AVNET ABACUS

focus

Edition 39

Driving the electrification revolution

focus

Focus is the quarterly magazine from Avnet Abacus, featuring in-depth trend and technology reviews, new product spotlights, Avnet community news and interviews with market leaders.

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Features

News

Interview

Supplier technologies

Connectors

Power

Sensors

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Editor Anais Dupont
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Print Image Evolution

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Welcome to the latest edition of Focus magazine, in which we investigate the power system transformations taking place within the transportation sector.

Though much of the media interest in electrification of our transport networks deals with road-based Electric Vehicles (EVs), this is in fact only part of the story. Our articles go beyond that - addressing this subject from several different perspectives. We'll explain the market dynamics that are driving innovation elsewhere and the engineering obstacles that must be overcome.

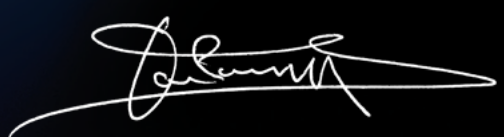
In our first article, the robots are coming, Hagen Götze looks at the growing deployment of Automated Guided Vehicles (AGVs) for carrying out materials handling and logistical functions in smart factories. It discusses the advanced sensor capabilities required so that AGVs can navigate their way around without risk of injuring people, as well as communications, processing and power requirements that will enable effective, low maintenance operation.

The electrification opportunities in agricultural equipment and construction machinery are covered in our second feature, when your next tractor is a Tesla. The diesel engines currently utilised are going to be replaced with electric motor drives. This will lower energy costs, reduce noise pollution and avoid harmful emissions, while at the same time boosting productivity. Applying electrification here will present challenges though, with far great power demands involved. Here Alessandro Mastellari investigates the potential solution of combining batteries with supercapacitors to provide greater quantities of power when needed.

Rail remains vital for both freight transportation and getting commuters to their workplaces. Decarbonising initiatives have been underway here for several years - and this has resulted in reduced fuel costs and air pollution. There's still a lot left to do though. In our final article, engineering better railways, Philip Lechner explores the advanced energy storage resources and robust DC-DC converter technology that will be required to take rail transportation into a greener, more sustainable future.

As we continue to push towards more sustainable ways of living in all aspects of society, it's clear that the transportation industry has a big part to play. We hope this edition of Focus helps you to think about design developments in your own projects.

Rudy Van Parijs
President, Avnet Abacus



AVNET ABACUS

focus

The robots are coming...

...if we can just sort out a few details first!

Industrial robots can be enormously effective for automating high-value, repetitive, and often unsafe processes, such as handling heavy castings or welding body seams on vehicle production lines. They may also offer advantages to small-and medium-sized companies that need flexible help with a changing roster of process-oriented tasks. The only issue with industrial robots is... using them.

Despite the challenges of doing so, to which we will return shortly, the uptake of robots has accelerated over the past couple of years, especially in the US, where demand for robots is growing as companies invest in automation.

Total US orders for robots were 20% greater in the first quarter of 2021 than in the same quarter in 2020, according to America's Association for Advancing Automation (A3). Companies working in metals processing spent 86% more on robots, those in life sciences and pharmaceuticals 72% more, those in food and consumer goods 32% more, and the rest of the non-automotive industries spent an aggregate 12% more. Figures from A3 also show that 2020 was the first year in which companies outside the automotive sector spent more on robotics than the car makers.

Speaking on publication of the results in May 2021, Jeff Burnstein, President of A3, said:

"While advances in robot technology, ease of use, and new applications remain key drivers in robot adoption, worker shortages in manufacturing, warehousing, and other industries are a significant factor in the current expansion of robot use. COVID didn't create the move toward automation, but certainly has accelerated trends that already were underway."

Hagen Götze

Senior Director Marketing, Avnet Abacus

THE INDUSTRY 4.0 VISION

One reason that there is a gap between our view of the value of industrial robots and their actual utility may spring from the Industry 4.0 strategy introduced by the German government in 2011. Industry 4.0 was presented to improve manufacturing by building bridges between the physical world of production lines and the digital world of work scheduling, equipment monitoring, statistical quality control, and predictive maintenance. Under an Industry 4.0 strategy, factories would evolve inexorably towards 'smart factories', in which every physical action on the production lines was matched with real-time data capture, advanced analytics, and action requests handled by cloud-based computers reached over robust communications networks.

This is still a vision of the future for many. A research brief on the status and future of industrial robotics, published by the Interactive Robotics Group at MIT in November 2020, laid out some reasons why this is so.

THE INTEGRATION CHALLENGE

One of the biggest challenges in using industrial robots is integrating them into production lines. Industrial robots are often large, fast, powerful machines that must be fenced off to protect factory workers, distorting existing workflows.

Industrial robots can be difficult to program: the industry lacks a common language with which to program the movement of robots, each manufacturer tends to have its own user interface, and even the manual controllers differ. This makes programming robots such a specialist skill that it is often outsourced to third-party integrators, whose work can cost more than the robot itself. If the programmed function needs to be changed, for example because a part has changed, companies may need to get the integrators back in to make the adjustment.

The robots are coming

Some in the industry have even floated the idea of offering 'robots as a service', as a way for companies to outsource the pain of making robots work well for them.

THE SMART FACTORY CHALLENGE

Even companies that embrace industrial robots may be sceptical about other parts of a 'smart factory' strategy, such as the Industrial Internet of Things (IIoT), because they're concerned about privacy, security, and keeping control of their data. Factories that do take up the IIoT to monitor robotic production lines need to implement an extremely robust communications network to reach all the distributed sensors and actuators.

For example, when grocery-delivery and fulfilment-centre automation company Ocado wanted to provide communications for its very large robotic warehouses, it installed a private 4G network.

There are also concerns with using cloud computing to gather, store, clean and analyse data for a smart factory. The promise of cloud computing is that it provides processing power on tap, like a utility. The reality is that cloud computing systems can have issues that become mission critical when they are used to manage a production line.

The real elephant in the room, though, is that gathering a lot of data is not the same as creating actionable insights. Senior management may look at the cost of implementing the infrastructure that turns a standalone robot into part of a smart factory and ask, "Where's the return on my investment?"

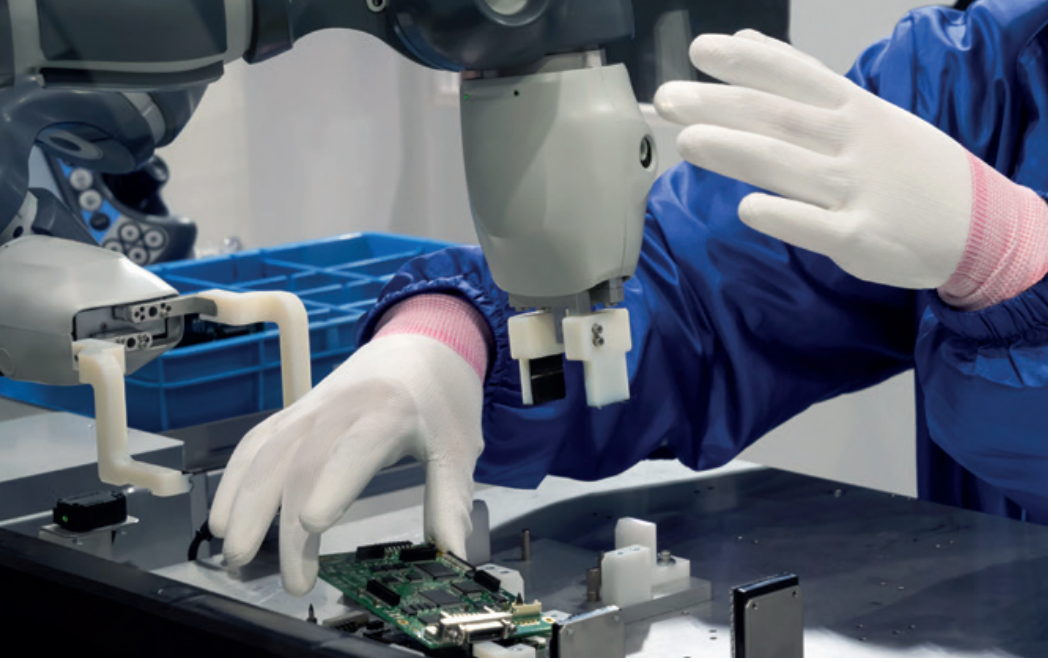
THE COBOT ALTERNATIVE

One alternative way forward is the collaborative robot, or cobot, which enables people and robots to work more closely without endangering worker safety.

Cobots tend to be smaller, lighter robot arms, designed to handle less mass, and move more slowly than standalone robots. Many of these arms include sensing facilities so that they stop moving if they encounter an obstruction – such as a human limb. These can include passive contact sensors, light or laser curtains, proximity sensors within the working area, or even capacitive 'skins'.

This approach, used by Bosch Rexroth in its APAS Production Assistant cobots, can sense people within its working area without making contact, and slow or stop the cobot's operation. Unsurprisingly, there is an ISO standard, ISO/TS 15066, which defines safety requirements for collaborative robots.

'Some in the industry have even floated the idea of offering 'robots as a service', as a way for companies to outsource the pain of making robots work well for them.'



A cobot working with an operator on an assembly line to boost productivity.

Cobots face similar programming issues as larger robots, but their size and accessibility may make it easier to gain enough familiarity with them to adapt them to new tasks quickly.

AUTOMATED GUIDED VEHICLES

Automated Guided Vehicles (AGVs) are an important subspecies of robot that can navigate factory floors to move material under their own control, using sensors to find their way and avoid obstacles. The good news is that work on developing self-driving cars is advancing the state-of-the-art in key concepts such as simultaneous location and mapping, as well as encouraging the development of more sophisticated sensing technologies such as time-of-flight sensors and LiDAR.

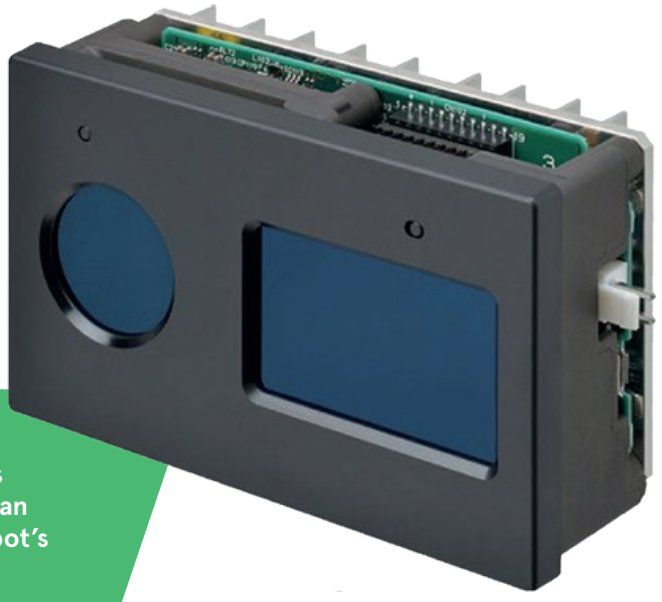
The slightly less good news is that a lack of standards is making it more difficult to manage a fleet of AGVs from multiple manufacturers as a group.

ENABLING TECHNOLOGIES

As the AGV example illustrates, one of the key enabling technologies for future robotics will be standards that bring a common approach to key development issues such as programming, communications, and co-working.

There are already efforts to achieve this – the open-source Robot Operating System (ROS) is a collection of tools, libraries, and conventions, popular with individuals and academics, to create complex and robust robot behaviours on a wide variety of robotic platforms.

The ROS justifies the project like this: "Why? Because creating truly robust, general-purpose robot software is hard. From the robot's perspective, problems that seem trivial to humans often vary wildly between instances of tasks and environments. Dealing with these variations is so hard that no single individual, laboratory, or institution can hope to do it on their own. As a result, ROS was built from the ground up to encourage collaborative robotics software development."



OMRON EMC's B5L sensor

'The other major category of enabling technology is sensors, which can do everything from monitoring an AGV's battery status to helping microposition a robot's manipulator so that it can pick up a component.'

The other major category of enabling technology is sensors, which can do everything from monitoring an AGV's battery status to helping microposition a robot's manipulator so that it can pick up a component. Such sensors need to be robust, highly accurate, have long operating lifetimes, and produce consistent results in rapidly changing environmental conditions.

For example, the authors of the MIT report found that some sophisticated robot vision systems worked well in lab conditions but failed in the varying lighting of a real production line.

One response to this could be to use infrared time-of-flight sensors, such as OMRON EMC's B5L sensor (above), to measure distances to objects to create 3D models of their position in space. The sensor is designed to reject the effects of varying ambient light and is protected against mutual interference so that up to 17 of the units can share a working environment.

As previously discussed, though, better sensors are only valuable if they are backed up by a communications, computing and decision-making infrastructure that can absorb, analyse, and act fast enough to deliver some practical advantage in the way that the robot operates.

Conclusion

Industrial robotics has a long history of successful application, especially in the car industry. But it still faces some of the same issues it has always had, such as understanding the position of objects in space, and programming them to manipulate those objects at a distance. Although there are pathways and strategies for wider application of robotics, turning them into a reality will involve sorting out a lot of details on multiple fronts.

Murata

6-DOF XYZ-AXIS GYROSCOPE AND XYZ-AXIS ACCELEROMETER WITH DIGITAL SPI INTERFACE

Murata offers MEMS-based inertial sensor with digital SPI interface for high-precision industrial machine control and GNSS positioning support. An accelerometer is used to measure the angle of inclination relative to the centre of the earth and a gyroscope is used to measure the speed that the angle changes. The product delivers the highest performance available on the component level in key parameters like bias stability and noise.

FEATURES

- Single package 6DOF component
- Cross-axis calibration enables better than 0.14° orthogonality error
- Gyro bias instability down to 1°/h level
- Gyro noise density level 0.0015°/s/√Hz
- Stable offset and sensitivity over full temperature range
- Excellent linearity and vibration performance
- Extensive self-diagnostics features
- ±300°/s angular rate measurement range
- ±6g acceleration measurement range
- −40°C ~ +110°C operating temperature range
- 3.0V ~ 3.6V supply voltage
- RoHS compliant robust SOIC housing component size: 19.71mm x 12.15mm x 4.6mm (l × w × h), 32 pins
- Can be used in safety critical applications

APPLICATIONS

SCHA63T is targeted at applications demanding high performance with tough environmental requirements.

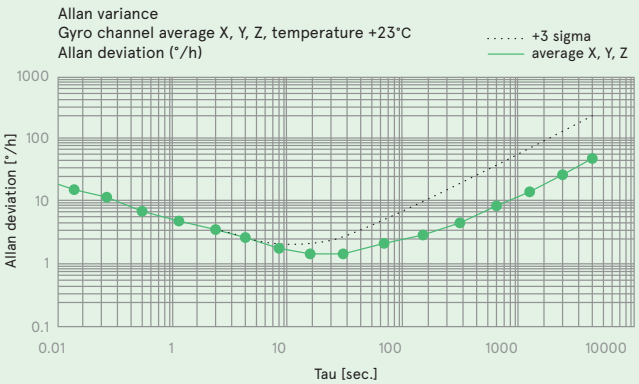
Typical applications include:

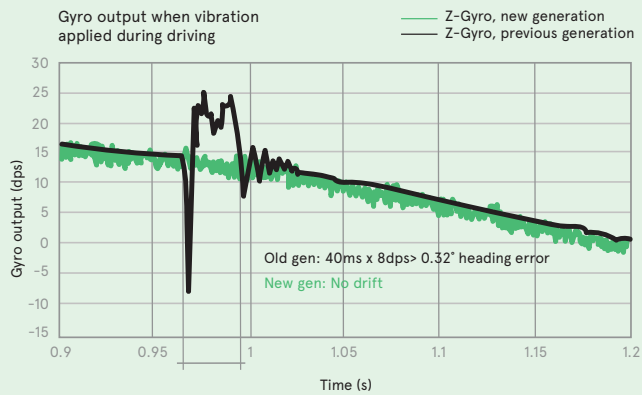
- Inertial Measurement Units (IMUs)
- Navigation and positioning
- Machine control and guidance
- Dynamic inclination
- Robotic control and UAVs

SIZE
19.71 X 12.15 X 4.6MM

PRODUCT TYPE	Ω XYZ	ACC XYZ
SCHA63T-K03	±300 °/s	±6g

MEASUREMENT CHARACTERISTICS	Ω XYZ	ACC XYZ
Range	±300°/s	±6g
User selectable low pass filter	13, 20, 46 or 300Hz	13, 20, 46 or 300Hz
Sensitivity (Typ)	80LSB/°/s	4905LSB/g
Offset temperature dependency	(XY) ±0.65°/s (Z) ±0.85°/s	±7.3mg
Noise density (Typ, 13Hz filter)	0.0015 °/s/ √Hz	59.5mg/√Hz





muRata
INNOVATOR IN ELECTRONICS

For more information visit avnet-abacus.eu/murata

FEEDING THE WORLD WITH SMART AGRICULTURE

The world of agriculture is facing a daunting array of challenges with the global population predicted to reach nearly 10 billion by the middle of the 21st century. Agriculture must compete for land, as the growing population results in increased urbanisation, and the search for renewable energy sources will see farmland taken over by solar and wind energy infrastructure.

PRODUCING MORE WITH LESS

Therefore, farmers are looking for ways to increase food production while using less land and fewer resources. However, agriculture has always been an innovative industry, and it is quick to adopt the latest technology. The need to produce more food for the growing population is being met by the latest developments in high-speed communication, which are delivering new solutions for farmers.

THE LATEST TECHNOLOGY

The introduction of 5G communications has huge potential for use in industry. The capabilities of 5G mean that it provides a powerful tool for the agricultural industry. Not only does 5G compete with the speed of wired alternatives, but it can also connect rural areas that have traditionally not had access to high-speed communications.

THE SMART FARM

This has enabled the creation of smart or precision farming. 5G communications provide connectivity across the large areas covered by the smart farm, allowing even its farthest reaches to be integrated into a unified network. This network encompasses the latest sensor, computing, and connectivity technologies, and uses data to enable farmers to maximise their yield.

The data collected is being used to help decide strategy. Studying soil conditions or monitoring the health of livestock allows the farmer to manage the best use of resources to ensure the greatest productivity. New technology is therefore vital to manage this information. Modern electronics offer reduced size, lower production costs, and efficient power consumption, and make it possible to deploy sensors and connected devices even in the remotest areas.

A TOUGH ENVIRONMENT

This new technology will be used in a variety of applications, including static sensors and the latest heavy machinery. Farming is a tough business, and equipment must be able to resist all extremes of weather. A wide range of temperature, moisture, and prolonged exposure to sunlight means that agricultural equipment must be designed with care.

RF COMMUNICATIONS

RF or radiofrequency communication is at the heart of many of these innovations. In the current age of digital technology, it is easy to forget that wireless systems still depend on high-frequency radio transmitters and receivers to communicate. With the latest equipment sending data at staggering speeds and volumes, designers depend on high-performance RF connectors.

THE MOLEX ADVANTAGE

Molex has many decades of experience manufacturing complete solutions for RF applications. Embracing the latest 5G technology and designed for superior signal integrity, Molex cables and connectors are available for frequencies up to 65GHz, even in the tough conditions found in the agricultural industry. Partnered with Avnet's global reach, Molex is an innovation leader in the smart agriculture industry, providing connectivity solutions for tomorrow's farmers.

To learn more, please visit **avnet-abacus.eu/molex**

When your next tractor is a Tesla

Image ref: https://www.deere.co.uk/en/agriculture/future-of-farming/

Alessandro Mastellari

Technical Specialist Wireless & Sensors,
Avnet Abacus

'The promise of lower energy costs, increased productivity and greater reliability, and the pressure from emissions regulation, is driving rapid innovation in many forms of NRMM.'

The automotive industry is rapidly shifting toward Electric Vehicles (EVs), but there's another category of vehicles ripe for electrification: 'Non-Road Mobile Machinery' (NRMM), as the regulators put it. This category includes tractors and other agricultural equipment; municipal and property maintenance equipment; materials and goods handling and transportation; and construction forestry and mining equipment.

Electrifying these vehicles will be challenging, because they have more varied duty cycles than road EVs, more complex mechanical requirements, and often need much more power than even the fastest electric sports car. Nonetheless, the promise of lower energy costs, increased productivity and greater reliability, and the pressure from emissions regulation, is driving rapid innovation in many forms of NRMM.

When your next tractor is a Tesla

The pollution and climate imperative

The EU began regulating the emissions of NRMM in 1997, addressing the pollution caused by powered garden tools, agricultural and farming machinery, trains, inland waterway vessels, and construction machinery. The EU's legislation has evolved since then, with its most recent form, Stage V, calling for equipment being sold now to produce 97% fewer particulates than similar equipment produced back in 1997, and 94% less nitrous oxide and hydrocarbon emissions.

Achieving these standards will mean that non-road engines will have to be fitted with mitigation technologies including diesel oxidation catalysts, diesel particulate filters, exhaust gas recirculation systems, and common-rail fuel injection. Engines of more than 56kW will also need selective catalytic reduction modules to cut nitrous oxide emissions.

These systems will be complex to implement and may limit the utility of the vehicles to which they are fitted. Some observers also argue that, because the regulations do not explicitly address carbon dioxide emissions, there could be unhealthy trade-offs between reducing air pollutants and minimising greenhouse gas emissions during the vehicle design process. The pace at which the regulations will be applied also means that some highly polluting NRMM engines may remain in service into the 2030s.

Opportunities for electrifying agriculture

One response to these regulations is the electrification of agricultural equipment. A 2017 article for Rural Engineering, carried out by a team from the Universidade Federal de Lavras (UFLA) in Brazil, reviewed current research on what it will take.

It argued that because tractors sometimes need to deliver very high levels of torque, especially when using accessories such as ploughs, they are often over-specified for day-to-day duties. This reduces their day-to-day efficiency, as well as making them more difficult to electrify.

However, it should be possible to build smaller tractors that can operate for an eight-hour workday from a single battery charge. The transition from Internal Combustion Engine (ICE) to Electric Motor (EM) drive will also give designers an opportunity to change tractor drivetrains. A first step would be to implement mild hybrid systems, in which an EM provides low-speed traction and contributes additional torque when the ICE needs it.

There is also an argument for installing super capacitors alongside rechargeable batteries in these vehicles to provide short periods of very high current delivery when the EMs need to deliver very high levels of torque. The drawbacks of this approach include the relatively low energy density of super capacitors, their size, and cost. On the other hand, their robust ability to store and discharge energy should reduce stress on the batteries and so extend their operating lifetimes.

The electrification of agricultural machinery faces the same battery energy density and cost issues as the car industry. There's another challenge, too; that of delivering large amounts of charging power in a rural setting. The obvious (but costly) response is to use photovoltaic panels and storage batteries to build up reserves of energy during the operating day that can recharge vehicle batteries overnight.

This would demand sophisticated controllers to make the most of the sun's energy, as well as efficient power electronics to charge the vehicle batteries.

A hybrid experiment

A team from the University of Padua, Italy, and the agricultural equipment maker Carraro Agritalia, undertook a feasibility study in 2019 on building electric versions of the small tractors used in orchards and vineyards. One reason for the study was that the additional emissions control systems demanded by Stage V NRMM regulations might take up so much space that even small tractors could not work in narrow orchard rows.

The team decided on a mild hybrid architecture so the tractor could handle both light and heavy-duty working. They reworked an 82kW ICE tractor design, downsizing the engine to 56kW and adding a 20KW electric motor. The two power plants are linked in a parallel hybrid powertrain, with an additional clutch so the ICE can be decoupled for pure electric working. Their study showed that in hybrid operation mode, the electric motor could make up for the loss of torque caused by downsizing the ICE. It also found that the electric motor could be used on its own for light duties, including pulling a heavy trailer at a constant low speed during harvesting.

The team proposed an electric motor design to suit their hybrid and noted that the motor controller circuitry would have to manage both the high currents needed to produce the motor's peak torque, and the dynamics of servicing demands for instantaneous torque.

Carraro is now developing this work. Its webpage details a tractor with a mild hybrid powertrain that uses a 55kW ICE, a 20kW electric motor, and a 25kWh LiFePO4 battery pack. Shifting to the smaller ICE avoids the need to install the extra catalytic converter required by Stage V NRMM regulations for larger engines, saving space and reducing costs.

The Carraro mild hybrid also employs the company's eTCH90 Long Drop torque-converter based, full-powershift transmission, which it has designed for use in a wide variety of hybrid and full-electric vehicles. Carraro says its hybrid system will cut fuel use and emissions, reduce maintenance costs due to less use of the ICE, and cut noise and vibrations.

'There is also an argument for installing super capacitors alongside rechargeable batteries in these vehicles to provide short periods of very high current delivery when the EMs need to deliver very high levels of torque.'

'Carraro says its hybrid system will cut fuel use and emissions, reduce maintenance costs due to less use of the ICE, and cut noise and vibrations.'

When your next tractor is a Tesla

Beyond electric agriculture

The tractor example serves as a good model for what is happening in other areas of the NRMM market. Innovation is being driven by both opportunity and regulation: for example, some construction equipment makers are moving to electric power because cities are declaring themselves emission-free zones, in which traditional equipment cannot operate.

A lot of manufacturers are beginning by substituting EMs for ICEs or developing hybrid versions of their most compact machinery. Many innovators are challenged by the rapidly changing duty cycles of NRMM. A digger might travel at low power to an operating site, use a lot of power to lift and move material, and then could recover energy as its bucket returns to rest. The digger may also have to provide mechanical power to drive auxiliary equipment and pumps to drive hydraulics, each with their own duty cycles. The complexity of the aggregate duty cycle makes it more difficult to correctly dimension power units to provide the power and torque necessary to do the job, and to control the resultant system for optimal efficiency.

The energy storage challenge of EVs is leading to extensive innovation in equipment architectures. For example, some manufacturers are building equipment with hot-swappable battery packs. Others are considering integrating energy-storage solutions such as super capacitors and hydraulic accumulators into their designs. It is also worth remembering that there is a whole class of tethered NRMM vehicle, such as the articulated loaders used in underground mining to avoid polluting the air, which are permanently connected to grid power or work with a combination of grid and battery power for greater flexibility.

Tethering equipment might demand a change in working practices, but it provides a new degree of design freedom for those who are prepared to use electrification as an opportunity for a radical rethink of their offerings.

A paper in the journal Energies, published in 2021, found extensive innovation in other areas of the NRMM sector, including street sweepers, refuse trucks, heavy-duty forklifts, excavators, road rollers, loaders, materials handlers, and towing tractors, among others. Although the challenge of full electrification is large in many of these cases, this rapid burst of innovation, coupled with the opportunity to use the evolutionary pressure to rethink product offerings, should see electrification spread rapidly beyond the highway.

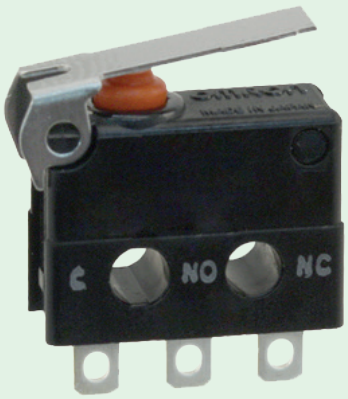
'Although the challenge of full electrification is large in many of these cases, this rapid burst of innovation, coupled with the opportunity to use the evolutionary pressure to rethink product offerings, should see electrification spread rapidly beyond the highway.'

OMRON D2JW sealed subminiature basic switch

OMRON

The OMRON D2JW is an ultra-small and highly sealed microswitch featuring a gold-alloy crossbar contact and coil spring that offer long durability and high contact reliability. It has a wide operating temperature ranging from -40°C to +85°C. Its degree of protection conforms to JIS waterproof standard and IEC IP67 (excluding the terminals in terminal models).

The D2JW is suited for applications where high level of repeat accuracy is required, such as industrial machinery and IIoT.



OMRON D2JW sealed subminiature basic switch

FEATURES

- Conforms to JIS waterproof standard and IEC IP67 (excluding the terminals in terminal models)
- Wide operating temperature from -40°C to +85°C
- Gold-alloy crossbar contact and coil spring offer long durability and high contact reliability

APPLICATIONS

- Industrial machinery
- Industrial IoT

OMRON G8N PCB automotive relay

The OMRON G8N is an ultra-miniature automotive PCB relay with a super-slim width (7.2mm) which enables high-density design. Despite its small size, the G8N is capable of high-wattage switching due to the contact and heat-release design. This relay has a durability of around 100,000 operations at 14VDC/25A (motor lock).

The G8N is ideal for application in DC motor control for automobile parts (door lock motor, power window motor, wiper control, etc.) and flasher lamps (indicator or hazard).

OMRON G8N PCB automotive relay

FEATURES

- Super-slim width (7.2mm) enabling high-density design
- High-wattage switching
- Around 100,000 operations at 14VDC/25A (motor lock)

APPLICATIONS

- DC motor control for automobile parts (door lock motor, power window motor, wiper control, etc.)
- Flasher lamps (indicator or hazard)

For more information and to download the white paper visit avnet-abacus.eu/omron

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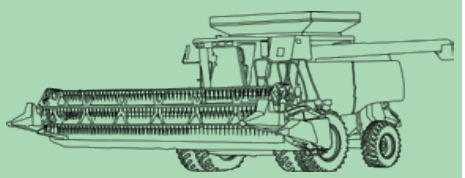
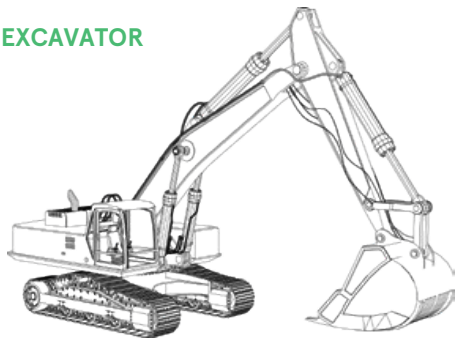
APPLICATIONS

- User interface controls
- Rotary angle position sensor
- Transmission speed and position sensor
- Brake and clutch pedal position sensor
- Pinned joint angle sensor

COMBINE



EXCAVATOR



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Engineering better railways

'For engineers, the complexity of the global rail market, and the wide array of technologies that enable it, means that there will be opportunities to innovate to achieve greater efficiency and lower emissions for decades to come.'

Philip Lechner

Technicial Specialist Power, Avnet Abacus

The pressure to decarbonise the economy affects every aspect of our lives, from what we eat to how we travel. It is driving innovation throughout the transport sector, and particularly in railways which, despite being one of the least polluting ways of travelling in terms of carbon dioxide equivalent (CO_2e) emissions per passenger mile, provide so much travel that their impact is significant.

For engineers, the complexity of the global rail market, and the wide array of technologies that enable it, means that there will be opportunities to innovate to achieve greater efficiency and lower emissions for decades to come.

The decarbonisation imperative

Why is decarbonising railways so important? According to the UK's Office of Rail and Road, in 2019 – 2020, UK passenger trains consumed 4186 million kWh of electricity, up 5.3% on 2018 – 2019, and 476 million litres of diesel, up 1.5% on 2018 – 2019. This upward trend was matched by rising passenger numbers, which therefore drove emissions per passenger kilometre down to 35.1g, 4.9% less than in 2018 – 2019. Aggregate CO_2e emissions for electric and diesel passenger trains were 2400 ktonne, 2.7% down on 2018 – 2019.

Engineering better railways

What's striking about these numbers is the impact that a 1% improvement in the efficiency with which energy is converted into passenger miles would have, saving almost 4.2 millionkWh of electricity, almost 5 million litres of diesel, and 2.4 ktonne of CO_2e emissions.

One of the main ways in which this sort of efficiency gain is going to be achieved, at least at the macro scale, is through electrification of the UK's railways. In a 2020 plan for decarbonising train traction in the UK, Network Rail, which manages the UK's rail infrastructure, said that of the 15,400km of UK rail which is as yet un-electrified, 11,700km should be electrified. Of the balance, 900km should be served by hydrogen-powered trains and 400km with battery-powered trains. The right technology for the remaining 2,400km of line is yet to be finalised, but the report suggested a further 1,340km of electrification, 400km of hydrogen-powered trains, and 400km of battery trains. A technology choice for the remaining 260km has yet to be made.

If this plan is implemented, up to 96% of passenger kilometres will be served with electric traction and 4% with hydrogen and battery units. For freight transport, around 90% of freight kilometres will be powered electrically, with the rest using diesel or other forms of traction.

Bridging the gap with batteries

Full electrification of the UK's rail networks will take decades, during which train operators will have to work with partially electrified networks. One way of doing so will be to use battery-powered or battery-enhanced trains, an idea that has already attracted both start-ups and established train manufacturers.

Recent start-up Vivarail, based in Southam, Warwickshire, has developed a battery-powered train for use on metro, commuter, and regional services. It's enabled by one of a set of technologies with which Vivarail says it can build new battery-powered trains, convert existing diesel trains, or add batteries to electric trains to extend their range. Vivarail has battery and hybrid trains in service, and one of the variants has a range of 60 miles on batteries alone. Vivarail has also built a charging system, consisting of a large battery bank trickle-charged by grid or green electricity and an under-train shoe-and-rail connection system. It claims this can recharge a train's batteries in ten minutes.

Hitachi Rail is developing electric trains that can draw power from overhead wires for both traction and battery charging, and then switch to battery-only operation in areas where it is not possible or cost-effective to install the overhead power infrastructure. The company is also suggesting using batteries to replace some of the diesel power units on its current or future intercity trains, reducing fuel costs by up to 30% and enabling the trains to enter non-electrified stations in battery mode, creating a quieter, cleaner passenger experience.

Hitachi ABB Power Grids is supporting Hitachi Rail's initiative by providing modular, containerised charging substations that can be distributed along popular routes to provide regular top-up charging. It is already using a similar approach for e-buses, for example on the route between Geneva airport and the suburbs. Here, the company has installed 'flash' charging stations at 13 of the route's 50 bus stops. When an e-bus arrives at a charging stop, it connects to an overhead gantry and then charges for 20s at 600kW. CAF Power & Automation has developed and installed a similar system in Seville, Spain, fast-charging trams via an overhead pantograph that connects with a charging system while stationary at the terminus.

For rail, a similar system will take power from the national grid, convert it to 25kV and deliver it to a short section of overhead wires, through which the train can get a high-power flash charge for a few seconds.

The conversion challenge

As with a lot of e-Mobility solutions, the efficiency with which power is converted between forms in electric trains will be critical to reducing their effect on the planet. If you consider that the energy for an electric railway may be distributed from the power station at 400kV, and yet passengers expect to charge their phones from a 5V onboard USB port, there's potential for many lossy conversion stages between the two voltage levels.

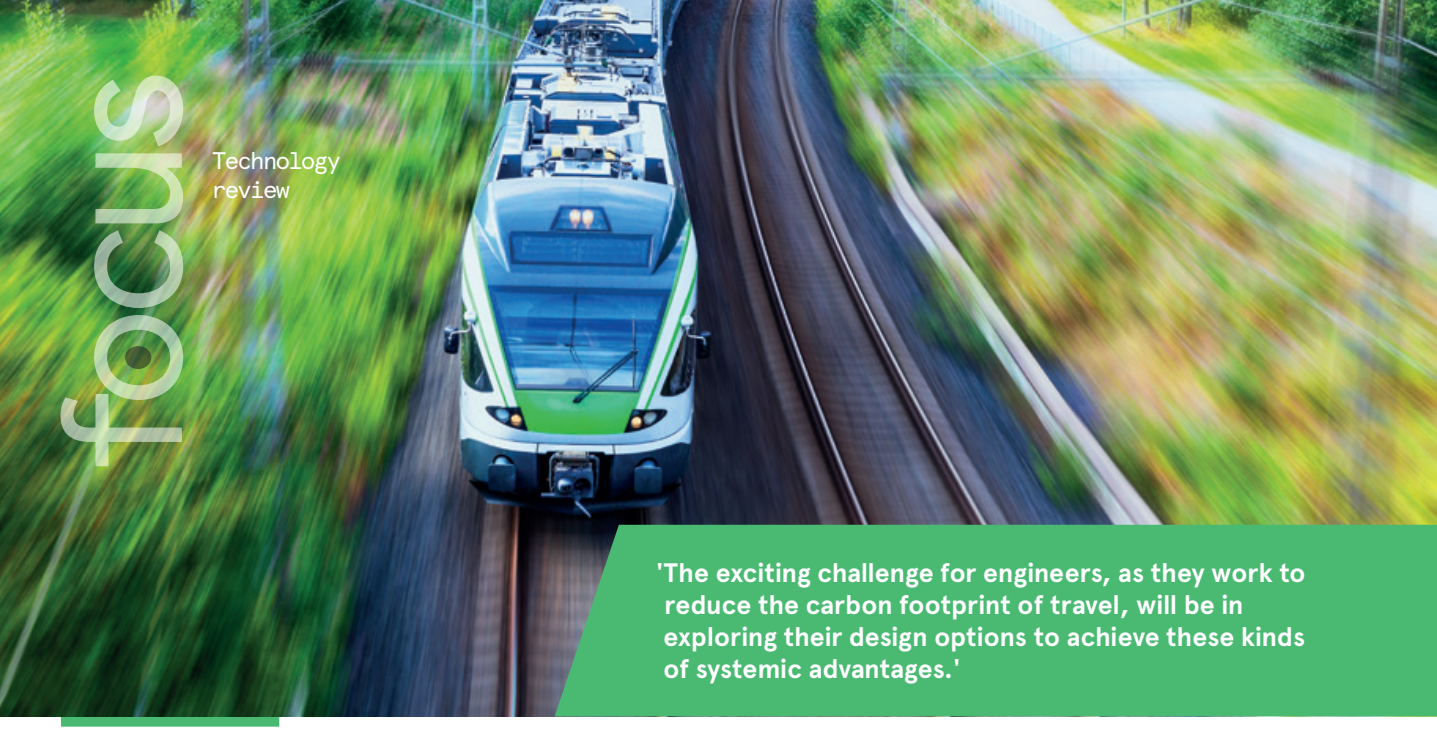
This concern is not unique to electric railways. DC-DC converter makers and the semiconductor companies that provide them with switching devices are constantly developing their circuitry and device architectures to achieve greater conversion efficiency. What makes this more difficult for companies serving the rail sector is the challenging environments in which they work, and the expectations of very long operating lifetimes.

Electronics for rail applications must survive environments that expose them to pollution and salt mist, wide temperature swings (–40 to +85°C) and high humidity, as well as extreme shock and vibration. They are also expected to be resistant to fire and smoke and protected against interruptions, variations, and reversals of their supply voltage.

'As with a lot of e-Mobility solutions, the efficiency with which power is converted between forms in electric trains will be critical to reducing their effect on the planet.'

Many of these requirements are set out in strict standards, which can only be met through good engineering coupled with extensive electrical and environmental testing.

Applications for DC-DC converters for the rail industry tend to be split into trackside usages and on-train applications.



'The exciting challenge for engineers, as they work to reduce the carbon footprint of travel, will be in exploring their design options to achieve these kinds of systemic advantages.'

Engineering better railways

Trackside uses can include railway signalling control and enabling communications infrastructure. On-train applications may include traction, braking and lubrication system control; safety systems such as door control, fire control, signage, and CCTV; and passenger comfort features such as lighting, infotainment, and heating and ventilation systems.

On-board mount low voltage DC-DC converter modules are often potted, for protection against dust and moisture ingress, and may also have an embedded heatsink to conduct excess thermal energy away from the embedded converter circuitry to enable effective cooling. They're supplied in standard formats that are widely used in the rail industry, such as what is known as a 'half-, quarter- or eight-brick' package.

Switching to silicon carbide

Most railway high voltage traction driver modules rely on silicon IGBTs, diodes and MOSFETs. But as efficient energy usage becomes increasingly important, some manufacturers are experimenting with using Silicon Carbide (SiC) devices instead. These devices can switch more quickly than silicon devices, which means that resonant parts of power-conversion circuits, such as coils, can be smaller. They also work at temperatures that would destroy a silicon device, allowing them to handle more power or use less cooling.

CAF Power & Automation, based in the Basque Country, is developing an electric traction power system using SiC devices, which it claims could provide energy savings of up to 15%, compared with conventional approaches. The train maker is working with the IKERLAN technology centre and Euskotren, a local public -transport operator, to develop and try out the technology.

CAF claims that using SiC will reduce losses in the traction converter alone by 70% and allow high switching speeds for greater efficiency. It will also support much higher operating temperatures than silicon and can dissipate that heat more quickly because it's a thermal conductivity that is three times higher than that of silicon. This helps simplify the cooling regime, and so contributes to reducing the volume and mass of the overall traction solution by 25%. This, in turn, makes the trains quieter, improving passenger comfort.

The work on this development has been underway since 2016 as part of a European Horizon 2020 research project, funded by the EU. The prior version of the traction system used a Si IGBT inverter and SiC diodes, demonstrating new technologies can be taken up incrementally and contribute significantly to the rail industry.

Innovation in the rail industry will be full of this sort of systemic optimisation opportunity, in which an improvement in one narrow aspect of a train's design will lead to advantages in other aspects. The exciting challenge for engineers, as they work to reduce the carbon footprint of travel, will be in exploring their design options to achieve these kinds of systemic advantages.

Hirose DF50/DF50A series, 1mm pitch, wire-to-board connector with a robust lock

Hirose

The low profile and robust connector is designed with surface mount contacts and a pitch of 1mm, which allows for maximum space saving on the board, reducing the mounting area needed.

In addition, the metal lock provides a consistent and positive tactile click with repetitive mating; this ensures the connector is fully engaged guaranteeing complete electrical and mechanical connection. The lock is located at the centre of the connector to avoid uneven locking and cable entanglement.

Single and double row versions are available in vertical and horizontal variations to give design flexibility.

Suitable applications are LCD displays, wireless LAN, industrial controller units, office equipment, car navigation, car audio, POS terminals, desk phones and amusement equipment.

FEATURES

- Pitch: 1mm
- Rated current: 1A
- Rated voltage: AC/DC 100V
- Operating temperature: -35°C to +85°C
- Contact positions: 2 to 16 (DF50A single-row) - 7, 9, 11, 13, 14, 15 (DF50A vertical type only)
- Contact positions: 20, 30, 40, 50 (DF50 double-row)
- Mating cycles: 30
- Termination AWG: 26 to 32
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Technology Interview

The exciting developments in smart batteries that are energising industrial e-Mobility markets

e-Mobility offers exciting opportunities for the future, not only for cleaner and more sustainable personal and public transport but also in a multitude of industrial applications such as mobile robots including Automated Guided Vehicles (AGVs) and drones. Here, Hagen Götze, Senior Director Marketing at Avnet Abacus, chats with Marc Eichhorn, Product Marketing Manager for Batteries, about how the latest developments in batteries are helping to make it happen.

Hagen Götze: *We are receiving increasing enquiries from customers that have imminent applications in many diverse markets such as warehouse automation, smart farming, professional lawn mowers, underwater exploration etc. which, we believe, is generally due to demands for more efficient supply chains, greater productivity and environmental concerns. The COVID situation, also, has focused attention on increasing automation.*

Marc Eichhorn: *Yes, with regard to warehouse automation in particular the AGV market is predicted to grow by over 31% CAGR over the next five years, to more than US$13 billion. With the latest connectivity technologies and the ability to store and analyse big data, these vehicles offer tremendous opportunities to streamline and optimise processes. In addition, there have been some important advancements in battery technology that enhance cost-effectiveness and usability.*

HG: *Historically, lead-acid batteries have been chosen to power a wide variety of small electric vehicles, like golf carts and forklifts. What's changing?*

ME: *Indeed, lead-acid is tried and tested and still offers a satisfactory solution in many cases. In particular, the cost is lower than alternatives such as lithium batteries and they are thermally stable. However, for new applications, or first-time electrification, lithium is usually the way to go and allows an extended operating envelope and lower cost of ownership. The energy density and cycle life are significantly greater, while weight is lower. Protection circuitry, of course, is mandatory, although smart functionality such as communication and system management are usually built-in too.*

HG: *Can you comment on the best lithium chemistries for e-Mobility?*

ME: *There are two main lithium technologies for e-Mobility applications: Lithium-Nickel-Manganese-Cobalt-Oxide (NMC), which is also widely used in consumer devices and power tools, and Lithium-Iron-Phosphate (LiFePO4). While NMC offers the highest energy density of the two, LiFePO4 batteries can deliver four-to-10 times the cycle life, so selection depends on performance priorities.*

HG: *What other factors should be considered?*

ME: *Whether to choose an off-the-shelf battery or bring up a custom design can have a major effect on the project outcome. A custom battery can be designed to provide a specific voltage or conform to a certain physical shape or dimensions. On the other hand, there are Non-Recurring Engineering (NRE) costs and product-approval costs to consider. In addition, the whole process can be a distraction for the design team; if your organisation's expertise is in, say, precision agriculture or materials management, you want to focus on your special competencies or market-specific IP that will make your end product stand out against the competition.*

HG: *So, an off-the-shelf battery is probably the fastest to market and fastest to revenue, and the most cost-effective?*

ME: *In most cases, yes. Also, you will be able to get samples immediately from stock and a matched charger that will work out of the box. I'm excited that VARTA has recently introduced two families of off-the-shelf batteries that cater for emerging e-Mobility applications very well. These Application-Specific Battery (ASB) families are available in both Li-ion and LiFePO4 chemistries and a choice of 24V and 48V nominal voltage. The Easy Block LiFePO4 family offers batteries with up to 14.5kWh capacity and cycle life up to 10,000*

cycles. The second line, Easy Blade, benefits from the greater energy density of Li-ion chemistry to offer up to 37.5kWh capacity with about 1200 cycles lifetime.

***HG:** What more can you tell us?*

***ME:** Since each is an off-the-shelf product line, they come with safety features built-in and are pre-certified according to IEC 62133-2:2017 and UN38.3. Of course, constituent cells are tested according to UL 1642. The batteries come ready to communicate with the charger using the robust CANOpen standard, which simplifies design-in.*

***HG:** What about the charger?*

***ME:** Actually, VARTA has partnered with Delta-Q to handle this. They have come up with a scalable solution based on a charger design that is supplied pre-loaded with firmware and allows stacking up to six units to address a wide range of system power requirements. It means customers can get a turnkey charger for next-day delivery if needed. As with the batteries, the charger is certified to relevant safety standards. These include UL 1564 and EN 60335.*

***HG:** And when they are out there in the field?*

***ME:** Smart batteries like VARTA ASB enable remote monitoring and predictive maintenance, which we can support through our Avnet IoTConnect cloud solutions. This also enables future business models like "battery as a service".*

***HG:** There is more to a complete electrification project than the battery. How else can Avnet Abacus help customers achieve a successful solution?*

***ME:** Key system-design challenges include suitable power switching and isolation around the battery, as well as ensuring simple and robust signal and power connections. Another of our suppliers, AVX, has a solid-state switching solution for applications up to 48V that is a perfect companion to the VARTA ASBs. The switches sit between the battery BMS system, the vehicle and the charger to provide protection and safely disconnect the battery, electronically, when needed. These switches provide much faster acting protection for the battery than conventional mechanical relays and can support smart features such as pre-charging. They can be up to 85% lighter, have much longer cycle life, and are also silent in operation.*

***HG:** You mentioned signal and power connections?*

***ME:** Yes, battery-swapping modules like Amphenol's BSM series address the challenges here. The smart features of lithium batteries call for both power and signal connections, so bringing these together in the same*

Typical application for VARTA ASB battery modules

connector saves time mating and unmating. The BSM series provides self-correction for positional deviation up to ±2mm in X and Y directions and up to ±5mm in Z axis to allow fast and secure mating. They are available in various power ratings up to 600VDC and 100A.

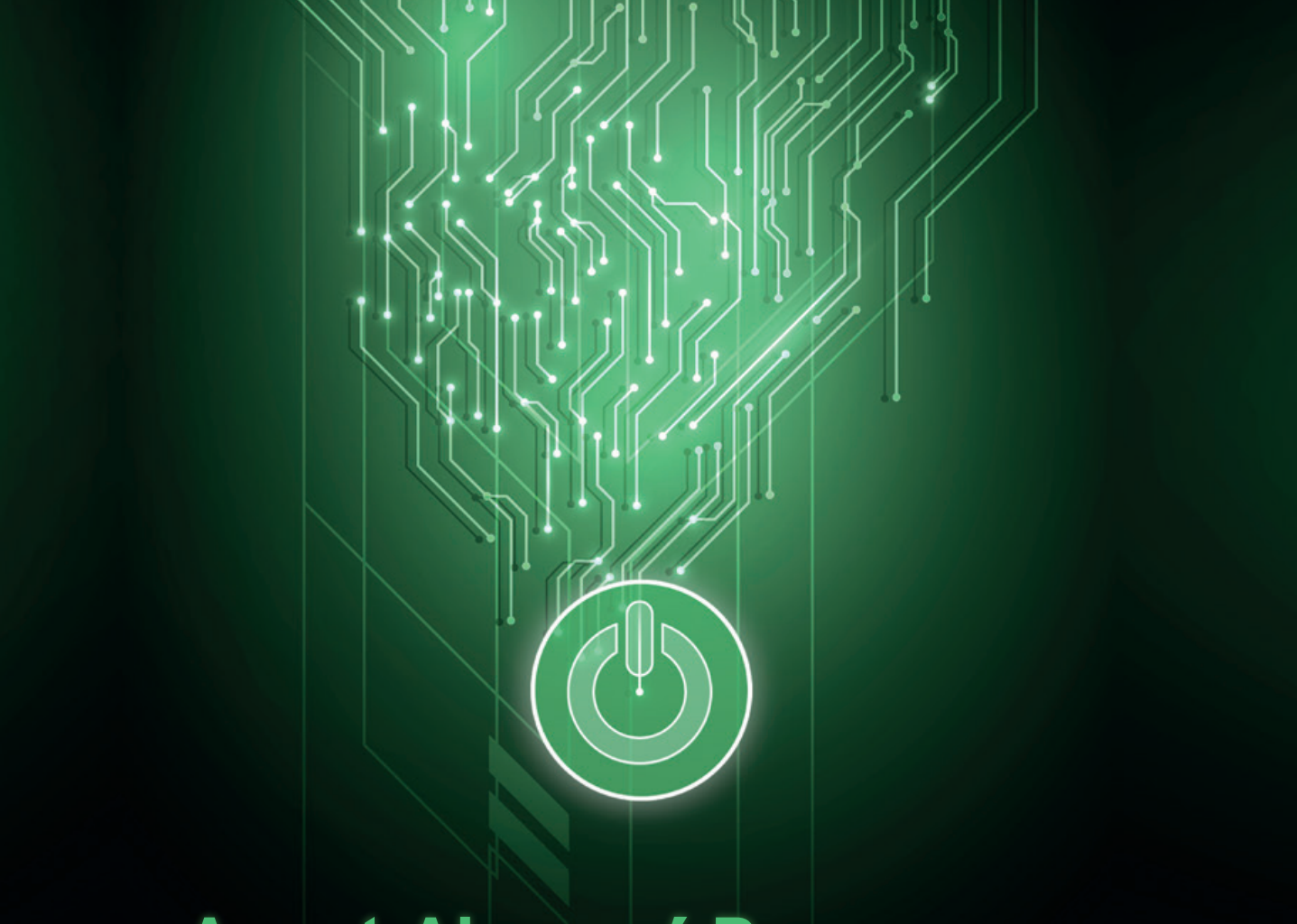
***HG:** The pace of battery-technology development is perceived as being quite slow. Is there anything new on the market to shake things up?*

***ME:** You're right, progress does often appear glacial, although there are always improvements and optimisations that draw a little more from what we've got. But now VARTA has introduced a new line of Li-ion cells that address demands for rapid recharging, which is important in e-Mobility. These cells, called V4Drive, are 21700 (21mm diameter x 70mm height) cells that fully charge in under six minutes, while keeping temperature below +35°C and ensuring stable cycle life. They are designed to absorb regenerative energy efficiently and also have excellent low-temperature performance. At least one prestige vehicle brand is working with VARTA to design these cells into next-generation road cars. They are also ideal for applications like power tools and cordless appliances.*

***HG:** And Avnet Abacus can help customers take advantage of these technologies?*

***ME:** Yes, we are ready to supply the ASB lines and associated chargers, and our engineers work with customers and VARTA to handle the design-in needs. There is plenty of reference documentation including a comprehensive technical handbook and charger design-in guide, which are available with no commitment required on the part of the customer. For the V4Drive batteries, production will ramp up in 2022 for supplying key customers, and mass-market availability will begin 2023.*

***HG:** That gives plenty to think about for upcoming e-Mobility projects. Thanks, Marc, for sharing your insights.*



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Harwin's 5 star award 2021

José Ramón Blázquez, Account Manager and Dieter Kuhn, Senior Field Application Engineer – Interconnect & Electromechanical at Avnet Abacus have received the 5 Star Award 2021 from Harwin for their exceptional contribution to the success of the Harwin line.

The award is presented to individuals and organisations who have assisted in gaining significant commercial traction for Harwin's innovative interconnect technology, creating many exciting opportunities in new applications and geographic regions.

Left to right: José Ramón Blázquez Avnet Abacus, Eneko Ansoleaga, Business Development Manager for Southern Europe at Harwin and Dieter Kuhn, Avnet Abacus

"These awards provide a great way of showing our appreciation to our channel partners. In what has been a challenging period for global supply chains, the distribution network's responsiveness and closeness to customers is more important than ever," said Andrew McQuilken, Chief Revenue Officer at Harwin.

José Ramón has played a key role in securing Harwin design wins in a variety of markets, including the increasingly vibrant electric vehicle sector. Dieter has made a significant contribution by providing technical support in a series of high-profile customer projects.

Engineers' Insight: the Avnet Abacus blog

Solving design challenges

Avnet Abacus' technical blog, Engineers' Insight, is designed to help you solve key challenges across the breadth of markets and technologies we serve.

From electronics phenomena such as equivalent series resistance in electrolytic capacitors, to discussions on the best approaches to new wireless technologies, to in-depth design guides for power solutions, this is a blog written for engineers, by engineers.

Where to read?
avnet-abacus.eu/engineers-insight

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