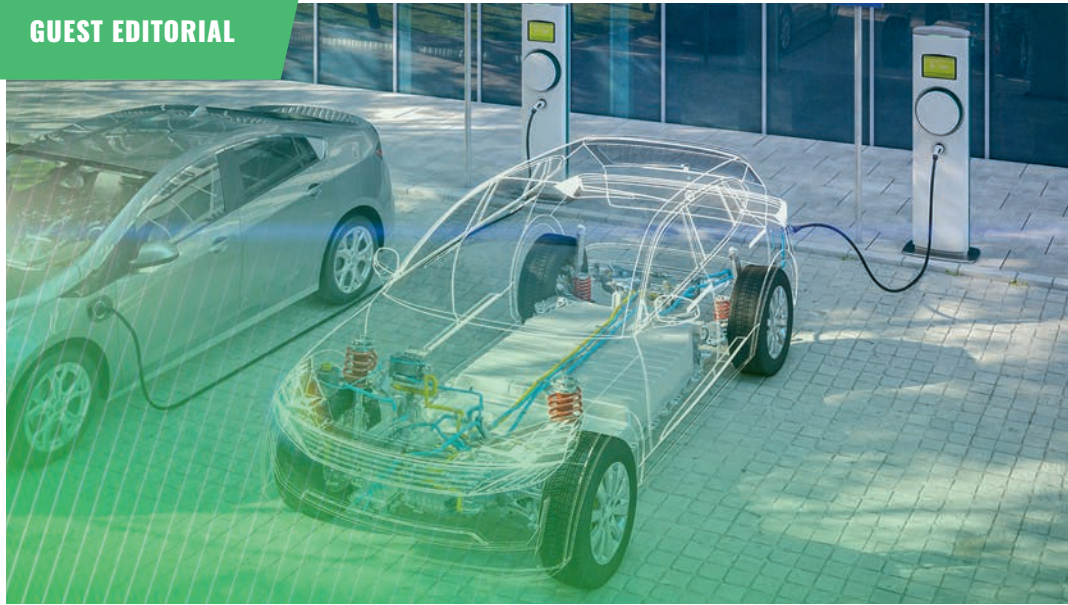
Source: Verified Market Research

### V2X connects all traffic participants



range of wireless applications, such as 4G or 5G cellular telephony, WiFi, Bluetooth, and keyless entry to the vehicle. Smart antennas simplify the design even further as they include not only the antenna itself, but also all the electronics you would find in a conventional telematics control unit, such as the application processor, memory, and vehicle electronics interfaces. In summary, innovative V2X antennas not only mean more efficient operation, but also a streamlined design for the vehicle's networking concept. /

The growing emphasis on reducing road accidents, improving traffic management, and enhancing driver safety has resulted in increased adoption of V2X.



# CONNECTIVITY AND ELECTRIFICATION IN FUTURE VEHICLE DESIGN

**We depend on vehicles every day. From the car that takes us to work to the truck that delivers our groceries, modern vehicles are critical to the global economy. These vehicles are constantly being developed, offering new features and improved capabilities. However, the automotive industry is on the edge of a revolution that will see changes not only in the technology that vehicles use, but also in the way in which they are manufactured.**

This rapid rate of change in vehicle technology is the result of several key innovations that are all maturing at the same time. The level of sophistication that we will see in future vehicles is forcing manufacturers to re-evaluate how they design and build their products.

At the very heart of the changes in the automotive market is the interest in electric vehicles (EV). Consumers around the world are seeking alternatives to conventional fossil fuels, and there has

been a rapid growth in demand for electric and hybrid vehicles. The advances in battery technology, along with the latest battery management systems, mean that electric vehicles are delivering new standards of reliability and performance. However, the growth of the EV market is just one of the changes that is revolutionizing car design. The automotive industry is benefitting from developments in other fields to deploy new and exciting functionalities into our vehicles.

Vehicles will also provide a new standard of connectivity as they share information with other road users in a network known as V2X (Vehicle to Everything). Using the latest 5G wireless communication network, vehicles will be able to transmit information about their location, road conditions, and intentions to other vehicles, smartphone-carrying pedestrians, and even the city infrastructure. This information will allow other road users to build a complete picture of their local environment, thus enhancing road safety.

## HOW ARE EVOLVING VEHICLE ARCHITECTURES AFFECTING THE NEED FOR CONNECTIVITY?

Despite all these advances in automotive technology, the way in which cars are designed and manufactured has changed little over the last decades. The installation of sophisticated components has happened gradually over many years, and vehicle cable harnesses have grown in complexity as a result. When new features are added to the existing vehicle wiring, each is controlled by its own module, known as an electronic control unit (ECU). Each ECU is provided with its own dedicated wiring that connects it to the rest of the vehicle.

The result of this approach is that modern vehicles can now be fitted with up to 150 ECUs, along with the associated wiring harnesses. This means that manufacturers are running out of space in their vehicles for new technologies, and their wiring requirements are approaching the point of saturation.

Modern cable harnesses are tasked with delivering power, data, and signals all over the vehicle, and their complex shape means that they are costly to make. Despite the adoption of highly automated production lines, cable harnesses are one of the few systems of any vehicle that are largely made by hand. Manual assembly of any component is expensive.

There is also a significant impact on quality. Robots are poorly equipped to manufacture or install vehicle cable harnesses due to their complexity and pliability. Wiring harnesses are designed to flex, twist, and move freely, making them difficult for a robot to handle. The profusion of ECUs and the complexity of the cabling that connects them makes it difficult to integrate the next generation of technology without changing how vehicles are designed. This has led to a new concept known as zonal architecture. /

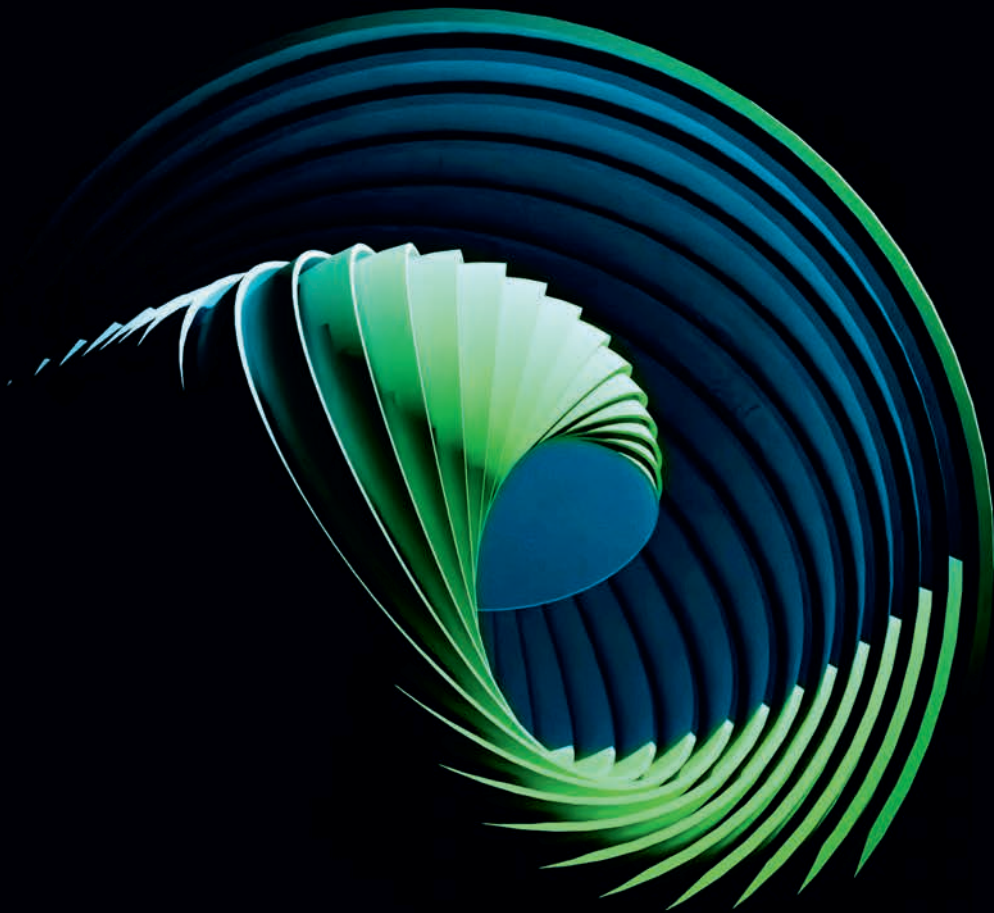
## WANT TO KNOW MORE?

/ To access insights into the broad range of factors affecting connector development for electric vehicles, the capabilities of Molex's various solutions, and how to employ the right connectors in your designs, download our electrification whitepaper here:



**molex**

# SUCCESS STORIES



POWERED BY  
AVNET ABACUS

## ABILITY TO DELIVER AND **CUSTOMIZE** SOLUTIONS

Products and solutions available in Avnet Abacus' portfolio are used in diverse applications. Avnet Abacus' expertise in providing best fit solutions together with its first-in-class suppliers and fast sampling capabilities are three reasons to buy solutions from Avnet Abacus. Having the right stock profile and delivering the required quantity to the customer at short notice makes Avnet Abacus capable of accompanying the customers from design to production and turning ideas into reality in a short time to market.



### **POSITION SENSOR WITH REDUNDANT OUTPUT**

A hollow-shaft position sensor with a long life time was urgently needed for a multifunctional armrest of the type that may be used in tractors or construction machinery. For safety reasons, the sensor should have a redundant output. Avnet Abacus' application engineers recommended Piher's new PST360G2 series sensors. These combine a continuous shaft design with precise, absolute position feedback and a true non-contact sensor element. The rotary sensor has extensive configuration capabilities, offers various signal output options, and supports low and high voltage supply. Avnet Abacus was able to deliver samples for mechanical development and approval within a very short space of time.



### **PROMPT SUPPLY OF IMU SENSOR**

A leading manufacturer of mechatronic solutions for vehicle dynamics required samples of a precise IMU sensor at short notice for a new development. Inertial measurement units (IMUs) log rates of acceleration and rotation, which can then be used to record a vehicle's movement in a given space. This is an essential part of ensuring safe control for an automated vehicle. Avnet Abacus helped the manufacturer to select a suitable six-axis motion sensor from TDK Invensense, providing samples of the desired component on a tight timeline. In addition, Avnet Abacus had several thousand units of the chosen IMU sensor in stock, which were readily available for the later production process.



### TMR SENSOR COMPLIANT WITH ASIL D

For the design of a steering monitoring system, a tunnel magnetoresistance (TMR) angle sensor was needed in order to support precise and safe measurement in line with ASIL D.

Based on these technical requirements, Avnet Abacus recommended a TDK sensor from its portfolio. Unlike other TMR sensors on the market, it features a digital output. In addition, it combines high accuracy with a small design size. Avnet Abacus supplied the samples required for the development within a short time frame, and thanks to TDK's technical support, the customer was able to quickly integrate the sensor into its communication system.



### CUSTOM ELECTROLYTIC CAPACITOR

For a driver monitoring system, the customer in question needed an aluminum electrolytic capacitor. However, the available installation space proved to be too small for commonly available standard components.

Avnet Abacus worked with Nichicon to develop a custom component with adjusted ripple current and minimized package size. The component made a convincing impression thanks to its slender footprint and competitive price. The aluminum electrolytic capacitor has now been approved for mass production.



### IR SENSORS SUITABLE FOR AUTOMOTIVE APPLICATIONS

A non-contact temperature control was needed for use in a charger for electric cars to prevent overheating. However, it proved challenging to find a suitable thermopile infrared sensor on the market that met the requirements of the automotive industry. The customer therefore turned to Avnet Abacus.

Their experts recommended an IR sensor from Amphenol Advanced Sensors, consisting of thermocouples, a flat infrared filter, and a thermistor for temperature compensation, all in a hermetically sealed TO-46(18) enclosure. The thermopile infrared sensor is the best technical solution for the relevant application, and its specifications also satisfy the automotive sector's requirements.



### HMI INTERFACE AS AN INTEGRATED SOLUTION

In introducing a new, comprehensive crop production system, the manufacturer wanted to minimize the amount of machinery required in agricultural enterprises. This was based on a carrier vehicle with interchangeable implements that can be used for soil cultivation as well as sowing, crop protection, and harvesting thanks to integrated modules. The modular concept makes it possible to reduce purchase costs as well as potentially saving 20-40 percent in energy compared with conventional machinery. Avnet Abacus assisted the manufacturer with selecting an operator control system from Grayhill solutions for these machines that was tailored to their requirements. Grayhill HMI controllers and CANbus keypads provided the solution, with the systems supplied as integrated solutions that can be modified to suit customer specifications. They are very easy to integrate via CANbus J1939 (other protocols are also available).



### CONNECTORS IN STOCK

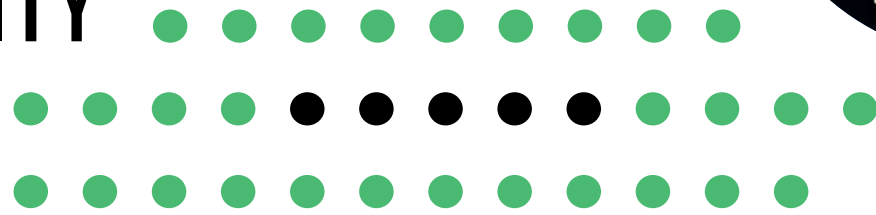
A manufacturer of overhead lighting for aircraft cabins needed connectors that were available at short notice. But the approval process for assembly is time-consuming in the aviation industry, so the customer could not find a suitable product on the market in time.

In stepped Avnet Abacus, whose inventory included connector units from TE Connectivity which fit the bill. The customer received the entire stock in one delivery, allowing it to stay within its set time frame. More orders followed. /

# THERE'S MORE TO SUSTAINABLE TRANSPORTATION THAN E-MOBILITY



**SARA GHAEMI TALKS ABOUT** the role of technology and technology distributors in the shift toward a sustainable transportation sector. This interview is an excerpt from the Avnet Abacus podcast "The Technology Addicts."



**A**ccording to the latest report of the Intergovernmental Panel on Climate Change, transport accounts for 15 percent of global greenhouse gas emissions. The vast majority, around 70 percent, is emitted by road vehicles. To improve its sustainability and contribute to global emission reduction targets, the transport sector is in the midst of a technological revolution centered on electrification. In this interview, Sara Ghaemi, Director of Technical Development at Avnet Abacus, explains to what extent electromobility contributes to creating sustainable transport.

## HOW CAN TRANSPORT BE REALIZED MORE SUSTAINABLY?

**Sara Ghaemi:** Achieving complete sustainability in transportation requires a comprehensive approach which goes beyond electric vehicles. Especially in Europe, sustainability is seen as a much broader concept with three main dimensions. This relates to economic, social, and environmental aspects. Of course, the primary goal of sustainable transportation is to reduce pollution. We also need to reduce consumption associated with transportation activities, and at the same time we want to promote accessibility, safety, and efficiency. To reach all these goals, we also need to consider other aspects such as smart urban planning and intelligent

transportation systems. This means utilizing technology such as data communication systems to improve traffic flow and reduce congestion. It also means considering which transportation demand management strategies to implement, for example carpooling, ridesharing, and congestion pricing, in order to reduce the number of single occupancy vehicles on the road.

## WHICH TECHNOLOGIES DOES AVNET ABACUS FOCUS ON TO REALIZE SOLUTIONS FOR SUSTAINABLE TRANSPORT?

**S. G.:** We provide technology solutions and components for a wide range of industries, not only the transportation sector, of course. One of the areas we cover is electric vehicle solutions and EV-charging infrastructure. Another area is smart energy. We provide solutions for the integration of renewable energy infrastructure such as solar panels or wind turbines into the transportation sector. This can also involve components and systems for solar-powered charging stations, energy management systems, and power conversion technologies. Additionally, we offer solutions for intelligent transportation systems, for example vehicle-to-vehicle and vehicle-to-infrastructure communication and advanced driver assistance systems. Last but not least, it is essential to consider energy storage in all aspects of the energy system and sustainability.

## SYSTEMS FOR INCREASING SUSTAINABILITY IN TRANSPORTATION ARE USUALLY VERY COMPLEX. HOW DOES AVNET ABACUS SUPPORT ITS CUSTOMERS IN ACHIEVING A COORDINATED OVERALL SYSTEM IN THIS CONTEXT?

**S. G.:** Avnet is a one-stop shop for its customers. We have a very successful marketing campaign. It is called "The Power of Three" and means we offer our customers a turnkey solution for EV charging applications. The strong internal collaboration between Avnet companies, our speedboat business model, and the ecosystem we have created help customers get the best possible solution for their overall product design and, of course, production.

## TECHNOLOGY ISN'T EVERYTHING. RAPID PRODUCT DEVELOPMENT IS BECOMING INCREASINGLY IMPORTANT IN ORDER TO SECURE MARKET SHARE IN GOOD TIME. FROM THIS POINT OF VIEW, DO YOUR CUSTOMERS DERIVE ANY BENEFITS FROM WORKING WITH YOU?

**S. G.:** It is important that we support the customer in selecting the right product. We also think it is always sensible – both for the customer and for Avnet Abacus – to have a component available for sampling, prototyping, and mass production. We have many examples of success stories based on design support and

our rapid sampling and delivery services, all of which have enabled our customers to reduce their time-to-market. In today's dynamic market, this is a very important factor. Avnet Abacus helps customers to be in the market with the right solution and the right product at the right time.

## FROM HERE TO THE FUTURE, WILL THE TRANSPORT REVOLUTION TOWARDS INCREASED SUSTAINABILITY SUCCEED? CAN THE TRANSPORT SECTOR ACHIEVE CLIMATE NEUTRALITY BY 2050?

**S. G.:** Let me just take a look into my crystal ball. While achieving climate neutrality in the transport sector by 2050 will be a very challenging task, it is not impossible. But it requires a multiple-faceted approach with strong commitments from governments, from industry leaders, and, from all individuals. Our success will depend upon a combination of factors: advancements in technology, supportive policies, infrastructure development, and consumer adoption. I hope that by 2050 we achieve the goals that we are setting for ourselves. /



“The Technology Addicts” is the podcast by Avnet Abacus. Knowledgeable guests discuss the latest advancements and successful projects in interconnectivity, passive components, power supply, and wireless technologies. Featuring industry experts, this podcast offers valuable insights for tech enthusiasts, engineers, and designers.

**E**xciting news! The first episodes are now live and ready for you to explore. Join us as we dive deep into the world of cutting-edge technology products, featuring inspiring interviews with industry experts and innovators.

#### EV CHARGING

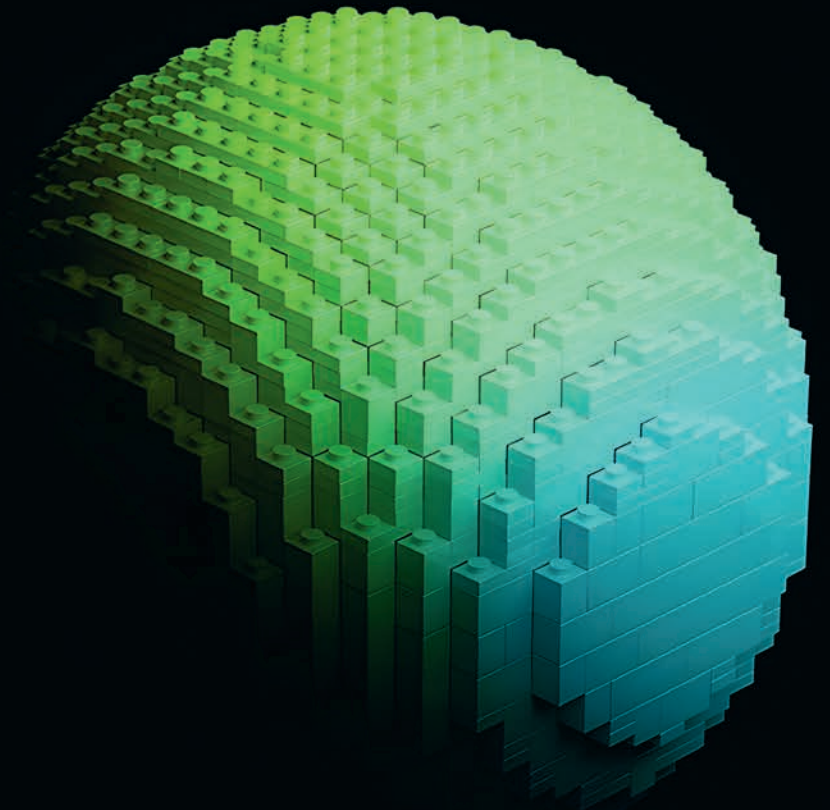
In the thriving EV charging market, we keep a close eye on the latest market news as we delve into essential topics, including building efficient infrastructure, accelerating development, tracking industry trends, and understanding the environmental and societal impacts of EV charging.

#### EXPERT INSIGHTS

You can also listen to the interviews with Sara Ghaemi, Director of Technical Development at Avnet Abacus, and Kirstin Hegner, Managing Director of the Munich-based startup accelerator. Simply scan the QR code for a deep dive into their discussions! //



# PRODUCT PRESENTATION



# EMPOWERING INNOVATIONS IN TRANSPORTATION

Murata's rail, transportation, and industrial DC-DC converters are designed to provide isolated DC power for applications requiring high reliability in demanding conditions.

Utilizing the latest in technology development, Murata's DC-DC converters are able to cover a wide range of battery input voltages from 9V to 160V DC in a single module (with input voltage ratios up to 10:1). Specific nominal

battery input voltage range converters are also available. Products are suitable for both on-board and trackside rail applications, industrial/manufacturing and farming equipment, and e-mobility applications.

## IRH/IRQ W80 SERIES

- / 16V – 160V DC 10:1 input range
- / 250W 1/2 brick or 150W 1/4 brick option
- / Hold-up function pin
- / -40 °C to +100 °C temperature range
- / 12V, 24V, 48V/54V outputs
- / Under voltage lockout feature
- / Remote sense
- / ±10 % adjustment range
- / Extremely high efficiency
- / EN50155 compliant



## IRV300 SERIES

- / 16V – 160V DC input
- / 12V, 24V, 48V/54V @ 300W outputs
- / Compliant to: EN50155, EN45545, EN50121
- / Environmentally qualified
- / -40 °C to +70 °C operating (+85 °C for 10 minutes)
- / Optional holdup, parallel functions
- / Connector kit available

# PRINTED CIRCUIT SOLUTIONS

As today's applications demand smaller form factors and microminiature components, many traditional printed circuit boards (PCBs) can be too rigid to accommodate advancing designs. Molex provides a versatile range of printed circuit solutions for customer innovations that need to be smaller, lighter, and adaptable to suit consumer demands.

## PREMO-FLEX FLAT-FLEXIBLE CABLES (FFC)

Product description: Premo-Flex Flexible Solutions deliver reliable flat flexible cables (FFC) optimal for a variety of dynamic applications with an extensive range of standard off-the-shelf and custom options that enable designers to maximize PCB space, reduce component costs, and provide devices with reliable board-to-board connections.

### Product highlights:

- / Enables versatile configurations
- / Terminates to fully mate with a wide range of Molex Easy-On connectors
- / Product offerings range from 50,000 to 2.5 million flex life cycles
- / Includes off-the-shelf options for faster time to market



## SILVER FLEX CIRCUIT SOLUTIONS

Product description: Molex silver circuit solutions are a flexible alternative. With the ability to print up to six layers and component SMT, silver flex offers an economical approach to traditionally etched copper products.

### Product highlights:

- / Polyester (PET) substrate provides a flexible substrate alternative
- / Proprietary soldering technique
- / UV-cured encapsulant offers robust connection that tolerates a wide variety of applications
- / Delivers low resistance and high conductivity, making this an effective circuit for a wide variety of low-power and low-signal applications





# BOURNS AUTO GRADE SOLUTIONS BOOST EFFICIENCY & SAFETY

Bourns, Inc. is a leading manufacturer and supplier of electronic components for power, protection, and sensing. Bourns' position/speed sensors, circuit protection, magnetic and resistive products meet the advanced technology requirements for automotive, industrial, and consumer market designs.

## BOURNS MODEL SM91542AL BMS TRANSFORMER

This AEC-Q200 compliant, automotive grade signal transformer includes common mode chokes for noise rejection. The transformer's pin auto-termination design helps increase efficiency and lower costs. It has a working voltage up to 1000 VDC and Hi-Pot isolation voltage up to 4300 VDC.

Developed for use with:

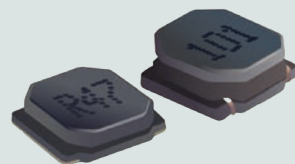
- / Analog Device's model LTC6804/681X
- / NXP's model MC3377X
- / Texas Instruments' model BQ79616



## BOURNS SRN4012BTA & SRN4018BTA SERIES POWER INDUCTORS

Delivering enhanced reliability and mechanical strength and stability, these AEC-Q200 compliant, automotive grade semi-shielded power inductors are designed for mission-critical automotive system, power supply, and DC-DC converter applications.

- / Bottom-soldered lead wire construction
- / Semi-shielded for low magnetic field radiation
- / Inductance values from 0.47 to 100  $\mu$ H
- / Operating temperature range of -55 °C to +125 °C



## BOURNS MODEL HCTSM110103HAL ISOLATION TRANSFORMER

Bourns' new high clearance/creepage isolation power transformer is automotive grade and AEC-Q200 compliant. It is designed for CAN, RS-485, RS-422, RS-232, SPI, I2 C, and lower power LAN interface power support. The transformer's features make it ideal for Industry 4.0 designs or other applications that require high voltage isolation such as in energy storage systems. Developed for use with Texas Instruments' model SN6501 and SN6505B, it is compliant with IEC/UL 60664-1 and IEC/UL 62368-1 requirements.

Product highlights:

- / 3.3 – 5 V input and 3.3 – 15 V up to 350 mA output
- / 1200 VDC working voltage; Hi-Pot isolation voltage up to 5000 VAC
- / -40 °C to +125 °C extended operating temperature
- / Ferrite toroid core delivers high coupling factor & efficiency



## BOURNS MODEL SRN4012BTA/SRN-4018BTA POWER INDUCTOR SERIES

These new AEC-Q200 compliant automotive grade model series feature bottom-soldered lead wire construction for enhanced mechanical strength and stability. They are designed as high-reliability solutions for mission-critical applications such as automotive systems. Their semi-shielded structure combines the features of non-shielded and shielded inductors, providing lower magnetic field radiation than non-shielded inductors and a more cost-effective alternative to fully shielded ferrite-based inductors.

Product highlights:

- / Inductance values from 0.47 to 100  $\mu$ H
- / Operating temperature range -55 °C to +125 °C
- / RoHS compliant and halogen free





# KYOCERA AVX | ACCELERATING INNOVATION

**KYOCERA AVX designs, develops and manufactures advanced capacitors, antennas, connectors, circuit protection & timing devices, sensors, controls, and RF/microwave components optimized for employment in 5G, IoT, aerospace, automotive, consumer electronics, industrial, medical, & military markets.**

The new automotive-qualified Supercapacitor products are tested to the stringent AEC-Q200 standard requirements. Both SCC & SCM Series supercapacitors from Kyocera AVX have a ruggedly constructed form factor, deliver high-reliability performance, and exhibits very high capacitance, very low ESR, with excellent power handling characteristics. Applications examples for the K-AVX automotive supercap products include electronic mechanical latching, emergency calling, electronic recording, regenerative braking, power, backup power systems.

- Product highlights:**
- / 2.7/3V cell ratings
  - / 10-100F range available, for different values, contact KAVX
  - / -40 °C to +85 °C temperature range
  - / Available in Ammo package for quick pick & place production
  - / Free of wetting phenomena



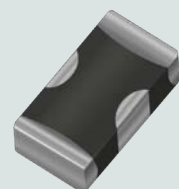
Kyocera AVX's conductive polymer TCQ series meets the AEC-Q200 specification providing a compact and robust form factor that's ideally suited for space-constrained, harsh-environment applications including body electronics, cabin controls, comfort and in-fo-tainment systems, aftermarket automotive electronics, DC/DC converters, and coupling/decoupling. TCQ series exhibit low DC leakage (0.1CV), high capacitance, and stable electrical performance in operating temperatures extending from -55 °C to +125 °C. They also satisfy AEC-Q200 humidity bias testing requirements (Ur at 85 °C and 85 % RH for 1,000 hours) and deliver exceptional endurance and stability for 2,000 hours at 125 °C, exceeding the already-stringent AEC-Q200 operational life requirement by 100 %.

- Product highlights:**
- / Robust design for automotive applications, meets requirements of AEC-Q200
  - / Basic reliability 1%/1000hrs@85 °C Vr with 60 % confidence level
  - / -55 to +125 °C operation temperature
  - / Full voltage range: 2.5-50 V
  - / DCL 0.1 CV
  - / 3x reflow 260 °C compatible
  - / 100 % surge current tested



KYOCERA AVX's range of automotive MLVs provide bi-directional overvoltage protection and EMI/RFI attenuation in a single SMT package. A single MLV can replace TVS diode with significant space savings and in many cases also an EMC capacitor. Wide range of components are available, including low capacitance parts for data lines (e.g. 100/1000-T1 Ethernet, CANBUS), high energy parts with load dump capability, parts with FLEXITERM® for severe flexure stress applications including VW80808 qualified parts for voltage supply terminals, integrated components combining MLV with MLCC for DC motors.

- Product highlights:**
- / Operating temp range: -55 °C to +125/150/175 °C
  - / No derating over temperature
  - / Bi-directional protection and EMI filtering
  - / Fast response (<1ns) and multiple strikes capability
  - / Small size and weight
  - / AEC-Q200 qualified



As ADAS adoption increases rapidly with the electrification of automobiles crystal devices are critical and more complicated circuit configurations drives demand for miniaturization and modularization. Consequently, smaller components such as 2.0 x 1.6 mm crystal units and oscillators will be widely required. KYOCERA AVX supply high-reliability seam welding type of crystal units CX2016SA used by global tier 1 customers in Europe. KYOCERA AVX also offer two series of platform clock oscillator (SPXO); the MC-Z series, which can be developed flexibly to realize various frequencies; and the MC-K series, which provides outstanding low-phase noise characteristics.

- CX2016SA:**
- / Size: 2016/0.5 mm
  - / Freq: 16 to 60 MHz +/-10ppm
  - / Temp tol: ± 50ppm @ -400 °C to 1,250 °C
- MC-Z:**
- / Size: 2016/2520
  - / Supply: 1.71 to 3.63 V
  - / Temp tol: ± 30ppm @ -400 °C to 1,250 °C
- CX2016SA:**
- / Size: 2016/0.5 mm
  - / Freq: 16 to 60 MHz +/-10ppm
  - / Temp tol: ± 50ppm @ -400 °C to 1,250 °C

# IMPRINT

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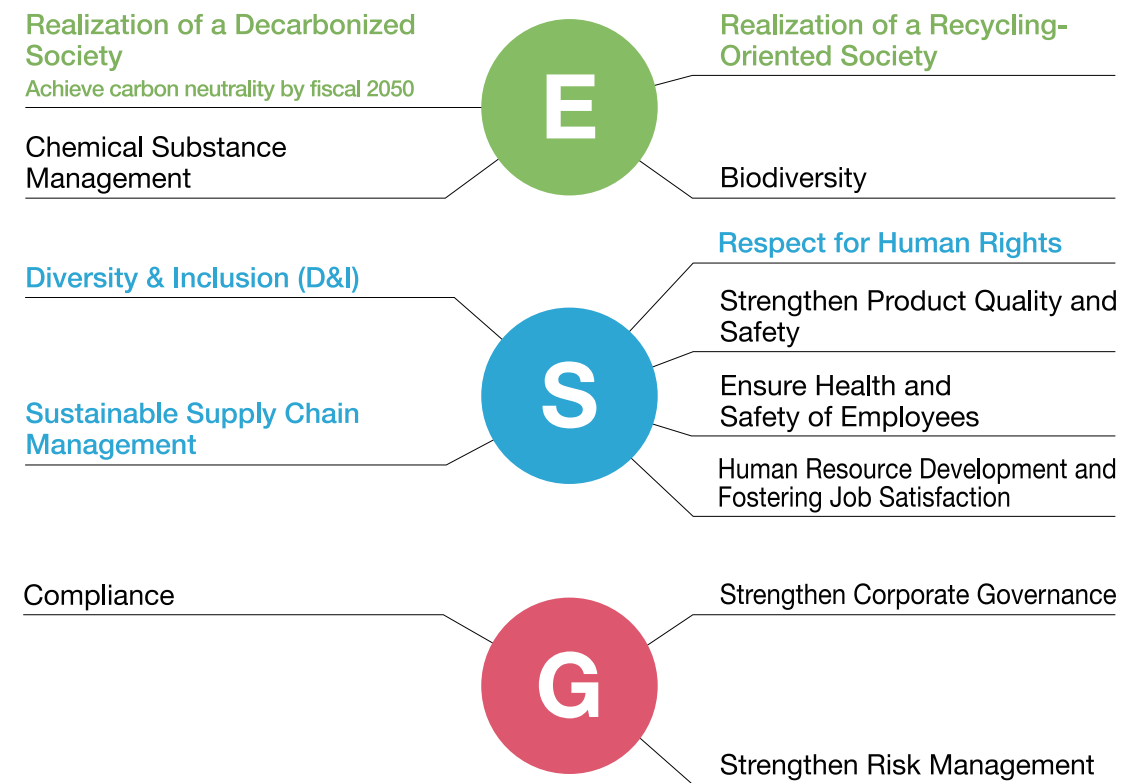
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## Maximizing Value Creation and Achieving a Balance Between CSR and ESG through Implementing ESG Management



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NEXT ISSUE

**THE INTERNET  
OF EVERYTHING**

The connected universe of  
people, data and objects