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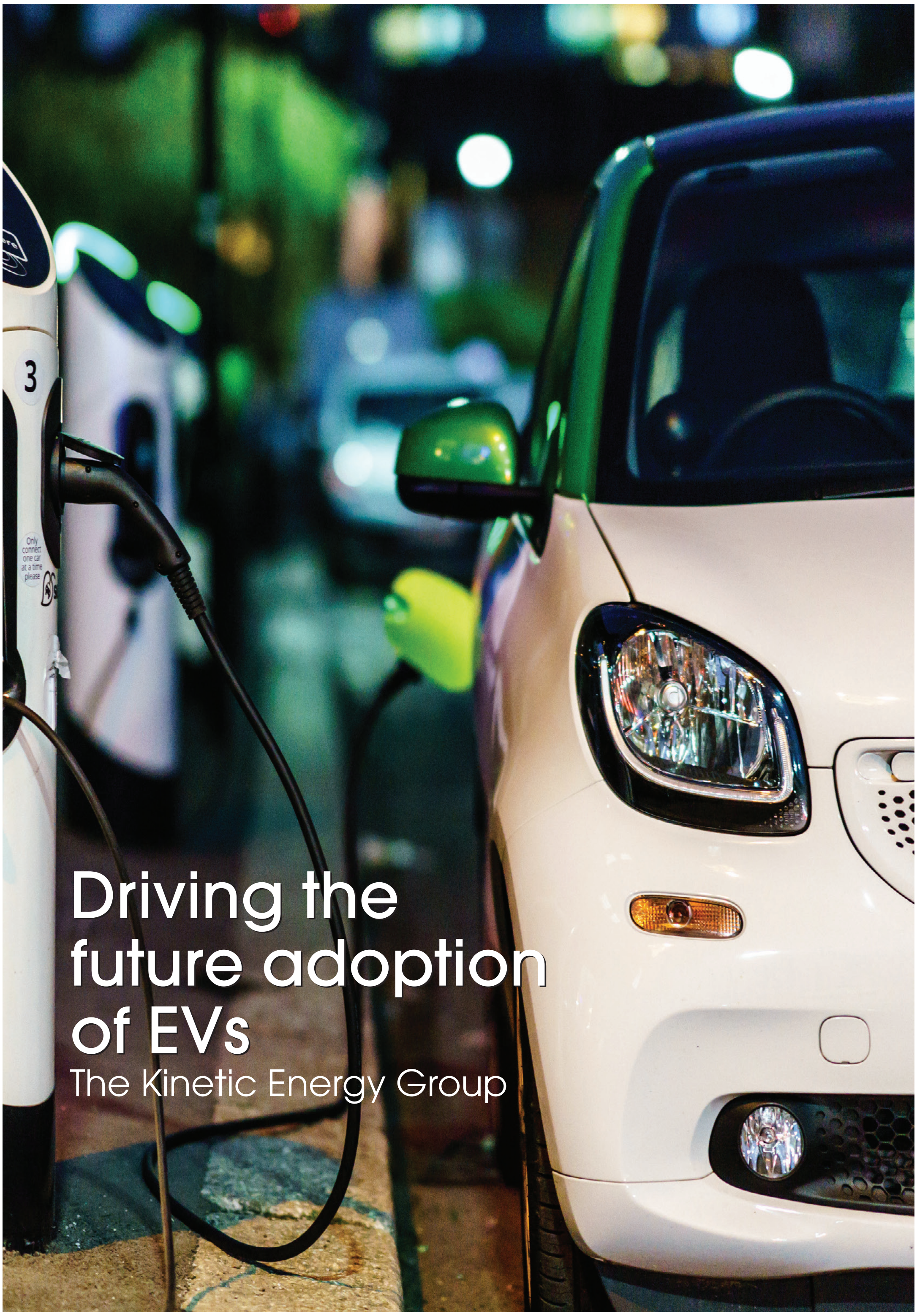
High-efficiency GaN power switching topology

GaN power ICs with integrated sensors

Are utilities ready for the V2G movement?

Will all roads eventually lead us to EVs?

Valens offers new road to in-vehicle connectivity



Driving the future adoption of EVs

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Viewpoint

By Jackie Cannon, Publisher & Editor

Power electronics to see continuing growth

IT HAS BEEN A POSITIVE YEAR for the power electronics industry and the upswing is set to continue. According to new research published by Polaris Market Research the Power Management IC (PMIC) market is anticipated to reach $58.4 billion by 2026.

Polaris suggest that the increasing demand for battery operated devices and growing penetration of electric vehicles has boosted the adoption of power management integrated circuits.

In addition, the growing need for energy efficient equipment, depleting fuel resources, and increasing need to reduce energy consumption further supports the growth of power management integrated circuits market. As importantly, the increasing adoption of energy harvesting equipment, and advancements in next generation mobile networks such as 3G, 4G, and 5G will boost market growth.

Other factors supporting market growth says Polaris include supportive government regulations, increasing awareness, and technological advancements. Increasing adoption of data centres, development of Big Data and IoT technologies, and increasing demand for consumer electronics further boosts the market growth. Power semiconductor devices are witnessing high adoption for different power applications, fuelling the growth of the market.

Prospects for power electronics manufacturers looks rosy.
In this edition of PEW, we put the spotlight on some of these growth areas. GaN Systems brings us Part III of its three-part series on GaN design tips. Gallium nitride devices are playing an increasingly significant role in automotive applications including EVs and hybrids thanks to their greater ability to handle higher breakdown voltages at greater efficiencies.

Staying with GaN, Fraunhofer IAF says that it has significantly enhanced the functionality of gallium nitride (GaN) power ICs for voltage converters by integrating current and temperature sensors onto a GaN-based chip, along with power transistors, freewheeling diodes and gate drivers. The development could pave the way for more compact and efficient on-board chargers in electric vehicles.

As mentioned EV will be another driver of this growth but like all technological innovations, EVs will come with both their challenges and opportunities. While this rise promises a positive impact on the environment, it presents somewhat of a challenge for the electricity grid. Oracle Utilities explains what this will mean for supply and demand on the energy grid.

We hope you enjoy the latest issue of PEW and if you would like to be included in the next issue please contact me.

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news

EPC launches 3rd edition of GaN textbook

EFFICIENT Power Conversion Corporation (EPC) has announced the publication of the third edition of 'GaN Transistors for Efficient Power Conversion' a textbook written by power conversion industry experts and published by John Wiley and Sons.

This textbook is designed to provide power system design engineering students, as well as practicing engineers, basic technical and application-focused information on how to design more efficient power conversion systems using GaN-based transistors.

The third edition has been substantially expanded to keep students and practicing power conversion engineers ahead of the learning curve in GaN technology advancements and emerging applications. This book serves as a practical guide for understanding basic GaN transistor construction, characteristics, and a wide range of applications. Included are; discussions on the fundamental physics of these power semiconductors; practical guidance on layout and other circuit design considerations; and application examples employing GaN including lidar for autonomous vehicles, DC-DC power conversion, RF envelope tracking used in 5G communication networks, wireless power, class-D audio, and high radiation environments.

According to Fred C. Lee, director, Centre for Power Electronics Systems at Virginia Tech, "This book is a gift to power electronics engineers. It offers a comprehensive view, from device physics, characteristics, and modeling to device and circuit layout considerations and gate drive design, with design considerations for both hard switching and soft switching. Additionally, it further illustrates the utilization of GaN in a wide range of emerging applications."

Collectively, the authors have over ninety-years of experience working in power transistor design and applications. All four authors are pioneers in the emerging GaN transistor technology, with Alex Lidow concentrating on transistor process design and Michael DeRooij, Johan Strydom and David Reusch, and John Glaser focusing on power transistor applications.

Nissan and EDF collaborate to bring smart charging solutions

NISSAN and EDF Group have signed a cooperation agreement to accelerate the delivery of electric mobility together – particularly through the smart charging of electric vehicles. This agreement applies to the United Kingdom, France, Belgium and Italy. The cooperation agreement focuses mainly on developing smart charging solutions (vehicle to grid, or V2G) by bringing together technologies developed and mastered by both companies.

Smart charging refers to technologies that optimise the charging or discharging of an electric vehicle in an efficient and cost-effective manner.
As part of the cooperation agreement, Nissan is responsible for the sale of V2G compatible electric vehicles, and EDF Group in charge of V2G charging solutions and related services.

Fundamental to Nissan's Intelligent Mobility vision is the integration of electric vehicles into society, with V2G technology offering significant benefits to electricity grids and providing new financial opportunities to businesses.
As increasing numbers of drivers and businesses make the switch to 100% electric vehicles, Nissan achieved record sales for both the Nissan LEAF and e-NV200 van in Europe last year.
EDF Group is committed to promote clean mobility for everyone, in particular by developing "smart charging" solutions with tangible benefits to customers.
These fully integrated solutions include the management of the battery's charge and discharge as well as flexibility services to the grid available through storage. They are carried by Izivia, a wholly-owned subsidiary of the EDF Group specialising in charging infrastructure, and Dreev, the newly launched EDF-NUVVE joint venture, specialising in V2G commercial solutions.

This agreement follows a previous partnership in the UK between EDF Energy and Nissan. Signed last year, the two organisations agreed to collaborate around the development of shared offerings in the areas of electric mobility, smart charging, second-life battery use, energy storage and renewable energy sources.

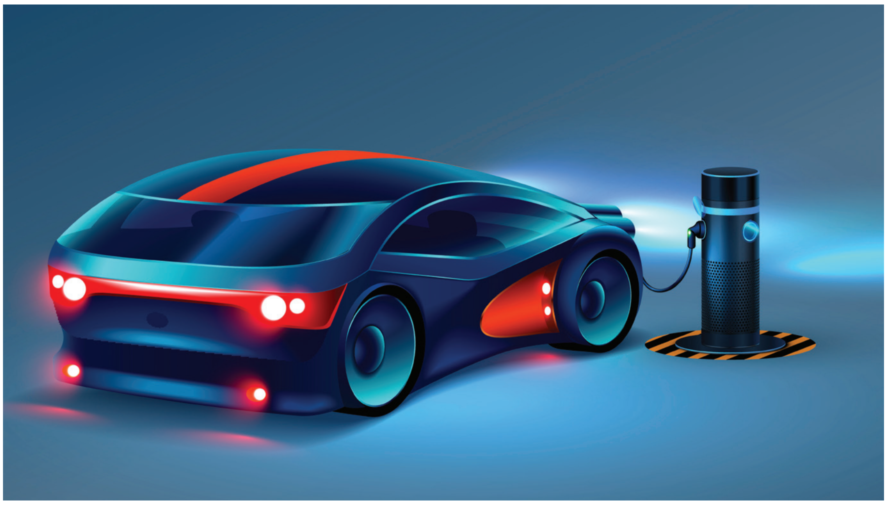
Smart charging solutions include technologies to control when vehicles charge and how quickly they power up, as well as allow the two-way flow of electricity between vehicle and charger. Thanks to V2G technologies, the energy accumulated in the batteries of electric vehicles can also be used for businesses own energy needs or the grid when required – a benefit that will become increasingly important as greater numbers of electric vehicles arrive on our roads and to help balance intermittent renewable generation.

The energy that is stored in an electric vehicle like the Nissan Leaf and e-NV200 van can be sold back to the grid by the customer, generating additional revenue to offset vehicle ownership costs.

The financial, environmental and societal benefits of V2G have made it a highly anticipated innovation in the market, but one which has not fully progressed to this point. The new collaboration between EDF Group and Nissan marks a huge step towards realising this electric future, creating a practical solution that benefits businesses and wider society alike.

Delphi and Cree partner on automotive SiC devices

DELPHI TECHNOLOGIES a provider of automotive propulsion technologies, and semiconductor firm Cree have announced a partnership to use SiC technology to enable faster, smaller, lighter and more powerful electronic systems for future electric vehicles (EV).



Cree's SiC-based MOSFET technology will be combined with Delphi Technologies' traction drive inverters, DC/DC converters and chargers to extend driving range and deliver faster charging times of EVs, while also lowering weight, conserving space and reducing cost. The Cree SiC MOSFETs will initially be used in Delphi Technologies' 800 Volt inverters for a premium global automaker. The inverters are being designed to provide vehicle engineers with additional flexibility to optimise powertrain systems.

Options include more range or a smaller battery; ultra-fast charging or smaller, lighter, cheaper cables; and greater harvesting of vehicle kinetic energy when brakinge. Production will ramp in 2022. "Delphi Technologies is committed to providing pioneering solutions to vehicle manufacturers," said Richard F Dauch, CEO of Delphi Technologies. "Our collaboration with Cree will create a significant benefit to automakers as they work to balance meeting stricter global emissions regulations with consumer appetite for electric vehicles. Overcoming driver anxiety related to electric vehicle range, charging times and cost will be a boon for the industry."

The adoption of SiC-based power solutions is rapidly growing across the automotive market as the industry seeks to accelerate its move from internal combustion engines to EVs. IHS estimates that, by 2030, 30 million high voltage electrified light vehicles will be sold representing 27% of all vehicles sold annually. Inverters are one of the highest-value electrification components and their efficiency has an industry-changing impact on many aspects of vehicle performance.

"Cree's technology is at the heart of the dramatic change underway in EVs, and we are committed to supporting the automotive industry as it transitions from silicon-based designs to more efficient, higher performing SiC solutions,"

said Gregg Lowe, CEO of Cree. "This partnership with Delphi Technologies will help drive the adoption of SiC in the automotive sector. As the world leader in SiC, Cree is continuing to expand capacity to meet market demands with our industry-leading power MOSFETs to help achieve a new, more efficient future."

Cree recently announced SiC capacity expansion to generate up to a 30-fold increase in capacity. The company offers SiC and GaN power and RF devices through its Wolfspeed business unit.

Advanced Energy completes acquisition of Artesyn Embedded Power Technologies

ADVANCED ENERGY INDUSTRIES has announced that it has completed the previously announced acquisition of Artesyn Embedded Technologies' Embedded Power business. With this highly strategic acquisition, Advanced Energy becomes a highly diversified, pure play power house with a global platform for accelerated earnings growth.

"Today marks a new chapter for Advanced Energy as we embark on the next phase of our diversification and growth strategy by adding broad sets of markets and industry-leading technologies.

With integration efforts already started, the new AE management team, with the addition of Dana Huth who leads the Artesyn Embedded Power business, is well prepared to deliver long-term, profitable and sustainable growth," said Yuval Wasserman, president and CEO of Advanced Energy.

"We are encouraged by the positive reaction to this acquisition by both the market and our customers. The added capabilities and expertise of the Artesyn team will allow AE to better meet our customers' needs," added Wasserman.

"On behalf of the entire Artesyn Embedded Power team, we are excited to be playing a key role in this new chapter for Advanced Energy," said Dana Huth. "I look forward to leading the Artesyn Embedded Power organization as together with Advanced Energy, we create a premier power conversion company developing power solutions that our customers depend on for mission-critical applications."

Bosch wins electromobility orders amounting to massive €13 billion

BOSCH has won electromobility orders worth roughly €13 billion ($14.43 billion), including production projects for electrical powertrains for passenger cars and light trucks. Thanks to these successful orders and its innovative strength, Bosch is holding its own in the currently difficult environment.

The Mobility Solutions business sector is again developing better than global automotive production in 2019. Technologically, Bosch is approaching the mobility of the future with an open mind. It is both further refining conventional powertrains and fast-tracking electrification. In addition, the company is working to make mobility automated, connected, and personalised. One key to this lies in electronics and software. The company's mobility operations currently employ some 14,000 software engineers, and annual expenditure on software expertise comes to €3 billion ($3.33 billion). The objective is to keep people mobile in an eco-friendly way and to ensure that mobility is accessible to everyone.

Bosch is leading the way in climate action, and this not only by making all its locations worldwide carbon neutral from next year. "We are also devoting ourselves to developing mobility solutions that have no appreciable impact on global warming and air quality," said Dr.Volkmar Denner, Chairman of the Bosch board of management. Each year, the company invests some €400 million ($444 million) in emissions-free mobility.

When it comes to electromobility, Bosch has a broader footprint than other companies – from bikes to trucks, and from mild 48-volt hybridization to the fully electrical powertrain. Bosch is aiming to achieve a leading position in the market with its 48-volt battery and has concluded a long-term cooperation agreement with the Chinese company Contemporary Amperex Technology Co. Limited (CATL) for the production of battery cells.
At the start of the year, Bosch forecast sales of €5 billion ($5.55 billion) by 2025 with electromobility components and systems for passenger cars and light trucks. Now it expects to exceed that figure. "Whatever the technology that brings about emissions-free mobility, we have to get the market to accept it. We will only manage that with affordable solutions. If we don't offer them, we won't help stop global warming," Denner added.

On its path to becoming the market leader in electromobility, Bosch also wants to create a mass market for fuel cells and is taking them into production.

Here, economies of scale will also help make the manufacture of this still expensive technology more cost-effective. "Bosch is making alternative powertrains affordable," Denner said.
In 2030, however, three-quarters of new vehicles will still have a conventional engine under the hood, some of them with electrical support from a 48-volt system or a plug-in hybrid. F

or this reason, Bosch is making not only the diesel engine but also the gasoline engine more efficient. Its most recent advance uses modifications to the engine and modern exhaust-gas treatment to bring particulate emissions from gasoline engines down to a level as much as 70% below the Euro 6d standard, even in real driving conditions. Bosch also wants to minimise particulate emissions from braking. Developments here include the iDisc, which generates as little as 10% of the brake dust produced by a conventional brake disc, and the regenerative braking system, which can cut brake dust by over 95% in electric vehicles.

Bosch is also posting substantial business success in automated driving. Driver assistance systems form the basis for this. In this area, Bosch will generate 12% growth this year, and sales of €2 billion ($2.22 billion). For the next levels of automated driving, Bosch will invest €4 billion ($4.4 billion) up to 2022. For the US and Asian markets, Bosch is currently developing level 2 systems that allow drivers to take their hands off the wheel on the freeway. In Germany, Bosch and Daimler were recently granted the world's first approval for a level 4 system – automated valet parking in the parking garage of the Mercedes-Benz Museum in Stuttgart. This automated valet parking service has thus progressed beyond the prototype stage. By the end of 2021, it is expected that a dozen other parking garages will be equipped with automated valet parking.

The transition in the mobility industry is giving rise to new market players. Bosch is also entering into business with these players. For example, the company is working with DiDi, Lyft, and Uber – the three biggest ride-hailing providers, who already arrange more than 50 million rides a day worldwide. DiDi, which is the leading Chinese provider of mobility services, is using Bosch's cloud-based battery services to help increase the service life of their vehicle batteries.

In the future, mobility service providers such as these will increasingly use shuttles to offer customised on-demand mobility. By 2025, it is expected that more than 2.5 million shuttles will be driving on the world's roads. With its solutions for electrification, automation, connectivity, and personalisation, Bosch wants to help these providers offer ride-hailing services featuring maximum comfort and security.

The undercarriage of such shuttles could be a rolling chassis – a ready-to-drive, modular platform that serves as a flexible basis for various bodywork designs.
In this area, Bosch entered into an alliance with the chassis and automotive specialist Benteler at the start of the year. Automobil Pininfarina will be the first customer to use the rolling chassis for its own vehicles and will also act as a reseller for the chassis.

ST to supply SiC power to Renault-Nissan-Mitsubishi

STMicroelectronics has been chosen to supply high-efficiency SiC power electronics by Renault-Nissan-Mitsubishi (Alliance) for advanced on-board chargers (OBCs) in its upcoming electric vehicles.

Renault-Nissan-Mitsubishi plans to use the new SiC power technology to build more efficient and compact high-power OBCs that will further increase attractiveness of electric vehicles for the users by cutting battery-charging time and enhancing driving range. As Renault-Nissan-Mitsubishi's chosen partner for advanced SiC technology, ST will provide design-in support to help maximise OBC performance and reliability

ST is also to supply Renault-Nissan-Mitsubishi with associated components, including standard silicon devices. The OBCs with ST's SiC are scheduled to enter volume production in 2021.
EVs need an OBC to handle charging from standard roadside charge points, when a dedicated home-charging system or super-charger is not available. The time to recharge is determined by the OBC power rating. The units in today's EVs have ratings between about 3kW and 9kW.

Renault-Nissan-Mitsubishi has already created a 22kW OBC for the Renault Zoe model, which can fully recharge the battery in about one hour. Now, by upgrading the OBC to SiC power semiconductors (MOSFETs and rectifier diodes), Renault-Nissan-Mitsubishi says it can further reduce the size, weight, and cost while increasing energy efficiency to make future models even more attractive for users and beneficial for the environment.

"As the pioneer and global leader in zero-emission electric vehicles, our objective remains to be the number one provider of mainstream mass-market and affordable EVs around the world," said Philippe Schulz, Alliance VP Design Electric and Hybrid Powertrain. "The small size, light weight, and high energy efficiency we can achieve using ST's SiC technology in our OBC, combined with the increased battery efficiency, will enable us to accelerate the adoption of electric vehicles by reducing charging times and extend the range of our EVs."

Marco Cassis, president, sales, marketing, communications and strategy development, STMicroelectronics, said, "SiC technology can help the world by reducing dependence on fossil fuels and increasing energy efficiency. ST has successfully developed manufacturing processes and established a portfolio of qualified, commercialised SiC products also in automotive-grade version.
"Building on our long cooperation, we are now working with Renault-Nissan-Mitsubishi to realise the many advantages SiC can bring to EVs. Moreover, this commitment helps ensure success by increasing the economies of scale to deliver superior-performing SiC-based circuits and systems that are also cost-effective and affordable."

New integrated point-of-load regulator for high-density applications

INFINEON has introduced the new OptiMOS IR3826(A)M integrated point-of-lo ad DC-DC voltage regulator. It is a fully integrated and highly efficient device in two versions (IR3826AM for 16 A and IR3826M for 23 A) for applications such as netcom router and switches, datacom, telecom base stations, server and enterprise storage.

The voltage regulator can operate from an input voltage of 12 V (5 V to 17 V) and provide up to 16 A or 23 A continuous current. It enables high-switching-frequency operations with enhanced efficiency and reduced power losses compared to previous generations of Infineon's offering. Furthermore, the device supports high switching frequency of up to 1.5 MHz for small PCB size and less capacitors.

Both current ratings are offered in PQFN package with 5 mm x 6 mm footprint for easy scalability. Parts are pin-compatible to the previous product offerings to allow risk-free efficiency upgrade with minimum design effort.

The IR3826(A)M solves the heat challenge without or with minimum airflow in thermally constrained application designs such us 3.3 V or 5 V supply voltages. Additionally, it supports applications that operate with high ambient temperature, e.g., 85˚C for telecom.

The state-of-the-art PWM Gen 3 engine of the devices allows operation with fixed frequency to reduce noise in multi-rail telecom or high-end Netcom applications, like base stations. The devices are fully RoHS2 compliant without an exemption to accommodate future regulations.

Everything on a single chip:

GaN power ICs with integrated sensors

Fraunhofer Institute for Applied Solid State Physics (IAF) of Freiburg, Germany says that it has significantly enhanced the functionality of gallium nitride (GaN) power ICs for voltage converters by integrating current and temperature sensors onto a GaN-based chip, along with power transistors, freewheeling diodes and gate drivers. The development could pave the way for more compact and efficient on-board chargers in electric vehicles.

FOR VEHICLES with electric drive to become a lasting presence in society, there needs to be greater flexibility in charging options, says Fraunhofer IAF. To make use of charging stations using alternating current, wall charging stations or conventional plug sockets where possible, users are dependent on on-board chargers.

As this charging technology is carried in the vehicle, it must be as small and lightweight as possible, and also cost-efficient. It therefore requires extremely compact yet efficient power electronics systems such as voltage converters.

Several components on a single chip

Fraunhofer IAF has been conducting research on monolithic integration in power electronics for several years. This requires several components such as power components, the control circuit and sensors to be combined on a single chip. The concept makes use of gallium nitride. In 2014, Fraunhofer IAF integrated intrinsic freewheeling diodes and gate drivers on a 600V-class power transistor. In 2017, a monolithic GaN half-bridge was then operated at 400V for the first time. The latest research results combine current and temperature sensors and 600V-class power transistors with intrinsic freewheeling diodes and gate drivers in a GaN power IC for the first time. As part of the project GaNIAL ('Integrated and efficient power electronics based on gallium nitride'), the researchers have provided functional verification of full functionality in a GaN power IC, achieving what is reckoned to be a breakthrough in the integration density of power electronics systems. "By additionally integrating sensors on the GaN chip, we have succeeded in significantly enhancing the functionality of our GaN technology for power electronics," says GaNIAL's project manager Dr Patrick Waltereit, deputy head of the Power Electronics business unit at Fraunhofer IAF.

The GaNIAL project is funded by Germany's Federal Ministry of Education and Research (BMBF). Since 2016, this collaboration between Fraunhofer IAF and the BMW Group, Robert Bosch GmbH, Finepower GmbH and the University of Stuttgart has been working to develop powerful, compact GaN-based components for electromobility.

Integrated sensors for direct control

Compared with conventional voltage converters, the new circuit simultaneously not only enables higher switching frequencies and a higher power density but also provides for fast and accurate condition monitoring within the chip itself. "Although the increased switching frequency of GaN-based power electronics allows for increasingly compact designs, this results in a greater requirement for their monitoring and control," says Stefan Mönch, a researcher in the Power Electronics business unit. "This means that having sensors integrated within the same chip is a considerable advantage."

Previously, current and temperature sensors were implemented externally to the GaN chip. The integrated current sensor now enables feedback-free measurement of the transistor current for closed-loop control and short-circuit protection, and saves space compared to the customary external current sensors.

The integrated temperature sensor enables direct measurement of the temperature of the power transistor, mapping this thermally critical point considerably faster and more accurately than previous external sensors, as the distance and resulting temperature difference between the sensor and the point of measurement is eliminated by the monolithic integration.

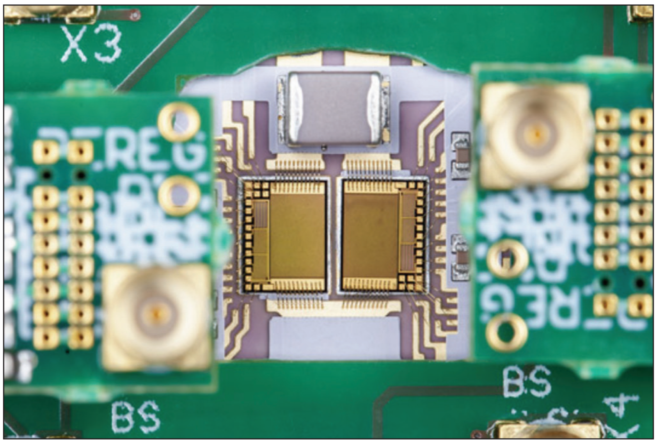
"The monolithic integration of the GaN power electronics with sensors and control circuit saves space on the chip surface, reduces the outlay on assembly and improves reliability," says Mönch, who designed the integrated circuit for the GaN chip. "For applications that require lots of very small, efficient systems to be installed in limited space, such as in electromobility, this is crucial," he adds. Measuring just 4mm x 3mm, the GaN chip is the basis for the further development of more compact on-board chargers.

Exploiting GaN's unique characteristic

For the monolithic integration, the research team utilized the gallium nitride deposited on a silicon substrate. The unique characteristic of GaN-on-Si power electronics is the lateral nature of the material: the current flows parallel to the surface of the chip, so all connections are located on the top of the chip and connected via conductor paths. This lateral structure of the GaN components allows for the monolithic integration of several components, such as transistors, drivers, diodes and sensors, on a single chip. "Gallium nitride has a further crucial market advantage compared to other wide-bandgap semiconductors, such as silicon carbide: GaN can be deposited on cost-efficient, large-area silicon substrates, making it suitable for industrial applications," says Mönch.

Radar sensors increase efficiency of production and automation

Sensors allow the automation of production and logistic processes and are consequently the foundation for effective added value. Precise sensor technology forms a cornerstone for industry 4.0. To date, radar-based sensors play a tangential role in industry. Yet, their advantages are evident: Compared to optical sensors, radar systems are unaffected by challenging visual conditions and, opposed to X-rays, they pose no threat to health. The Fraunhofer Institute for Applied Solid State Physics IAF develops compact and high-resolution radar systems, which can significantly increase the efficiency of different industrial processes. The newest technologies will be shown at Hannover Fair 2019 (Hall 2, Booth C22), from April 1-5.



GaN power ICs with integrated transistors, gate drivers, diodes and current and temperature sensors for condition monitoring.

The radar systems developed at Fraunhofer IAF work in the millimeter-wave range and are able to penetrate most non-metallic materials such as plastic, cardboard, wood, textiles or even dust, smoke and fog. They are able to precisely measure distances, spacings and speeds, even if the objects are barely visible or concealed. The scientists of Fraunhofer IAF utilize these properties of millimeter-waves to develop high-resolution radar modules for industrial sensor systems. At this year's Hannover Fair Fraunhofer IAF presents its compact W-band radar (75-110 GHz) which is able to inspect packaged goods for content and completeness remotely and in real-time. In this way, it can sort out faulty deliveries of goods before shipping and thereby minimize return flows.

Extremely precise even under challenging visual conditions

So far, mostly optical sensors, like lasers, are being used for presence detection during production processes. The challenge here is that lasers do not work under conditions of poor visibility and are not able to measure through optical barriers. The W-band radar, however, offers extremely precise distance measurement no matter the visibility condition and with a sub-millimeter accuracy. On top of presence detection, radar technology developed at Fraunhofer IAF offers a wide range of applications: »Our radar sensors can be used wherever contact-free material inspection or highly precise distance measurement under difficult conditions such as heat or restricted vision is needed«, explains Christian Zech, scientist at Fraunhofer IAF. Currently, Freiburg's Fraunhofer institute is working on multiple projects to adapt its radar technology for specific industrial requirements.

Safer human-robot collaboration

Zech's project team adapts the radar for human-robot collaboration, which will help to improve the safety of people. Humans and robots will be expected to increasingly interact directly with each other in confined spaces of production environments in the future. Safety systems are required to ensure the safety of people at all time. At the same time, a relatively uninterrupted movement of the robot must be ensured for maximum efficiency. Thus, the scientists work on a novel solution for the safety of people based on compact high-resolution radar systems that surveil the collaboration space, calculate dynamic safety zones and situationally adjust the speed and movement of the robots. By these means a robot is able to adjust its own movement according to human actions without interrupting its task, and therefore, guarantees a safe and efficient collaboration. »Such a radar safety system can utilize the maximum possible movement speed at minimal distance. This leads to a faster, and thus more efficient, collaboration between humans and robots«, sums up Christian Zech, project manager of »RoKoRa«.

Saving energy in the iron and steel industry

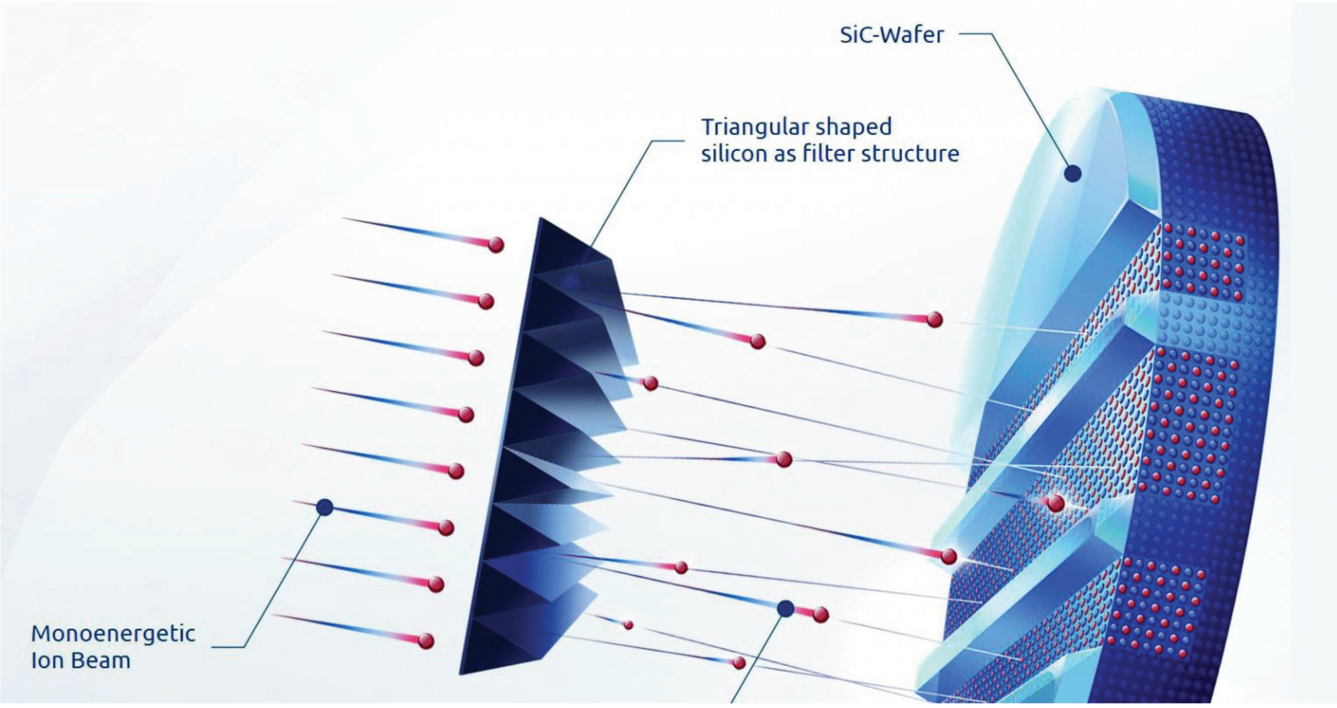
The steel industry is one of the most energy-intensive sectors. Thermoprocessing plants and industrial furnaces consume almost 40 % of the overall industrial energy demand. In order to remain internationally competitive, the steel industry needs to increase the efficiency of existing production plants and substantially lower the energy consumption. For this purpose, a multi-disciplinary consortium including Fraunhofer IAF develops a radar-based measuring technology for hot rolling mills: This radar sensor technology not only allows for a resilient high-resolution detection of distances and positions of flat steel, but also for precise and contact-free measurements of lengths and speeds. »Rough conditions dominate hot rolling mills – extremely high temperatures, dust, high humidity and steam complicate the use of optical measuring systems. High-resolution radar sensors control precise band and process sizes and thus ensure a reduction of defective goods, which corresponds to increased profit. This saves resources and energy«, explains Benjamin Baumann, project manager of »Rad-Energy« on the part of Fraunhofer IAF.

The production, assembly and operation of wind turbines is being refined each generation. The rotor blades made of fibrous composite materials in sandwich design, constructed as hollow parts, are required to withstand extreme forces during operation

Longer-lasting wind turbines

Millimeter-wave radar technology can not only determine dimensions of materials, but even penetrate them, for example to locate defects and their exact positions within materials. The scientists of project »InFaRo« develop an innovative testing method for wind turbine rotor blades that is able to detect defects as early as during production. This increases their quality significantly and also saves production and operating costs. The production, assembly and operation of wind turbines is being refined each generation. The rotor blades made of fibrous composite materials in sandwich design, constructed as hollow parts, are required to withstand extreme forces during operation. The increase in size of rotor blades from 40 m (2006) to over 80m (2014) leads to ever increasing demands on their manufacturing. Cracks and fractures in blades result in massive material damage and inefficient power plants and even pose a threat to life. »We develop an innovative measuring system based on radar and thermography, to detect even smallest material defects such as delamination, folding or air inclusions during production.

This ensures an increase in safety and efficiency of wind turbines, while at the same time lowering their cost«, says Dominik Meier, project manager and scientist at Fraunhofer IAF. Direct material inspection has several benefits: The quality of the rotor blades increases substantially, wind turbines become more durable and downtimes due to defects can be reduced to a minimum.



Addressing production of SiC super-junction MOSFETs

A novel ion-implantation technique improves the manufacture of SiC power devices, including super-junction MOSFETs

BY MICHAEL RUEB FROM MI2-FACTORY

IN THE RUN-UP TO THE TURN of the millennium, a silent revolution took place in the silicon power electronics industry. Back then, the on-resistance of commercial transistors plummeted by a factor of between three and ten, thanks to the introduction of a superjunction architecture in unipolar, high-voltage devices. To create this device, a super-junction is formed by creating *p* -type, high-aspect-ratio columns in n-doped vertical drift zones (see Figure 1).

Today, the super-junction is a cornerstone of the silicon power industry. It features in Infineon's CoolMOS, ST-Microelectronics MD-Mesh, Fuji's Super J MOS series, ON Semiconductor's Super FET and Toshiba's DTMOS. This class of devices, which is tending to operate in the 500 V to 900 V range, is serving in switched-mode power supplies in phones, laptops, computers and even server farms. They are a invisible, integral part of our daily lives.

One of the attributes of the super-junction transistor, compared with conventional devices, is a higher doping concentration in the n-doped vertical electron conducting path. Blocking capability of the device is maintained by the *p*-columns, which provide local charge compensation, thereby ensuring that the global electric field is low.

Thanks to this, uper-junction transistors provide an ultra-low ohmic switch with a high blocking capability. That's great from the perspective of a chipmaker, as they can manufacture chips that are smaller - and thus cheaper - for a given on-state resistance. What's more, these chips can fit into smaller packages.

Recently, sales of silicon power devices have faced ever-stronger competition from those based on SiC. This rival is setting a new benchmark for the efficiency of high-voltage diodes and transistors, which are being deployed in solar panels, wind turbines and electric cars. However, SiC chips are costly, so they need to improve their bang-per-buck.

Following in silicon's footsteps

A great way to do this is to bring to market SiC super-junction devices. This would lead to a step-change in on-resistance, and propel energy efficiency to a new high, particularly at the highest blocking voltages of 1.7 kV or more. These attributes would allow products to serve in the likes of solid-state transformers and highly efficient energy-transmission systems in high-speed trains.

Note that a related device, the SiC IGBT, is not up to this task: it suffers from a high threshold voltage - it is typically 2.7 V - and bipolar degradation of the material is an issue. Although the latter problem can be overcome, the most common solution so far is a very costly selection of the seed material and a significantly thicker epitaxial layer, leading to additional cost.

SiC super-junction devices also promise to lower the price of this wide bandgap technology, as chips can be smaller, and thus cheaper. Note that as the nominal breakdown voltage rises, the difference in drift-layer on-resistance between the super-junction design and that of the conventional, unipolar device grows, offering the potential for a greater reduction in chip size (see Figure 2).

Arguably, the biggest challenge associated with the commercialisation of the SiC MOSFET is the development of suitable, high-volume processes for the manufacture of these transistors. It is not possible

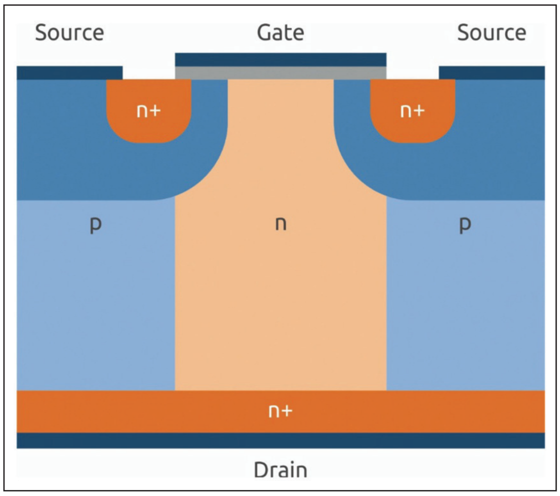


Figure 1. A cross-section of a vertical silicon super-junction device.

to simply adopt the techniques used for making silicon superjunction MOSFETs, due to significant differences between the two materials.

For silicon super-junction devices, manufacture tends to involve a multi-epitaxial approach. It begins by ion implanting *p*- and *n*- areas side-by-side in an undoped epitaxial layer to define the p-type pillars. Another epi layer is deposited on top, before the implanting process is repeated. Carrying out these steps up to five-to-ten times creates ohmic *p*- and *n*-pillars, which are then subjected to a high-temperature diffusion process (see Figure 3).

With SiC, this approach is not an option. That's because conventional dopants, such as aluminium and nitrogen, have extremely low diffusion

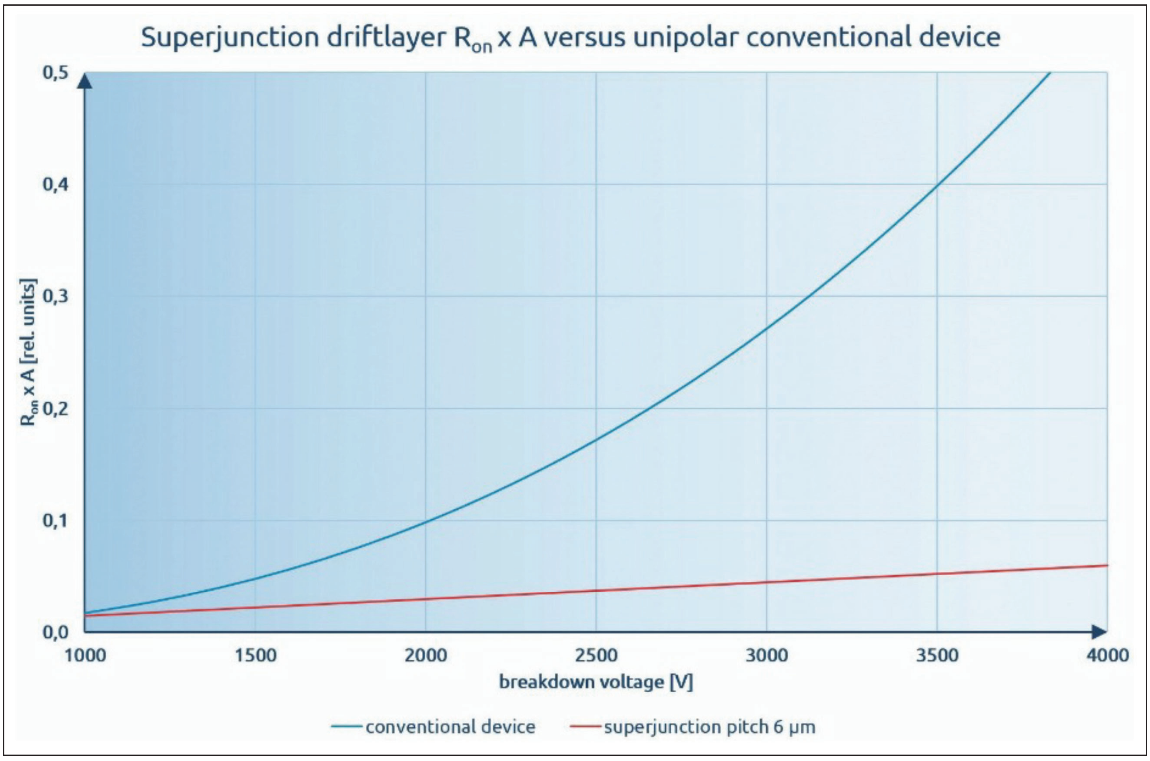


Figure 2. Drift layer on-resistance for conventional and super-junction SiC-power MOS, according to the theory described in Jpn. Patent 9701201.1

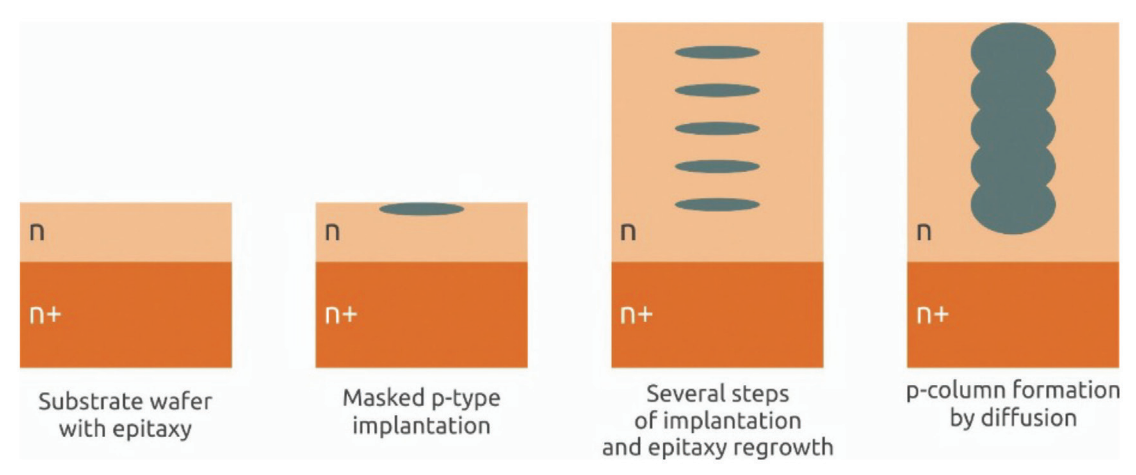


Figure 3. The manufacture of silicon super-junction devices includes a multi-epitaxy manufacturing step.

coefficients. This means that it is infeasible to diffuse over distances of 3-5 µm, which are required in SiC super-junction designs.

Whatever approach is used has to ensure charge-balancing in the device - and so must realise highly precise doping. That rules out technologies like p-doped epi trench filling, because the doping accuracy in the high-volume production of SiC epitaxial layers is rarely better than between +/- 10 percent and +/-20 percent.

The good news is that there is a solution that is applicable to high-volume production: ion implantation, but without diffusion. We are pioneering a form of this at mi2-factory in Jena, Germany. Our technology is capable of producing deep custom-tailored dopant profiles, and while its application to semiconductor manufacturing is new, in a slightly modified flavour it has been successfully applied in heavy-ion cancer therapy for many years.

Our approach differs from the conventional one, whereby monoenergetic ions are 'shot' into a pre-defined depth region known as the projected range. In that case, for a given substrate and ion combination, the projected range is just defined by the ion energy. A single shot creates a gaussian peak of implanted ions. However, it is possible to form extended profiles by creating a sequence of many gaussian profiles, each originating from a different implant energy (see Figure 4).

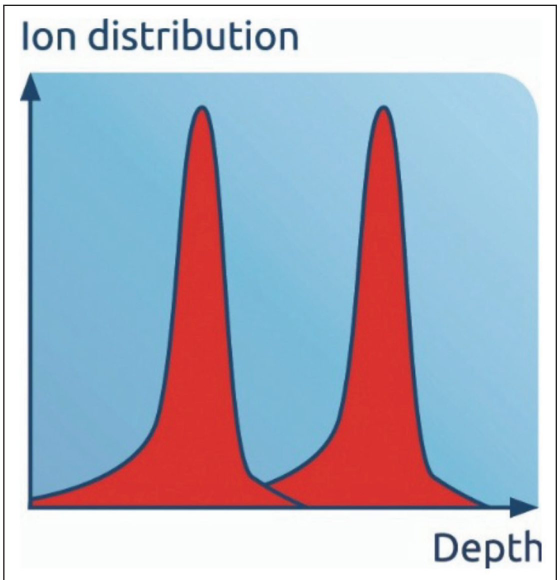


Figure 4. Two ion implantations with different energies result in essentially gaussian peaks.

Unfortunately, extended profiles require many shots. Simulations suggest that an extended depth range of a few micrometres requires a sequence between 25 and 50 individual implants with differing energies. That's expensive, complicated and error-prone. We advocate a far simpler approach: one shot, one ion energy and a very special filter. Known as energy filter for ion implantation, our technique involves the use of a micropatterned membrane, which converts a monoenergetic ion beam into a continuum of ion implant energies (see Figure 5). With the membrane in the path, ions are 'shot' not only into one depth, but simultaneously into all depths, where maximum depth is defined by the primary ion energy. With this approach, continuous depth profiles are accomplished in a very straight forward manner (see Figure 6).

Armed with our technology, high-volume manufacture of SiC super-junction transistors is possible. Our approach eliminates the need for diffusion, replacing this with a technique that delivers an extremely high level of precision. Production costs are low - just one step is required for ion implanting, with a process that is capable of both aluminium p-type doping and nitrogen n-type doping.

One of the primary limitations of our approach is the limited availability of mega-electron ion beams for SiC wafer manufacturing. To address this we offer SiC chip manufacturing customers a loop process option. This serves those in pilot production, and those manufacturing quantities up to medium-volume production - that is, several hundred wafers per

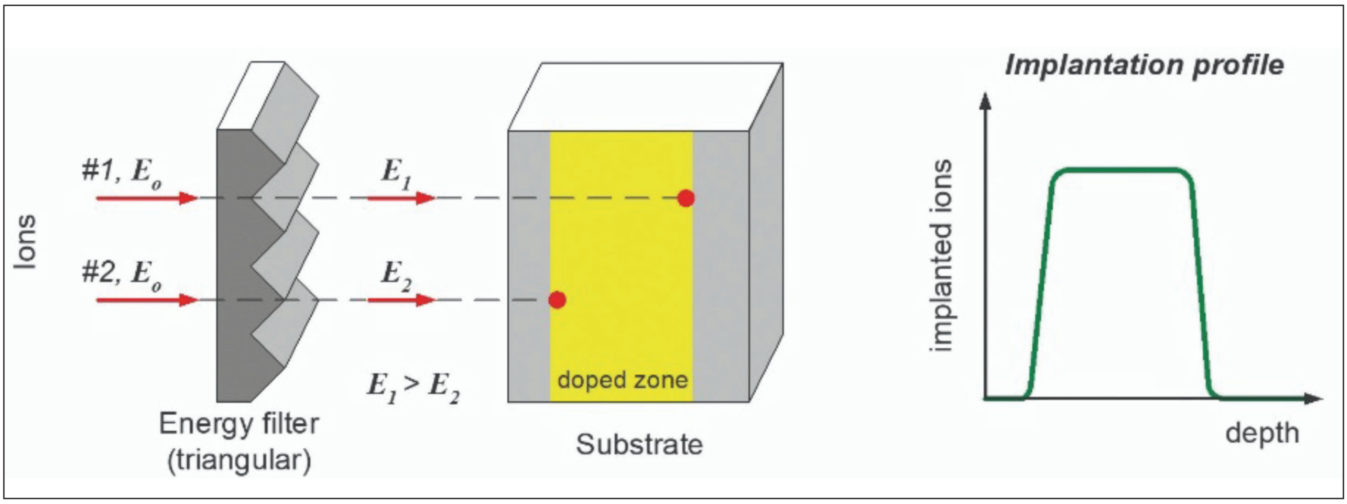


Figure 5. The energy filter for ion implantation pioneered by mi2 factory. The energy of primary ions is modified according to the path length individual ions have to travel through the filter membrane. The long path - through peak - leads to a high loss of energy, while the short path - through a valley - leads to a low loss of energy.

month. For higher volumes, we recommend that fabs install industrial tandetron implanters. Further down the line, we plan to refine our technology so that it is compatible with much simpler ion-implantation equipment, rather than just today's industrially applied electrostatic tandetrons.

Although the membranes for our energy filter for ion-implantation technology are consumables, that does not prevent them from supporting stable, reliable processing. Depending on the ion dose, as many as one hundred 6-inch wafers may be implanted with just a single membrane. Given the very low membrane cost per implant, chip costs generally fall when using our technology, due to benefits that include a reduction in device dimensions associated with the super-junction design. While our ion-implantation technique may make its case most strongly for the super-junction transistor, it also has a role to play in improving the performance of other SiC power devices, via improvements in doping accuracy (see Figure 7).

For example, 600 V and 1200 V SiC diodes can benefit from our technology. In these devices, the drop in forward voltage is primarily determined by drift layer doping level and thickness - and optimising these two characteristics is governed by the available epi processing technology. For instance, to head off the impact of unintentional low doping levels that result from process variations, SiC diodes are generally designed larger than they would be if optimum processing conditions were available.

By switching from in-situ doping during epi deposition to our superior energy filter for ion-implantation technology, we estimate that it may be possible to shrink the area of the 1200 V device by about 20 percent.

This claim for a reduced chip size is supported by work that we carried out several years ago. Back in 2014, in collaboration with an industry partner, we took part in an R&D project to investigate the impact of doping precision. During this programme, we compared the variations in key characteristics of 600 V merged p-i-n Schottky diodes from regular production with those formed with our ion-implantation technology. We found far narrower parameter distributions for differential resistance, blocking voltage and leakage current, highlighting the potential of our energy filter for ion-implantation technology to reduce chip sizes (see Figure 8).

factory can be used for making diodes and transistors. Today, our technology is well-placed to provide the essentially homogenous doping profiles that are needed for diodes and super-junctions. In future, the design of these devices is tipped to evolve, with the introduction of graded drift-layer doping profiles that will propel efficiency to a new level. We intend to support this, having just started to develop an advanced form of our technology that will be capable of delivering more complex doping profiles.

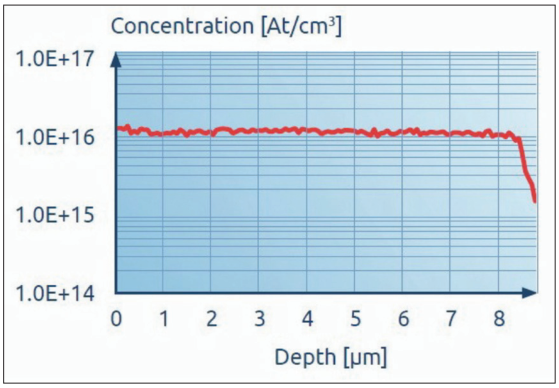


Figure 6. Nitrogen depth profile for 1200 V SiC devices.

Figure 7. The energy filter for ion-implantation technology developed by mi2

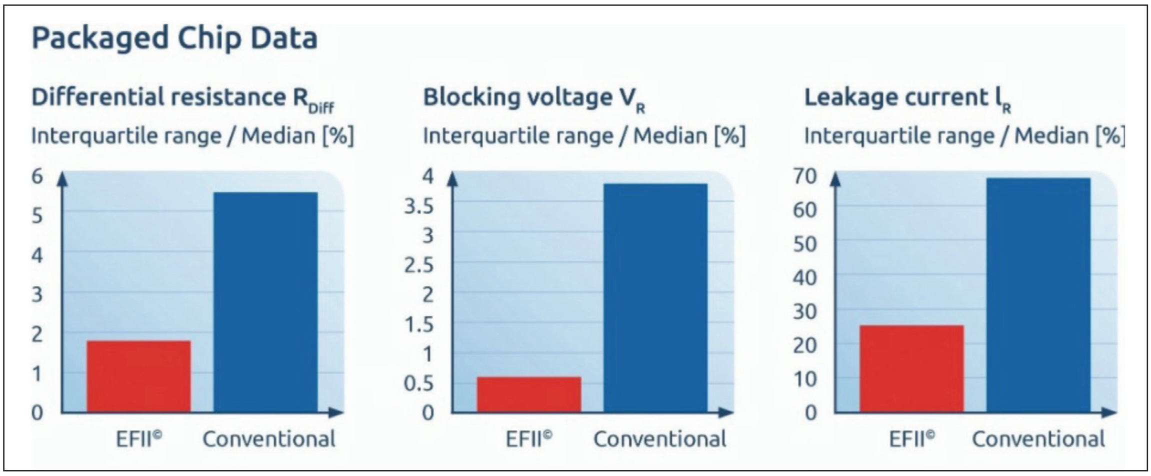


Figure 8. Results from an early R&D project with a chipmaking industrial partner highlight the reduction in the spread of key attributes for diodes.

To support this work, and ultimately our customers, we have developed a software tool that is capable of simulating all types of filter-substrate constellation. This includes masked substrates (see Figure 9).

We are confident that interest in our technology will grow. The SiC super-junction is destined to deliver a hike in power-transistor efficiency, and our energy filter for ion-implantation technology is a key enabling technology for the production of these devices.

Other diodes and transistors will also benefit from our approach to doping, with the greater accuracy provided by our technology enabling a trimming of dimensions, leading to significant cost savings.

Further reading
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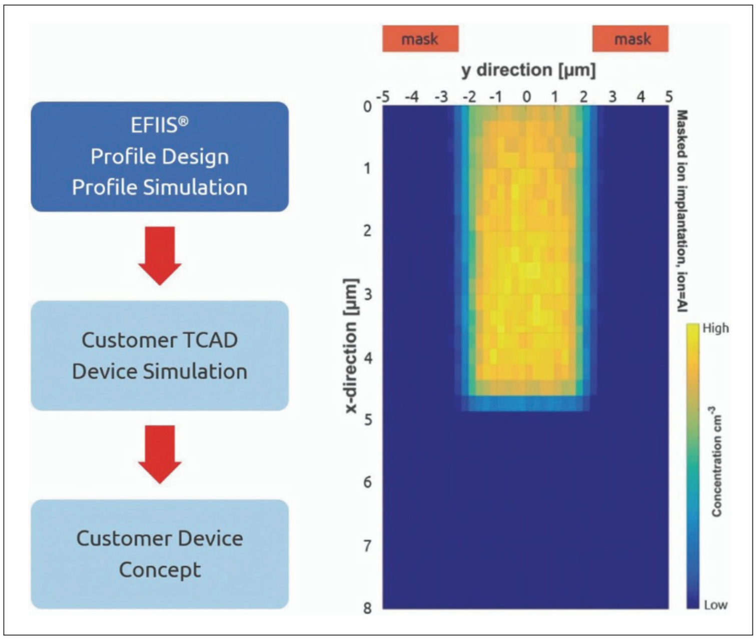

Figure 9. Left: The approach that mi2 factory takes for supporting customer device design with its energy filter for ion-implantation. Right: A 5 µm-deep *p*-column created in SiC using an energy filter for ion-implantation.

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Driving the future adoption of
Electric vehicles

Increasing the adoption of electric vehicles (EVs) has become a top priority worldwide as governments strive to hit ambitious carbon reduction targets. The number of early adopters of EVs is increasing rapidly around the world, with the International Energy Agency forecasting that the number of electric vehicles in use internationally will rise to about 125 million by 2030.

Adam Pigott is Engineering Manager at Kinect Energy Group

THE NUMBER OF EARLY ADOPTERS of EVs is increasing rapidly around the world, with the International Energy Agency forecasting that the number of electric vehicles in use internationally will rise to about 125 million by 2030.

More steps are still needed, however, if fossil fuelled cars are to be phased out and EVs to become the vehicle of choice in 10 years' time. Currently only one in four people would consider purchasing a fully electric car in the next five years, but as people become more environmentally aware, the idea of owning a low or zero emission car is becoming more attractive. Potential adopters are being deterred by a number of factors – the cost of vehicles versus traditional fuel powered cars, insufficient charging points available, the time it takes to charge an EV, and also the limited models available.

Fully electric vehicles can often appear more expensive to purchase than traditional alternatives. This is because typically, the upfront cost is more widely considered when buying a car and drivers rarely think ahead and look at long-term running costs.

Car manufacturers are starting to bring a wider range of vehicles to market, but for those that can't afford a brand new EV, it will take a number of years for a wider range of more affordable, second-hand vehicles to be available. As demand rises for EVs, the number of available charging facilities will need to increase significantly, and the usability of charging points will also need to be addressed. On average, an EV can do approximately 133 miles on a full charge – which is convenient for local driving but limiting for those wanting to use their cars for longer distances. Drivers who use their vehicle for longer commutes are more likely to have to plan their journey around distances between accessible charging facilities, and potentially waiting if the charging point is low powered.

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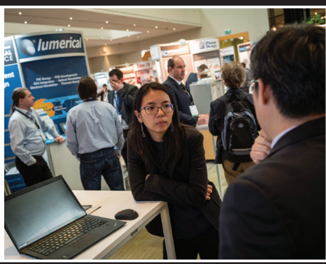


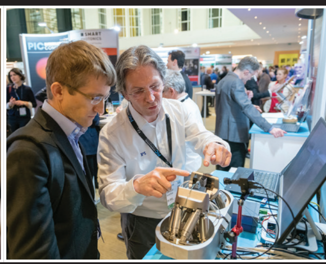


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A typical electric car (60kWh battery) takes just under 8 hours to charge from empty-to-full with a 7kW charging point, or up to 30 minutes for a quick charge.

Going contactless

One of the biggest challenges with EVs has been public charging. All public charging facilities require the customer to have a registered account in order to use that specific charging point. This results in the need for drivers to have multiple accounts, cards and applications registered with the charging point provider to ensure they can access all charging points when needed. Imagine being limited to where you can refuel your petrol or diesel car, depending on which account or card you hold with a major fuel supplier.

The UK government recently announced that charging points will need to have contactless card payment options by 2020 in a bid to attract new users and streamline payment methods. The introduction of a one card payment option is designed to make it easier for drivers to locate and access charging points and avoid the use of multiple smartphone apps or membership cards. The new legislation means that by 2020, operators of new high-powered 50kW, electric vehicle charging points will have to offer a pay as you go debit/credit card payment option, as well as a roaming solution across the entire network.

From the perspective of the consumer (and the desire to remove obstacles to wider EV adoption) this can only be a good thing. Introducing a more streamlined and simplistic payment method will ensure ease of use across the entire charging network. Similar to traditional fuelling stations, drivers can simply top up, pay and get back to their journey. Credit and debit card payments for fast chargers is a natural, and necessary evolution. Higher powered facilities will see a higher volume of drivers topping up for short periods of time, as opposed to waiting for a full charge, which can be time-consuming. A higher-powered charger is a more costly investment so the increased technical complexity of accepting debit and credit cards is less of an issue. Additionally, the high-speed charging process is supposed to be more akin to traditional refueling, so the payment experience needs to be too. High speed charging will see a large number of drivers using the facility each day for a short period of time, as opposed to low speed on-street charging which may see one or two cars a day.

For lower power chargers, those less than 50kW, having a roaming card which covers all public EV charging point would be a more sensible option due to the increased technical complexity of introducing card payments. For example, a small 3kW charger on the street delivers lower power and therefore cost to an EV that may be plugged in all day.

The shift from petrol to electric

Whether you are a business considering EVs for your fleet or a consumer, incentives are available to help you drive onto that electric ladder. Governments across the globe are starting to introduce a number of incentives to encourage drivers to make the switch, and even help towards the upfront cost.

Although differing across countries, most incentives for EVs adopters, include tax rebates, exemption from congestion charges and even a reduction in parking charges. Some governments also offer a plug-in car grant to assist people with the initial cost. Taking into consideration all these savings and future plans for EVs to streamline the practicalities of owning one, it is becoming clear that electric vehicles are just as affordable as combustion models and can actually work out cheaper long-term.

The automotive market is shifting, as vehicle costs start to fall, and choice widens. Governments around the world are working hard to increase the number of registered electric vehicles on the roads, making them more user friendly for new adopters. Whilst there is still some work to be done, advancements are continually evolving and the number of EVs purchased continues to grow year on year across the globe.

Are utilities ready for the V2G movement?

Electric vehicles are poised to take over our roads. But what will that mean for supply and demand on the energy grid.

DAN BYRNES, SVP OF PRODUCT DEVELOPMENT, ORACLE UTILITIES EXPLAINS

Though electric vehicles (EVs) have long been touted as the future of transportation, sales growth has remained moderately temperate – until now. In June alone, Tesla sold just under 40,000 Model 3s, and every major manufacturer from Porsche to Volkswagen have new models in the works. Moreover, the International Energy Agency predicts the install-base of EVs could reach as much as 125 million in 2030, compared to 3.1 million in 2017.

Like all technological innovations, EVs will come with both their challenges and opportunities. While this rise promises a positive impact on the environment, it presents somewhat of a challenge for the electricity grid.

Created long before EVs were commercially viable, most existing grids are not designed to support the fluctuating energy demands electric vehicles will create.

This is where the opportunity comes in. A consortium in the UK including National Grid, Western Power Distribution, Moixa, Nissan's European Technical Centre and others are actively researching what they deem "driver-centred business models to support a rapid roll-out of vehicle-to-grid (V2G) technologies, allowing millions of electric car batteries to become a vital part of the UK energy system."

As the announcement adds, "If electric vehicles are left plugged into smart, two-way charging points when not in use, their batteries can feed power into the network at times of peak demand."

But while this sounds like a great solution to the energy supply and demand issue, the first step for utilities involves gaining full visibility over the current footprint of EVs within concentrated areas, and the energy consumption habits of their owners.

Luckily, technology is already available to support both initiatives. By applying machine learning and advanced analytics to household energy consumption patterns, as well as data gathered using Advanced Metering Infrastructure, utilities can detect and disaggregate the presence of EVs within a household.

This technology allows utility companies to ascertain the time and frequency of charging, helping them to more accurately predict energy consumption and forecast future demand as more EVs come online. This is critical for several reasons. For one thing, the ability to understand and predict demand enables utilities to make more informed decisions on future grid investments. It also helps them give their customers more informed guidance about how EV charging is affecting their energy footprint and bill.

Using these insights, utilities can launch customer engagement programs to encourage charging outside of peak times. For example, they can build incentives encouraging EV owners to plug-in at off-peak times or create EV-specific rate plans which can save customers money, and support the health of the grid. In the future, similar programs could be applied to encourage EV owners to participate in the V2G movement – in essence, enabling utilities to buy back excess energy from customers' EV batteries, creating an interactive energy grid that can balance supply and demand during peak times.

EVs are already changing the way the world travels, and with it, changing the way we consume energy. The challenge for energy utilities is to cope with the impact this shift will bring. Advanced analytics, machine learning and meaningful customer engagement will be key to helping retail energy providers manage the shift, and ensuring that the impact of EVs remains a positive one, for consumers and energy grids alike.

Valens offers new road to **in-vehicle connectivity**

Before autonomous vehicles can enter markets en masse, electrical and electronic architectures need to be rethought, according to Valens, a fabless IC company on course to simplify those systems. Without a new approach, future vehicles will be unable to handle a growing tidal wave of data generated by increasingly sophisticated electronic systems, cameras, sensors and vehicle gateways. Valens created its HDBaseT Automotive technology to address these issues as well as a growing concern over the impact of electromagnetic interference (EMI) on new auto systems; the MIPI Alliance now plans to utilize HDBaseT as a basis for its upcoming A-PHY interference mitigation standard.

Daniel Adler

IN-VEHICLE DATA BOTTLENECKS are on the brink of imperiling advances in automotive electronic systems thanks to the proliferation of data, 'old-school' architectures and power-hungry components counted on to deliver enhancements in passenger safety, navigation, communications and entertainment connectivity.

Vehicles on today's roads aren't grinding to a halt due to poor system level communications networks. But industry insiders and standards organizations such as the MIPI Alliance are cautioning that future, powerful in-vehicle systems may imperil ongoing development goals if auto makers do not change their traditional approach of adding new electronic systems without necessarily reengineering a vehicle's wiring and data communications networks. Auto makers are confronting a serious concern: how will the industry achieve vehicle autonomy or even further ADAS advances if manufacturers are wedded to a patchwork of electronic control systems and networks that add complexity and potential failure points throughout their vehicle fleets?

Valens, a fabless design and development company based in Israel, believes it has an answer: the high-speed HDBaseT concept they created for secure and simplified in-vehicle and electronic system connectivity. HDBaseT has entered advanced testing at several automakers and Tier 1 suppliers, according to the company. It will next move to its first production program, an automotive infotainment system in a 2020 model Mercedes vehicle platform. When the MIPI Alliance A-PHY physical layer standard that targets advanced driver-assistance systems (ADAS) and autonomous driving systems (ADS) and other surround sensor applications in automotive (e.g., for displays, cameras), is released it is expected that most auto makers will move to HDBaseT or a proprietary approach to address the MIPI standards as across future production fleets.

Current vehicle electronics systems are a mish-mash of connectivity challenges, according Valens. Some microprocessors and devices run on the Controller Area Network (CAN) bus communication protocol; others operate via FlexRay, Linux, TTP (Time Triggered Protocol) or Ethernet networks. Systems vary by auto maker and there are few universal standards other than those required by national safety or communications regulators. Given the rigorous demands of automotive qualification, once a system is

approved for in-vehicle usage, it tends to stay there for many production cycles, business facts of the industry that could impact future advances.

While today's approach may seem 'haphazard' these practices came into being simply because some automotive systems perform better with specific protocols. But to share data throughout the vehicle, networking gateways are needed to serve as an interface and 'translator' so that one system can inform and operate cooperatively alongside others, sharing data as needed. But this approach also drains in-vehicle power and slows performance, not to mention adding complexity, weight and cost to the 'computers on wheels' that automobiles have become.

HDBaseT promises to solve vehicle makers communications problems, Valens contends, because it can work well as the connectivity solution for all onboard applications. Power Electronics World Technical Editor Mark Andrews spoke recently with Daniel Adler, VP and Head of Automotive for Valens, concerning the challenges faced by automakers, and how the Valens' solution could help untangle the increasingly dense array of in-vehicle networking challenges.

"As we move towards autonomous driving, cars need more devices – such as cameras, sensors, displays. With more devices, we need the computing processing power and the bandwidth to handle the increasing amounts of data being circulated in our cars. While there is much buzz in the industry regarding the amazing technologies that will enable autonomous driving, the silent element in this revolution is the in-vehicle infrastructure and connectivity that must transmit unprecedented terabytes of data between the devices and the high-performance compute elements in the car. That is the main challenge facing the industry right now: current in-vehicle connectivity solutions are not able to deliver the bandwidth and robustness necessary to guarantee safe autonomous driving," said Adler.

The executive went on to explain key benefits of the company's technology and ways that HDBaseT fits the needs of automotive manufacturers:

- **Bandwidth:** HDBaseT Automotive enables the transmission of multi-gigabit data over a single cable (such as unshielded twisted pair), with near zero latency. In addition, it converges several interfaces over the same cable, reducing the number and weight of cables.

- **Electromagnetic compatibility:** one of the challenges of the connected car is the increased risk of EMI as more and more devices are crammed inside the vehicle. Those risks are compounded by the increase in mission-critical autonomous functionality. HDBaseT Automotive is highly resistant to such interference, while also minimizing its own emissions, even over UTP.
- **Robustness and reliability:** HDBaseT Automotive is an "all-delivered" technology, eliminating the risk of dropped or non-delivered packets, with redundancy capability for further reliability.
- **Flexibility:** HDBaseT Automotive brings architecture flexibility for the transmission of video and data, supporting daisy chaining, multi-streaming and networking topologies.

Valens has recently promoted its automotive product solutions with a focus on the advantages they provide in mitigating EMI effects, so we asked the company to address whether EMI appears to be a greater problem than it was perceived to be when HDBaseT was developed.

The challenges of mitigating EMI within vehicles only increases with time as more systems automate and control more in-vehicle operations for safety or convenience sake. "EMI has been less of an issue so far because until now, low speed (applications) have been the norm in today's vehicles

"One thing that Valens has been highlighting in our discussions lately is the need for higher and higher bandwidth in connected and autonomous cars, as we add more applications and features. Higher bandwidth is needed to support the multiple safety-critical autonomous systems that are now being integrated into vehicles, systems that yield greatly increased risks should EMI-related failures occur. As we mentioned in the original article, more applications mean more devices. The increased number of devices and cables, the higher bandwidth necessary, and the longer distance expected among devices make it much harder to handle the EMI challenges.

Valens' HDBaseT Automotive relies on unique physical layer (PHY) mechanisms that ensure the necessary resilience under this challenging condition. These mechanisms are RTS (local retransmission), adaptive modulation, and real-time noise cancellers. In fact, our EMI-resilience capabilities were one of the main factors that lead the MIPI® Alliance to choose Valens' technology as the baseline for its upcoming high-speed automotive PHY standard (A-PHY)," Adler said.

Experts disagree about the likelihood of autonomous vehicles becoming an 'everyday' fact of daily driving within the next five years. Fatalities occurring in the US State of Arizona led Governor Doug Ducey to ban Uber's autonomous vehicle testing program in March 2018 after a pedestrian was killed during tests on public roadways. Uber discontinued tests on California roadways as well, which has caused a ripple effect with other companies actively developing autonomous systems; while companies are reevaluating their processes, technologies and safeguards, testing has resumed and most across the automotive supply chain expect varying degrees of autonomy to be introduced in the coming years, with more advanced ADAS systems that Valens' products support being added every year.

As manufacturers add more autonomous systems to their vehicles, the risk of EMI interference increases largely because of more in-vehicle, bandwidth intensive devices and applications. "The risk of EMI interference will come mostly from within the vehicle – from all the additional devices, compute units, cables, connectors. This is compounded by the very tight space limitations, leading to the equivalent of cross-talk interference (as the wires and devices are so close together), and also from the increased bandwidth and long-distance data transmission going on inside the car. EMI issues coming from outside the vehicle relate more to the high bandwidth expected (5G, for example) in smart antenna, and the challenge of distributing the content received from the smart antenna to the head unit and other devices in the car. Irrespective of where the EMI noise is coming from, the more autonomous the car, the more safety-critical systems, and therefore, the higher the risks," he explained.

The challenges of mitigating EMI within vehicles only increases with time as more systems automate and control more in-vehicle operations for safety or convenience sake. "EMI has been less of an issue so far because until now, low speed (applications) have been the norm in today's vehicles. We are just now seeing some 1Gbps-enabled cars, but the majority is still way lower than that.

So yes, EMI will become an increasingly problematic issue as the bandwidth goes up. More than that, another major challenge we see is that some EMI testing standards are not strict enough to respond to the increased bandwidth expected. This is why the work being done by the MIPI® Alliance's A-PHY standard is so important, as they are focusing on high-speeds while definitely the appropriate EMC specifications for it," he said.

While autonomy and various levels of self-driving operations could be enabled by Valens Automotive technology, creating autonomous vehicles is not the company's sole pursuit. Valens focuses on enabling very high bandwidth and ultra-low latency data transmission. One key question, which also happens to affect those aiming to create autonomous vehicles, centers on the best means to enable high-speed data processing in moment-by-moment situations that occur whether a human is behind the wheel or not.

While some automakers may want to rely on cloud-based resources to help augment data intensive scenarios, and thus reduce on-board processing requirements, all recognize that cloud connections will only be possible in some situations. An autonomous vehicle needs to navigate and perform all its critical functions independently of wireless data links.

"The overload of data is another major issue automakers face. Cloud-based resources, such as data centers, are not a possible solution. Autonomous cars cannot rely on wireless connectivity to distant data centers to guarantee safety and proper functioning of autonomous systems. What happens when the network drops, or when there is interference from different systems in the region, or when there is no wireless access?

The automotive 'data center' must be located inside of the car. When Valens realized the ways that the automotive sector were evolving, the company understood the value that our resilient mechanisms (RTS, adaptive modulation, and real-time noise cancellers) would have.

These mechanisms are particularly effective as they are PHY-based (physical layer), and as such do not add additional complexity to the software stack. Also, by guaranteeing uncompressed transmission, HDBaseT Automotive reduces latency to near-zero levels, for more secure and reliable connectivity," he said.

"With more and more data comes an increased number of computing units (ECUs), which must communicate with one another and with the different devices in the vehicle. One of the challenges OEMs face is how to reduce the number of necessary ECUs in the car – because of space, weight and cost considerations – without compromising autonomy features. This is one of the benefits of HDBaseT, which provides increased flexibility on where to position ECUs, and how to leverage different ECUs for different needs in the car, in an 'as-needed' manner. Cars are becoming a data center on wheels, and the ability to reach virtualization of resources is a must."

Vehicles without robust electrical systems could be putting passengers and other vehicles sharing the roads at risk. "EMI can cause complete link failure, also in critical applications. As stated above, it is paramount to toughen the EMC requirements in the automotive sector to avoid catastrophic consequences due to EMI failures. Another must is the need for redundancy, to guarantee safety if there is a failure, a cable disconnect, or too much EMI affecting data transmission. Of course, this risk becomes increasingly more serious as we move towards a more connected and eventually autonomous car," he explained.

While the HDBaseT system Valens advocates is flexible, Adler said it was not intended to be a replacement for all automotive electrical and control systems. For example, usage in powertrain systems or electric vehicle (EV) recharging could be relevant, but automakers would not necessarily need HDBaseT flexibility to replace electrical wiring systems, so if they could choose to utilize current systems for sake of continuity across a vehicle platform this. "As such, it is likely that OEMs will maintain the existing solutions in the market today, such as CAN, MOST, etc. HDBaseT can co-exist with and even tunnel these different technologies over one cable, optimizing the overall connectivity within the car," he remarked.

Valens is a founding member of the HDBaseT Alliance, which today boasts more than 200 members. The Alliance advances and promotes the core technology for wired connectivity across both automotive sectors and audio-visual component makers, in-vehicle infotainment developers and other groups within the automotive supply chain. Founded in 2007, Valens is a top provider of advanced IC devices for the distribution of uncompressed high definition (HD) multimedia content (through a single cable) for audio-visual, automotive, industrial and consumer electronics.

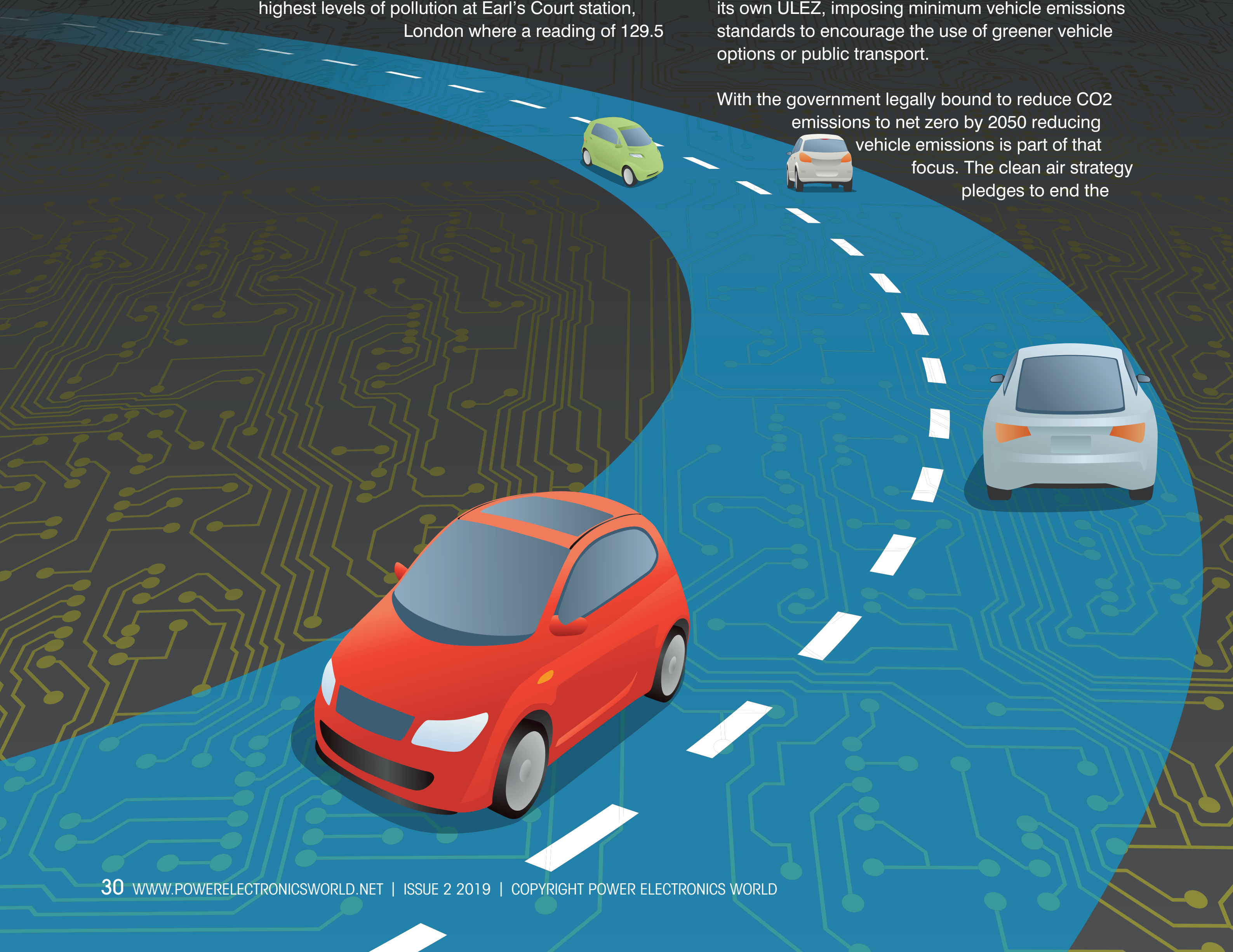
Will all roads eventually lead us to EVs?

Siemens Smart Infrastructure: concerns persist over the charging infrastructure and price of electric vehicles (EVs)

ALMOST 2,000 locations across England, Wales and Northern Ireland have levels of air pollution that exceed safety limits, says Friends of the Earth*. Road traffic emissions are a leading source of nitrogen dioxide (NO2) with the pollutants worsening chronic illnesses, shortening life expectancy and potentially damaging lung development.

The study by the climate campaigners found the highest levels of pollution at Earl's Court station, London where a reading of 129.5 micrograms per cubic metre was recorded, against the government air-quality limit of 40μg/m3. Greater London has introduced a number of measures to improve matters including: hybrid or zero emission buses, a £48m scrappage scheme to swap older cars and vans for cleaner alternatives, more grass and greenspaces and a pollution charge for older vehicles entering the capital's new Ultra Low Emission Zone (ULEZ). Heathrow airport also plans to adopt its own ULEZ, imposing minimum vehicle emissions standards to encourage the use of greener vehicle options or public transport.

With the government legally bound to reduce CO2 emissions to net zero by 2050 reducing vehicle emissions is part of that focus. The clean air strategy pledges to end the



sale of all new conventional petrol and diesel cars and vans by 2040.

The decarbonisation of transport: the road to Electric Vehicles (EV)

With the political will and clear and consistent policies to encourage take-up, optimism is high for the mass adoption of EVs. However, doubts linger over insufficient charging points, limitations with respect to connecting charging infrastructure to the power grid and high vehicle prices.

Bernard Magee, Director Siemens Future Grid commented: "The decarbonisation of transport will require the major expansion of today's electric and low emission vehicle infrastructure but these barriers are not insurmountable. To date approximately 120,000 charge points [DfT] have been installed in the UK and more are needed, particularly in remote locations. There were also nearly 60,000 new EV and hybrid registrations last year. While the figure represents a relatively small percentage of overall vehicles sales the industry is confident the uptake will continue to drive investment at national and local levels."

EV infrastructure today

According to Zap-Map, monitors of the UK charging-point map, there are now 8,471 EV charging sites in the UK with a total of 13,613 chargers, compared with 8,400 fuel stations**. The number of charging sites has surpassed that of fuel stations for the first time and has increased by 57 per cent in the last 12 months. Although an important milestone the UK is still said to need an additional 28,000 public charging points by 2030 - double the current number, to support an estimated fleet of seven million EVs by the end of the next decade according to research by Deloitte***.

The road ahead

Magee continued: "By leveraging existing infrastructure, these 'electric avenues' provide accessible, reliable, affordable and simple charging points to help accelerate the increase in privately-owned EVs. Charging your car is becoming as simple as charging your phone, they're less expensive to run, nicer to drive and are much better for the environment"

Adequate infrastructure is also a primary concern for fleets that are exploring an electrification strategy. While sixteen of the UK's largest van fleets have committed to zero tailpipe emissions from vans in cities by 2028**** fleet operators face numerous complexities including vehicle charging management, data usage, total cost of ownership (TCO) for vehicles and significant up-front capital costs. "New mobility providers such as car-sharing clubs and specialised rental companies covering shorter distances in urban spaces are the biggest operators of EV fleets today. And the appetite for them among larger operators will grow as the technology improves, prices come down and battery charging infrastructure improves," Magee explained. "Heavy goods vehicles are further from

electrification than light duty vehicles, so expect a mix of power sources to be part of the transport landscape for the foreseeable future."

Looking ahead ultra-fast charging and improved battery technologies will address the range limitations. A rapid charger at 50kW charging rate can fully recharge a standard EV in approximately 40 minutes. Next generation chargers at 350kW will allow vehicles to reach full charge in under 10 minutes. As car manufacturers launch vehicles with more advanced larger capacity batteries, high power charging will allow motorist to recharge more quickly and travel greater distances in a day. New batteries currently under development will power cars for up to 600 miles.

On pricing, Magee added: "Better technology, improvements in energy density and more choices plus the economies of scale will drive prices down. We can expect EVs to reach cost-parity with conventional cars in a matter of years from now."

As one of the world's largest providers of sustainable traffic and transport solutions, Siemens offers a comprehensive turn-key solution for all EV charging infrastructure projects and has extensive experience of installing EV charging and traffic control equipment on highways, public sector and private land.

*https://friendsoftheearth.uk/clean-air/nearly-two-thousand-locations-across-england-wales-and-northern-ireland-breaching-air

For further information on Siemens Intelligent Infrastructure, please see https://new.siemens.com/uk/en/company/topic-areas/intelligent-infrastructure.html

Further reading

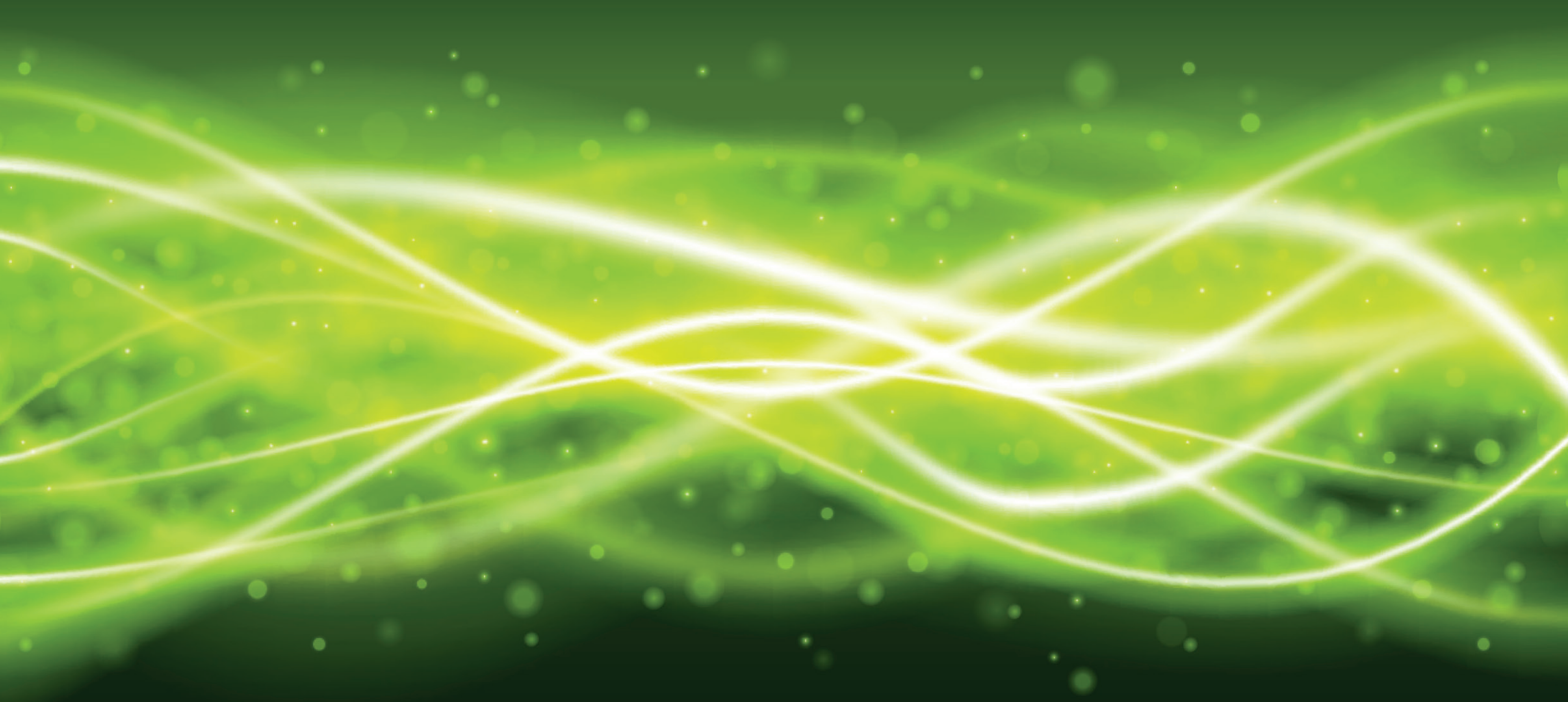
** https://www.zap-map.com/ev-charging-sites-outnumber-petrol-stations-for-first-time/

*** https://www2.deloitte.com/uk/en/pages/press-releases/articles/nearly-30000-new-public-electric-vehicle-charging-points-needed-in-next-ten-years.html

**** https://www.cleanairday.org.uk/news/launch-of-clean-van-commitment-to-kickstart-a-revolution-on-our-roads

Power density, high-efficiency
GaN power switching topologies

Power Electronics World invited the experts at GaN Systems to provide an inside look at design challenges and opportunities with this powerful high density, wide bandgap technology. This article is the third and final installment.



MARKET DEMANDS call for major improvements in size, performance, and cost of electronic equipment. While Moore's law has continued to prove true for the "signal path," the "power path" has been slower to yield dramatic improvements. Thanks to the advances in Gallium Nitride (GaN) as a power transistor technology, power conversion has emerged as an enabling technology – making possible remarkable improvements in power efficiency, size, and cost. GaN power switching technology delivers higher levels of efficiency and enables new applications. The first two parts of this three-part article provided a brief overview of the fundamentals and discussed technical details of applying GaN devices. This final part presents four high-power-density high-efficiency/low power switching loss topologies based on GaN technology.

Bridgeless totem-pole power factor correction

GaN E-HEMT capabilities and performance advantages are applicable to both soft and hard-switching applications. Bridgeless totem-pole power factor correction (BTPPFC) is a good example of a hard-switching converter with the advantage of lower Eon/Eoff losses by using GaN technology.

In a conventional diode bridge power factor correction (PFC) circuit, it is a challenge to achieve higher than 98% efficiency due to the large diode losses in the bridge. A conventional 2-phase interleaved bridgeless PFC with Si-MOSFETs adds components and has low component utilization. In contrast, using GaN devices without the parasitic bipolar junction transistor (BJT) and integral body diode of the MOSFET there is no

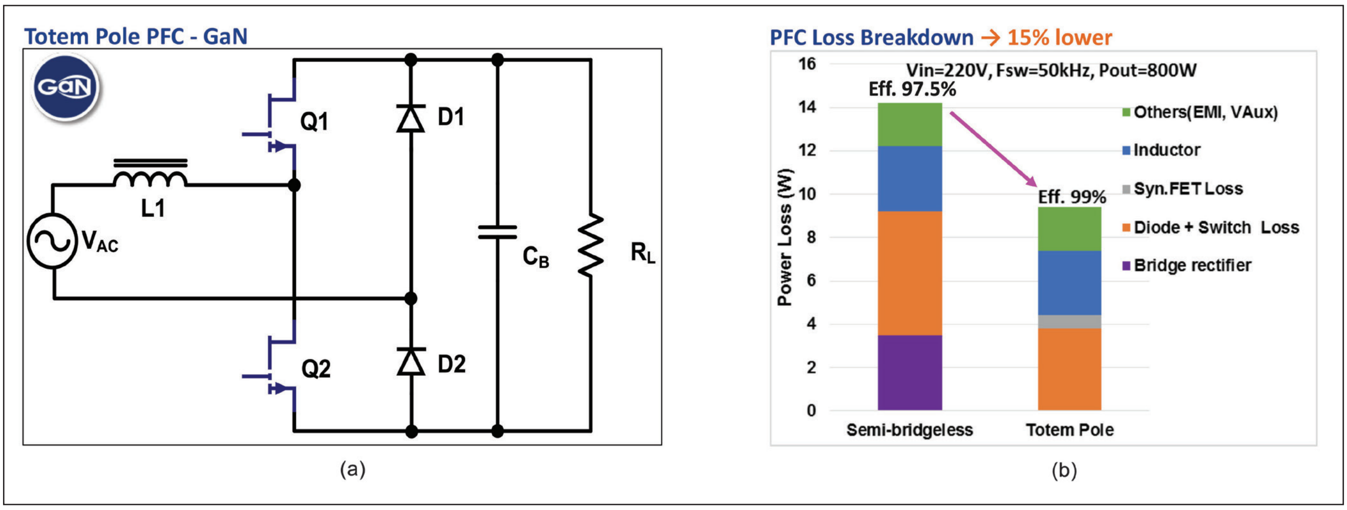


Figure 1: An 800-W CCM TPPFC GaN design (a) and resulting loss reduction (b).

reverse recovery and an anti-parallel diode is not required.

As a result, a GaN BTPPFC can easily meet the efficiency requirements for each 80 Plus certification level in 115 V and 230 V powered applications at 10%, 20%, 50% and 100% loads. For example, the PFC efficiency budget for the 80 Plus Titanium level at 50% requires 96% efficiency. With GaN devices this is:

$$\mathbf{Eff_{AC/DC} = Eff_{DC/DC} \times Eff_{PFC} = 99\% \times 99\% = 98\%}$$

Unlike a MOSFET-based bridgeless totem-pole PFC that has severe limitations in each type of switching mode design, GaN devices can address and reduce the challenges in each mode, including:

- Discontinuous-conduction mode (DCM) --> High inductor current ripple
- Critical conduction mode (CrCM) --> Complicated control
- Continuous-conduction mode (CCM) --> The challenge of reverse-recovery loss Qrr

Figure 1 (a) shows the GaN BTPPFC circuit. Using GaN devices, fewer and smaller parts are required. Since the Qoss is much smaller and there is no Qrr loss, the circuit has higher efficiency and since there is no Trr, the GaN design achieves higher switching frequencies too. Circuit operation at higher frequencies means smaller filters can be used and since it has lower losses smaller heatsinks can be used.

Figure 1(b) defines the elements that contribute to power loss in a standard MOSFET PFC circuit vs. a GaN-based Totem Pole topology. The combined power losses in the MOSFET design are significantly higher than in the GaN design. As shown in Figure 1 (b), the PFC loss is 15% lower with increased efficiency (from 97.5% to 99%) for a totem pole GaN PFC circuit compared to a Si-MOSFET design.
A 3-kW CCM BTPPFC evaluation board has been built with GaN HEMTs, achieving a 99.1% peak efficiency in the 50% power range and a power factor above 0.8 over a wide operating range.

Data center power is an exceptional application for the GaN BTPPFC topology. Typical power supplies employing silicon MOSFET technology have efficiencies of 94–96% and half the power losses occur in the supply's PFC stage. The significant efficiency improvements plus the lower component count of the BTP enables the design of smaller, higher density power supplies. And since is it has been estimated that 40% of the cost of operating a data center is energy costs, making the power supplies more efficient is a significant achievement.

Energy storage systems (ESS) and on-board bidirectional battery chargers (OBBC) in electric vehicles are also ideal applications of the GaN BTPPFC topology since it can handle the power flow in both directions in each application. In telecom applications, the topology can provide increased efficiency and reduce system size as well as reduce system bill of materials (BOM) cost.

Inverters

GaN E-HEMT switches can also be used in single-phase inverters. This is essentially an extension of the TPPFC application. GaN technology can provide two different design approaches.

In a unipolar mixed-frequency sinusoidal pulse width modulation (SPWM) single-phase inverter, GaN switches in the first two switches provide a high-frequency leg with Si MOSFETS providing the line-frequency phase leg as shown in Figure 2 (a). The goal of this topology is efficiency.

As shown in Figure 2 (b), a high-frequency single-phase unipolar SPWM inverter uses GaN E-HEMTs for all four switches, so both legs achieve high frequency.

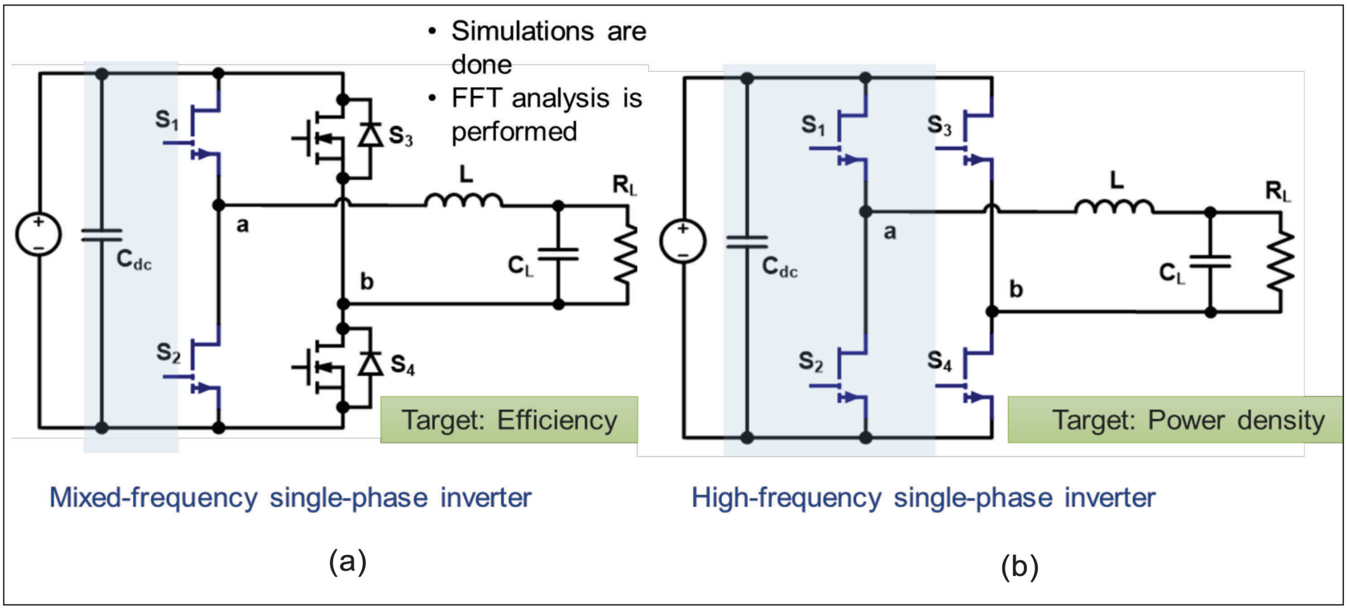


Figure 2: Single-phase inverters using GaN switches for a single (a) and both (b) legs have different design goals.

The goal of this topology is power density. Loss analysis and total harmonic distortion (THD) comparisons were performed using the same GaN devices in both mixed-frequency and high-frequency, single-phase 2-kW inverter simulations.

In switches S1 and S2 for the mixed-frequency inverter, deadtime loss was a small fraction of the total 6-W loss for each switch, with 2.7 W attributed to conduction losses and about 3.3 W for switching losses. Switches S3 and S4 only had conduction losses that were 1.5 W each. For this design, the resulting efficiency drop contributed by the switches was 0.76%.

For the high-frequency design, the losses of all four switches were identical (6 W each), with conduction losses of about 2.8 W, switching losses about 3.1 W and the remainder being deadtime losses. The efficiency drop contributed by the switches in this approach was 1.21%.

Fast Fourier Transform (FFT) analysis was performed on simulations of both designs. For the high-frequency design, harmonic ripple starts at two times the switching frequency. As a result, less than 10% THD occurs at substantially higher frequencies (essentially two times) for the third harmonic than in the mixed frequency design, since the third harmonic for the high-frequency design is six times the fundamental frequency.

High power-density LLC DC/DC converter

A GaN-based resonant LLC DC/DC converter design can provide several design advantages for soft switching applications. Figure 3 (a) shows a GaN-based zero voltage switching (ZVS) converter circuit. The consistently lower Coss in GaN devices (as much as 60 times less at drain voltages under 20 V and from 20 to 30% less at higher voltages) compared to Si MOSFETs provides a key part of the advantages.

This means lower stored energy compared to an SI-MOSFET, much as five times less energy at lower voltages (50 V or less) and at least two times less energy at higher voltages. Lower Coss also provides as much as seven times faster charging times at turn off enabling the LLC converters to be operated at higher switching frequency.

For the high-frequency design, harmonic ripple starts at two times the switching frequency. As a result, less than 10% THD occurs at substantially higher frequencies (essentially two times) for the third harmonic than in the mixed frequency design, since the third harmonic for the high-frequency design is six times the fundamental frequency

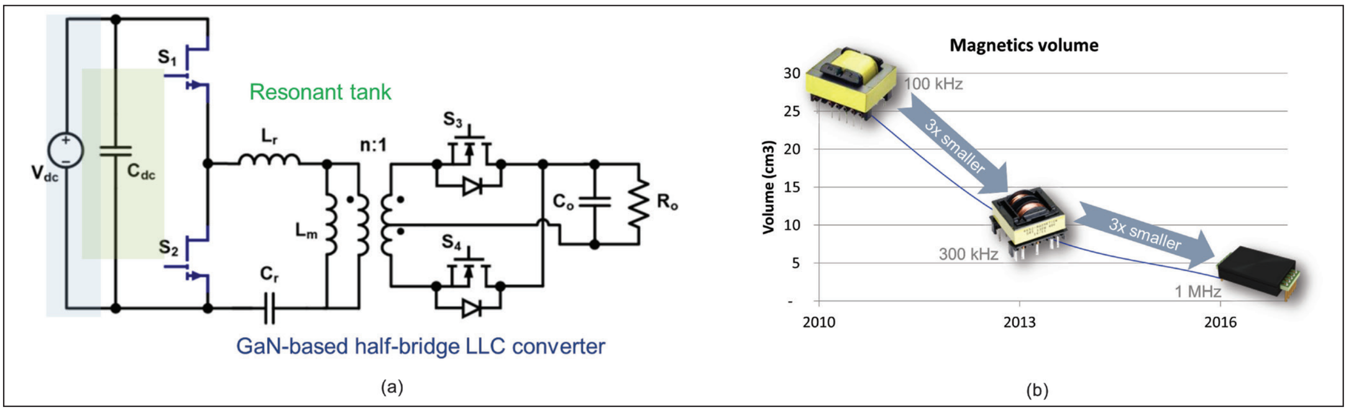


Figure 3: A soft switching ZVS LLC converter circuit using GaN half-bridge (a) and the resulting reduction of magnetics volume (b).

The smaller C_{oss} in the GaN-based half-bridge converter means a smaller air gap in the resonant tank for lower $P_{trans\_loss,}$ and lower I_{rms} for lower P_{sw_cond} losses. The combination provides high efficiency for the LLC converter. In addition, the ability to operate at higher frequencies provides high power density as well. As shown in Figure 3 (b) this has allowed the magnetics volume to decrease by a factor of three every three years since 2010 providing size reduction as an additional advantage.

GaN can also be used for high frequency, low power LLC, soft-switching converters. This design approach can focus on the lower Qg by using GaN and thus achieve faster switching speeds and lower gate driving losses.

Three-phase half-bridge inverter for motor

As shown in Figure 4 (a), GaN E-HEMTs can be used in an inverter for three-phase motors. The light-load and overall power loss improves considerably over an IGBT inverter (see Figure 4 (b)). The lower losses mean smaller, less expensive heatsinks while the high efficiency provides the ability to meet stringent regulations. In addition, GaN's high switching frequency capability means:

- No acoustic noise for quiet operation
- Smaller and less expensive filters
- Sinusoidal output filter for less expensive, unshielded cabling and longer cable lengths

Using GaN E-HEMTs to meet or beat design expectations

The practice of engineering is often described as an optimization process – applying technology to produce products that provide the best combination of performance and cost. The advances in GaN power conversion technology are making significant gains in efficiency, size, and cost. GaN was once cynically called the "technology of the future…and always will be." Those days are over as these four examples demonstrate the improvements that GaN technology can provide to common power electronics topologies.

Depending on the design goals, high efficiency, high power density or a combination of both can be achieved with similar or reduced constraints of size, weight, power dissipation, and system cost. Engineers who embrace this new technology will place themselves and their companies on the leading edge of the most significant technology since the invention of the MOSFET.

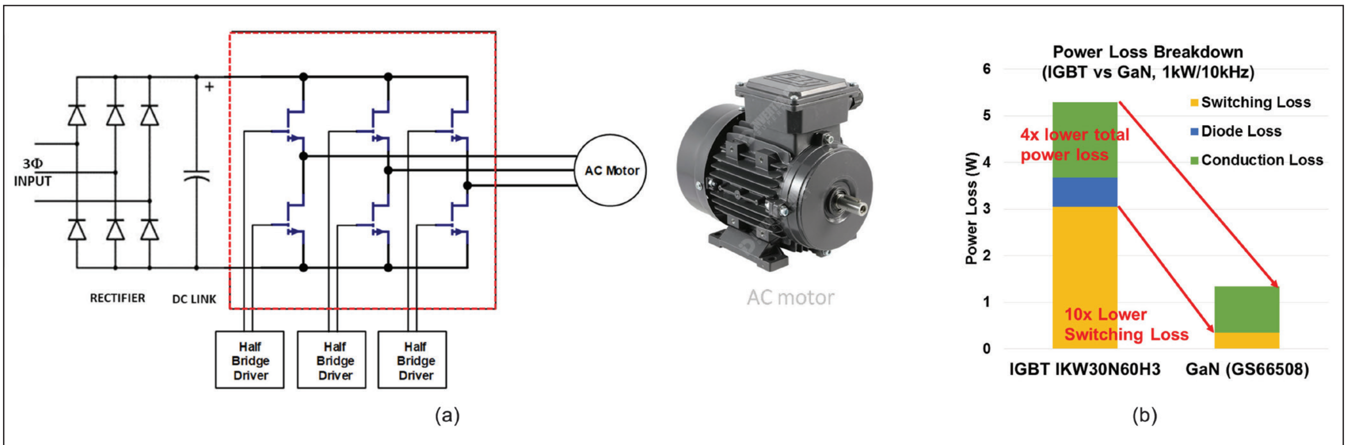


Figure 4 Circuitry for three-phase half-bridge inverter for an AC motor (a) and comparison of loss improvements from an IGBT inverter (b).

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