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Bodo´s Power Systems®

Electronics in Motion and Conversion

January 2024

Silicon Carbide for Sustainable Transportation

PULSED INDUCTANCE MEASUREMENT

POWER CHOKE TESTER DPG10/20 SERIES

Inductance measurement from 0.1 A to 10 kA

KEY FEATURES

Measurement of the

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- **Secant inductance** $L_{sec}(i)$ and $L_{sec}(\int Udt)$
- **Flux linkage** $\psi(i)$
- **Magnetic co-energy** $W_{co}(i)$
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KEY BENEFITS

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- **Lightweight, small and affordable price-point** despite of the high measuring current up to 10000A
- **High sample rate and very wide pulse width range** => suitable for all core materials

APPLICATIONS

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- **Development, research** and **quality inspection**
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Technological leader in pulsed inductance measurement for 18 years

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Content

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Back with a Bang!

First things first: I wish you all a Happy New Year! I hope that you enjoyed the holidays and had a chance to recharge your batteries. I did, and I'm ready for another 12 issues of Bodo's Power Systems. I promise to deliver on time every month, whether you prefer your printed copy or the e-book. Stay tuned for an exciting update in next month's viewpoint, right here on this page!

Bodo's WBG Event in Munich was a tremendous success. We are still working on the final summary, but here are a few key facts. We had nearly 150 visitors to the keynote, where the six experts answered questions from the auditorium for two hours straight. By the way, there was not a single prepared question, they all came from a highly qualified audience, which led to numerous statements from the panel, which included: Dr. Alex Lidow, Dr. Ranbir Singh, Aly Mashaly, Philip Zuk, Guy Moxey and Dr. Gerald Deboy. The following come-together was a pleasant reunion of the industry with countless informal conversations in the impressive foyer of the Hilton. On the second day, almost 200 visitors came to the two halls and listened to a total of 42 presentations. Bodo and I received very positive feedback on our format of keeping the presentations short and comprehensive. I was amazed that the rooms were full even for the last presentations in the late afternoon. That clearly speaks for the quality of the content. But enough self-praise, it is difficult to express in words what such an event stands for. You have to experience it! Did I mention that we have already spoken to the Hilton about December 2024?

I'd like to thank everyone involved. All the speakers who made the event what it was and also for staying within their speaking time slot. It surely was a tight schedule, and the moderators and I appreciated that not a single speaker overstressed their time. Speaking of the moderators, they also did a great job leading through the program. Thank you, Alfred and Roland! Also, a huge thank you to my mother, sisters, and my wife for supporting Bodo and myself in Munich. Family business as it should be! Thank you to all the exhibitors and sponsors for allowing us the opportunity to host the event in such a convenient and classy venue. And to all the attendees for joining us. Let me answer one of the most frequently asked questions here again: Yes, we are working on the proceedings and will share them with all the registered soon. Thank you for your patience here.

One last thing, the next big event is just around the corner with APEC taking place in February. Obviously, our next issue will be the show issue. If you would like to be included in one of the most important issues of the year, you need to be quick. All supporters will be on the floorplan with their logo again. Reach out to your established contact to discuss the opportunities.

Bodo's magazine is delivered by postal service to all places in the world. It is the only magazine that spreads technical information on power electronics globally. We have EETech as a partner serving our clients in North America. If you speak the language, or just want to have a look, don't miss our Chinese version at bodospowerchina.com. An archive of our magazine with every single issue is available for free at our website bodospower.com.

My Green Power Tip for the Month:
I've mentioned this one before I think, but it is just too good not to mention again: airdry your laundry outside, the current dry air and freezing temperature will do it faster than any dryer could.

Kindest regards,

Events

DesignCon 2024
Santa Clara, CA, USA
January 30 – February 1
www.designcon.com

India Electronics Week 2024
Bengaluru, India January 31 – February 2
www.indiaelectronicsweek.com

Advancements in Thermal Management 2024
Orlando, FL, USA February 14
www.thermalconference.com

The Smarter E India 2024
Gandhinagar, India February 21 – 23
www.thesmartere.in

APEC 2024
Long Beach, CA, USA February 25 – 29
www.apec-conf.org

EMV 2024
Cologne, Germany March 12 – 14
https://emv.mesago.com

CIPS 2024
Dusseldorf, Germany March 12 – 14
www.cips.eu

PLECS Conference 2024
Zurich. Switzerland March 12 – 13
https://plexim.com/events/seminars/2215

AMPER 2024
Brno, Czech Republic March 19 – 21
www.amper.cz

Materials Supplier to the Silicon Carbide Semiconductor Industry

The Hanau-based technology company Heraeus has acquired a significant stake in the start-up company Zadient. Heraeus considers the market of SiC base material highly relevant and a suitable addition to its other operations. The French-German firm Zadient specializes in the production of silicon carbide source material. Silicon carbide is a wide bandgap semiconductor material, which is currently gaining rapid traction in the semiconductor market. Its properties lend themselves to use in power semiconductors, which help to convert current and voltages. Its fundamental contribution is the dramatic increase in efficiency it provides over silicon by reducing the heat losses that occur while power passes through chips. Its ability to handle higher power densities with low losses allows for the transition from 400V to 800V battery systems in EVs which significantly shortens their charging time and increases their range. SiC based electronics are also smaller and lighter, which also contributes to increased range. These properties have led to the rapid adoption of SiC in applications ranging from the main inverters and on-board chargers in EVs to wind and solar power inverters, battery storage systems and even airplane power management modules. The breadth of these few examples is already an indication of the significant role SiC will play in the mobility and energy transition.

Through the partnership, Heraeus intends to accelerate the company's growth and support Zadient's innovative approach with its own know-how.

www.heraeus-group.com

Collaboration in Manufacturing Power Devices

A plan by ROHM and Toshiba Electronic Devices & Storage Corporation to collaborate in the manufacture and increased volume production of power devices has been recognized and will be supported by the Ministry of Economy, Trade and Industry as a measure supporting the Japanese Government's target of secure and stable semiconductor supply. ROHM and Toshiba Electronic Devices & Storage will respectively make intensive investments in silicon carbide (SiC) and silicon (Si) power devices, effectively enhance their supply capabilities, and complementally utilize other party's production capacity.

ROHM has already announced its participation in the privatization of Toshiba, but this investment did not serve as the starting point for manufacturing collaboration between the two companies. Under intensifying international competition in the semiconductor industry, ROHM and Toshiba Electronic Devices & Storage have been considering collaboration in the power device business for some time, and that resulted in the joint application.

ROHM SEMICONDUCTOR TOSHIBA

ROHM and Toshiba Electronic Devices & Storage will collaborate in manufacturing power devices, through intensive investments in SiC and Si power devices, respectively, toward enhancing both companies' international competitiveness. The companies will also seek to contribute to strengthening the resilience of semiconductor supply chains in Japan.

www.rohm.com

Lead Role in Drafting 2023 IEC White Paper

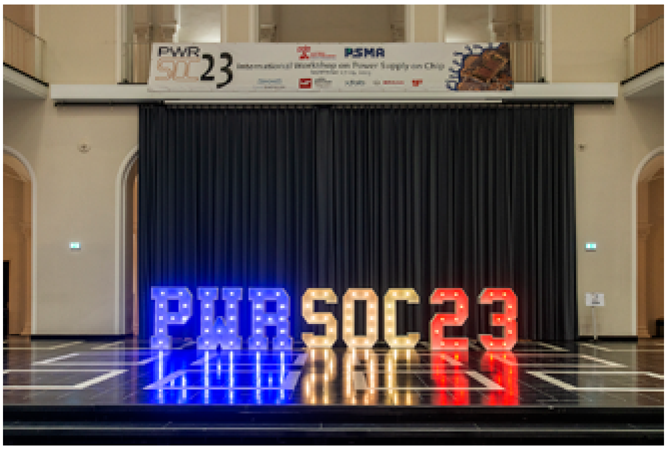
Mitsubishi Electric Corporation announced that it played the key role in leading the project to draft the 2023 International Electrotechnical Commission (IEC) White Paper entitled "Power Semiconductors for an Energy-Wise society". This is the first time for a White Paper, published annually since 2010, to issue recommendations for developing and expanding international standards and certification systems for power semiconductors.

Each year, the IEC White Paper focuses on electrical, electronic and electromechanical technologies requiring international standardization, and makes related recommendations to the IEC and other organizations. Mitsubishi Electric initiated a White Paper project within the IEC Market Strategy Board (MSB) in October 2022. Together with experts from around the world, the project team addressed issues related to power semiconductor technologies, markets, and regulations. The resulting White Paper summarizes the applications, sectors and technological trends of power semiconductors and highlights the need for the development, alignment, and expansion of respective international standards and certification systems. In particular, the White Paper focuses on the critical role that power semiconductor standards can play in helping to realize emission-free, carbon-neutral industries for a healthier and more prosperous world.

www.mitsubishielectric.com

PwrSoC 2023 – 145 Global Experts Discuss Power Integration

The eighth edition of the biennial International Workshop on Power Supply on Chip (PwrSoC) took place at Leibniz University Hannover, Germany, from September 27 through 29, 2023. It was the 15th anniversary of PwrSoC. 145 global experts came together to discuss the miniaturization and integration of power conversion and management solutions - on-chip, in-package, and module level. The Power Sources Manufacturers Association (PSMA) is a co-sponsor of PwrSoC together with the IEEE Power Electronics Society (IEEE PELS).



General Chair Bernhard Wicht, professor at Leibniz University Hannover, Germany and Technical Program Chair Bruno Allard, professor at Ampere lab, Université de Lyon, INSA Lyon, France, organized and presided over a well-received Workshop.

The workshop started with a plenary talk by Dr. Soh Yun Siah, Vice President of Technology Development of GlobalFoundries. Dr. Soh Yun Siah's excellent presentation highlighted the technological needs for the growing Heavy Computing and AI Markets. The audience was challenged to improve power delivery by taking a serious look at GaN+BCD (Bipolar CMOS DMOS) for power solutions that will increase density by up to a factor of 3, allow Heterogeneous Integration of GaN devices and a performance path to the future.

http://pwrsocevents.com

Doubling Production Capacity in Germany

Kyocera Fineceramics Europe plans to invest around 34 million euros in its two European sites in Mannheim (Baden-Württemberg) and Selb (Bavaria) in the current 2023/24 financial year. This is yet another example of how important Germany is to Kyocera as an industrial location and a driving force for the entire European market. The company has hired more than 200 employees since the acquisition and merger of its two predecessor companies, the non-oxide ceramics manufacturer H. C. Starck Ceramics in Selb and the ceramics business of Friatec in Mannheim. "After laying the foundations for the new administration and logistics centre in Mannheim in March of this year, we intend to expand our production facilities in a focused manner over the next few months. In Selb, we will also convert existing buildings and construct new ones on newly acquired land," adds Armin Kayser, Executive Vice President of KYOCERA Fineceramics Europe. "The expertise at both facilities – industrial ceramics in general in Mannheim, and ceramic materials for semiconductor production in particular in Selb – will be retained. Mannheim is also the headquarters for Kyocera Fineceramics sales in Europe, which sells Japanese products alongside those manufactured at the German sites. At the same time, Kyocera also wants to enable its sites to work together more closely," Armin Kayser summarises.

www.kyocera-fineceramics.de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Acquiring Newport Wafer Fab Intended to Accelerate SiC Production Plans

Vishay Intertechnology and Nexperia announced that they have entered into an agreement that Vishay will acquire Nexperia's wafer fabrication facility and operations located in Newport, South Wales, U.K. for approximately $177 million in cash. ATREG, the Seattle-based premier global firm for initiating, brokering, and executing the exchange of semiconductor manufacturing assets, served as Nexperia's transaction advisors. Newport Wafer Fab, located on 28 acres, is an automotive certified, 200mm semiconductor wafer fab that supplies primarily automotive markets. It is the largest semiconductor manufacturing site in the UK.

"Under new leadership in early 2023, Vishay set an ambitious goal of investing approximately $1.2 billion in capacity over a three-year period in order to position the company to seize the opportunities created by the megatrends of e-mobility and sustainability needed for a Net Zero economy. While this transaction is supplemental to our capex investment strategy, adding Newport Wafer Fab to our manufacturing footprint will be instrumental to achieving our goal of expanding capacity for our customers and to accelerating our SiC strategy," said Joel Smejkal, President and CEO of Vishay.

"By agreeing to acquire Newport Wafer Fab, our goal is to safeguard the positions of the highly skilled and dedicated employees and to invest the necessary capital to set up production for our SiC Trench MOSFETs and diodes. With its solid balance sheet and ample liquidity, Vishay will immediately bring stability and its reliable cash flow generation to ensure the facility becomes a fully operational and profitable fab" added Mr. Smejkal.

www.vishay.com

GaN ICs to Deliver Highest Output Power in Wall Sockets

Innoscience Technology has announced that Legrand is using InnoGaN devices in its latest home power sockets to meet the increased power demand from products such as fast-charging Type A+C and USB power adapters. Legrand has an estimated 19% share of the global switch and socket market. In China, the company's recently launched products Yijing 27W and Yijing PLUS 45W wall sockets both use Innoscience GaN HEMTs to greatly increase the output power available, and reduce heat generation within the same size. GaN also allows the wall plug to fit more closely to the wall, achieving ultimate slimness.

For example, the Yijing PLUS five-hole socket uses Innoscience's latest INN700TK190B GaN chip to deliver a maximum output power of 45W with a voltage resistance of 700 V and a conduction resistance of 190 mΩ. This device not only has the characteristics of gallium nitride - ultra-high switching frequency, no reverse recovery loss, low gate charge and low output charge, but is also packaged in a standard TO-252 can, keeping costs to a minimum.

Dr. Denis Marcon, General Manager, Innoscience Europe comments: "The 45W charging socket has the highest output power within the available size. Compared with silicon-based sockets, the power is increased by nearly 1.5 times. At the same time, the characteristics of GaN also reduce the temperature rise of the charging socket during use, making it safer and more energy-saving."

www.innoscience.com

Call for Papers Open – 2024 IEEE Symposium on VLSI Technology and Circuits

Calling all those interested in submitting a paper for the upcoming IEEE Symposium on VLSI Technology & Circuits. The Symposium will be a fully in-person event with live sessions onsite at the Hilton Hawaiian Village to foster networking, with OnDemand access to technical sessions available one week following the Symposium. The 5-day event will include educational Plenary Sessions, Technical Sessions. Evening Panels, Short Courses, Demo Session for outstanding papers, Workshops, SSCS/EDS Women in Engineering and Young Professional events, and Hawaiian Luau Celebration. Online paper submissions now open! Submission Deadline: February 5, 2024.

www.vlsisymposium.org

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www.fujielectric-europe.com

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Innovating Energy Technology

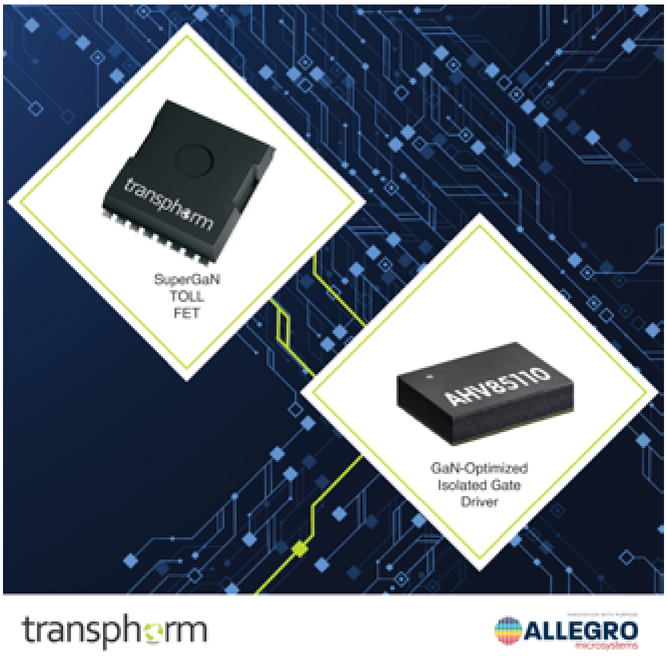
Subsidiary in New Zealand Opened

On the 24th October 2023, Wurth Electronics New Zealand, the 37th subsidiary of Würth Elektronik, officially celebrated with an opening ceremony. Ruth Poon, Managing Director Wurth Electronics New Zealand explains that Tasi Samu, Sales Area Manager has already been successfully serving and supporting customers in New Zealand since 2016. Wurth Electronics New Zealand Ltd has expanded the team headcount and will continue to build a powerful team across New Zealand.

"We are deeply grateful to our customers, because their loyalty and trust have brought us to the point where we can establish our own subsidiary," says Ruth. "The expansion strengthens us in fulfilling Würth Elektronik's claim: 'more than you expect.' We don't just want to sell components; we want our service to help our customers use them to make products that are as good and sustainable as possible." The clientele in New Zealand demonstrates their presence in World-Class electronics research and development across various markets and industries from high-tech startups to globally well-known brands. Wurth Electronics New Zealand is capable of servicing the market no matter the size of the client or intricacy of their supply chain from concept to manufacturing.

www.we-online.com

Teaming Up to Increase GaN Power System Performance for High Power Applications



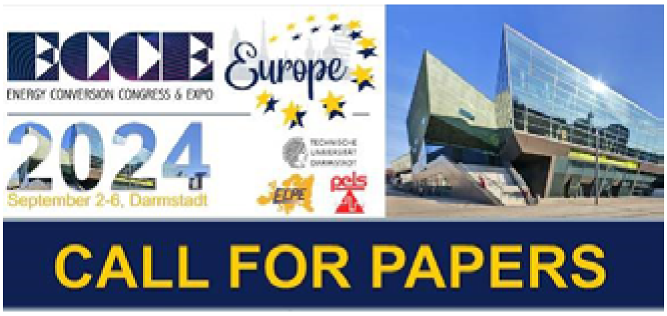
Transphorm and Allegro MicroSystems announced a collaboration including Transphorm's SuperGaN® FETs and Allegro's AHV85110 Isolated Gate Driver to enable the expansion of GaN power system design for high power applications. Transphorm's SuperGaN FETs are designed to work in various topologies and are available in several different packages to support a wide power range while also satisfying diverse end application requirements. SuperGaN FETs are used in multiple commercial products, including higher power systems where they are proven to notably increase reliability, power density, and efficiency.

Allegro's self-powered, single-channel isolated gate driver IC is optimized for driving GaN FETs in multiple applications and circuits. The AHV85110 is proven to enhance driver efficiency by as much as 50% compared to competitive gate drivers. This unique solution greatly simplifies the system design, reduces noise by 10x and common mode capacitance by 15 times compared to other solutions in the market. Those interested in testing the collaborative solution can do so via Allegro's APEK85110KNH-06-T evaluation board. The board incorporates both the AHV85110 designed to work in various applications along with Transphorm's recently announced TOLL package available in three devices with on-resistances of 35, 50, and 72 milliohms.

www.transphormusa.com

ECCE Europe 2024: Call for Papers

Commencing in2024, IEEE PELS is embarking on a collaboration with the European Center for Power Electronics (ECPE) for the PELS flagship conference in Europe: IEEE ECCE Europe 2024. The conference will take place at the Darmstadtium Conference Center in Darmstadt, Germany. The conference language is English in all presentations, discussions, and materials.

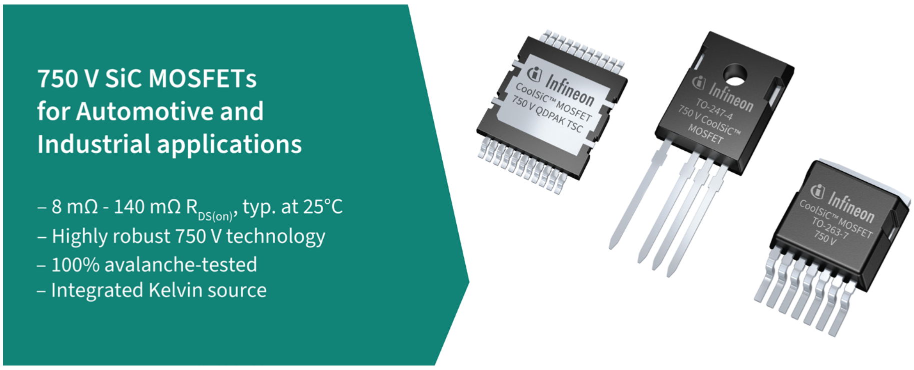


Important Dates:
February 26th, 2024: Submission of provisional full paper
April 22nd, 2024: Notification of acceptance
June 10th, 2024: Submission of final full paper

www.ecce-europe.org

750V SiC MOSFETs Bring Performance and Reliability to your Applications

Lighter, smaller, and more efficient designs at reduced system costs for automotive and industrial applications



Infineon's recently launched CoolSiC™ 750 V G1 MOSFETs add to the existing 650 V CoolMOS™ and 1200 V CoolSiC™ MOSFET portfolios. Their electrical performance enables designers to reach higher efficiencies in automotive and industrial applications like

- Automotive OBC, HV-LV DCDC converters
- Automotive static switches (eFuses, BMS)
- EV charging stations, wall-boxes
- Solid-state circuit breakers
- String PV inverters, energy storage systems

Infineon CoolSiC™ 750 V G1 MOSFET – built on the proven, highly reliable Infineon SiC technology, and in use for >20 years – is the most extensive, robust SiC portfolio available in the 600 V–750 V range for automotive and industrial applications that enables highly efficient systems.

Infineon's 750 V and 1200 V CoolSiC™ devices help EV makers create 11 and 22 kW bidirectional onboard chargers with increased efficiency, power density, and reliability. The devices leverage SiC characteristics to operate reliably at high temperatures (max T_j – 175°C). All devices use Infineon's proprietary .XT dieattach technology, delivering best-in-class thermal impedance for equivalent die sizes.

This technology provides very high robustness, especially against cosmic radiation, making it perfect for bus voltages >500 V. Thanks to their excellent immunity against spurious turn-ons, Infineon's CoolSiC™ 750 V G1 MOSFETs can be safely driven with zero-volt V_{gs} offstage voltage (unipolar gate driver), reducing system complexity, PCB area occupation, and BOM count. Their wide gatesource voltage rating (-5 V to 23 V, V_{gs} static) ensures compatibility with bipolar driving for increased design flexibility.

The devices feature a best-in-class $R_{DS(on)} \times Q_{fr}$ for superior efficiency in hardswitching half-bridges (CCM Totem Pole, 3-level). In softswitching topologies (LLC, CLLC, DAB, PSFB), excellent figures for $R_{DS(on)} \times Q_{oss}$ and $R_{DS(on)} \times Q_g$ enable higher switching frequencies.

This first-generation 750 V SiC family has a very granular portfolio with the $R_{DS(on)}$ (typical, at 25°C) between 8 mΩ and 140 mΩ. Among the three packages they come in (TO2474, D2PAK7, and QDPAK TSC), the topsidecooled QDPAK (released in JEDEC in 2023 and also available in 650 V CoolMOS™ CFD7A) helps maximize PCB space use, doubling power density, and enhancing thermal management via substrate thermal decoupling. Topsidecooled packages significantly reduce efforts in designing the cooling infrastructure, and are key to enabling power densities up to 4 kW/l, as Infineon demonstrated together with SAL in the "Tiny Power Box 1" cooperation project.

Together, all these features of the CoolSiC™ 750 V G1 MOSFET expedite the design process for futuristic applications (bidirectional charging or "V2X"). Vehicles charging appliances or powering construction equipment will be more feasible because of such devices.

For industrial applications such as EV charging, the new devices cut charging times and improve energy efficiency. PV inverter designs can be simpler and more robust, providing a trouble-free, longer lifetime. Finally, CoolSiC™ 750 V G1 enables designing solid-state circuit breakers and relays faster and with lower maintenance costs compared to mechanical- and thyristor-based counterparts.

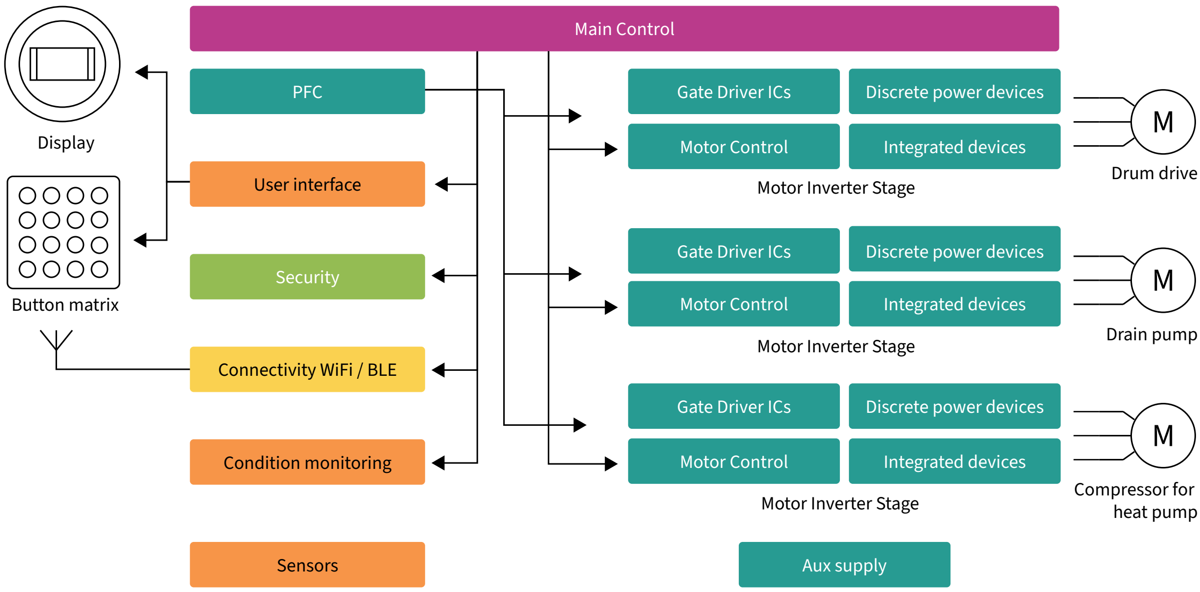
With the launch of this new family, Infineon is very well positioned across all power semiconductor technologies (silicon, SiC, and GaN), and recommends the best fitting technology for each customer, depending on the specific requirements and topologies used. As an example, hybrid-systems combining SiC MOSFETs and Si SJ CoolMOS™ or CoolSiC Hybrid™ in Totem Pole PFC can be used to optimize onboard chargers in system costs. Infineon offers a matching gate driver portfolio, digital isolators, sensors, and microcontrollers to complement and complete the system offering.

Click here to find the full portfolio of HV SiC MOSFETs online.

www.infineon.com

Innovative washing and drying with smart, power-saving laundry machines

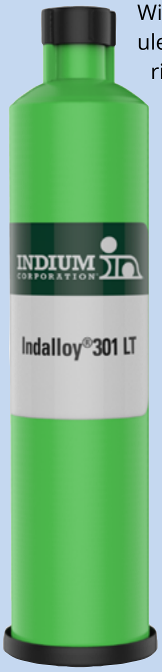
New laundry systems must save energy, operate quietly, look sleek, and connect to the smart home. And of course, they must stand the test of time, so reliability is of utmost importance. Infineon's semiconductor solutions play a key role in mastering all of these challenges, helping to reduce power consumption, system size and costs. Our semiconductor innovations are also paving the way for novel features with the ability to make your washing machine or dryer stand out from the competition.



Learn more:
www.infineon.com/washing

Package-Attach Solder Preform Technology

At Productronica in Munich, Indium Corporation® introduced an alloy technology that enables lower processing temperatures in preform soldering. Specifically developed for power module package-attach applications, Indalloy301 LT® is a bismuth-free alloy that prevents thermal defects in the module without sacrificing reliability like traditional bismuth-containing, low-temperature alloys.



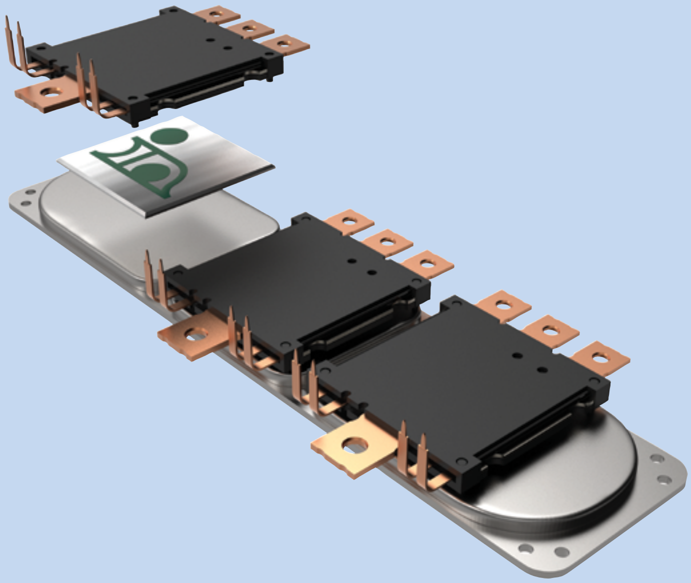
Indalloy301 LT Cartridge

With transition to Pb-free alloys for power module soldering applications, there is increased risk of re-melting or compromising the soldering integrity during subsequent soldering phases, including baseplate-attach or molded package-attach to cooler. Indalloy301 LT is a patented novel alloy; by leveraging this alloy technology in solder preform applications, designers can maintain precise solder volume, consistent manufacturability, and high-quality flux-free soldering performance.

Further, Indalloy301 LT availability in InFORMS® configurations offers a complementary solution for consistent bondline thickness and improved strength to enhance thermal and mechanical reliability of the solder joint while reducing processing temperature and energy input during manufacturing. InFORMS are reinforced matrixed solder composites. This process produces a reinforced solder fabrication with improved strength and creates a more consistent bondline thickness. A uniform bondline maximizes the thermal and mechanical reliability in the solder joint, therefore producing solder joints that are higher in reliability. InFORMS can be manufactured into a wide variety of shapes, including rectangles, discs, and custom shapes, to suit specific application requirements, and they are also available in ribbon form for automated assembly.

Indalloy301 LT alloy can reduce peak reflow temperature by 50°C, compared to commonly used alloys in power electronics assembly, with higher reliability than other standard low-temperature offerings. This enables complementary Pb-free high-reliability alloy technologies such as Indalloy276® to be used in power module die-attach, component attach, or interconnects without the risk of re-melt and degraded performance. Indalloy301 LT is available in preforms, ribbon, or InFORMS configurations and can be offered flux-free or with Indium Corporation's flux coating technology.

Indalloy301 LT offers a solution for consistent bondline thickness and improved strength to enhance thermal and mechanical reliability of the solder joint while reducing processing temperature and energy input during manufacturing. This enables complementary Pb-free high-reliability alloy technologies such as Indalloy276 to be used in power module die-attach, component-attach, or interconnects without the risk of re-melt and degraded performance. Indalloy301 LT is also available in preforms and ribbon configurations and can be offered flux-free or with Indium Corporation's flux coating technology.



Joe Hertline, Product Manager, explained on the Productronica booth: "With increasing mission profile demands in power electronics applications, such as EV power module-cooler integration, preform soldering offers superior thermal and mechanical performance compared to traditional thermal interface materials. By leveraging this new alloy technology in package-attach applications, designers can prevent warpage, encapsulation breakdown and delamination issues by reducing processing temperature, making preform soldering a viable approach with robust thermal and mechanical reliability performance."

Indalloy301 LT features:

- Reduced reflow peak temperatures by 50°C compared to commonly used alloys in power electronics assembly
- Prevention of warpage and delamination in molded power module package-attach
- Ability to step-solder with Pb-free alloys
- Excellent thermal and electrical conductivity
- Solid reliability performance (TST -40°C–125°C)
- Reduced energy consumption
- Available in preforms, ribbon, and InFORMS

www.indium.com

Outlook on the Future of Power Electronics

I had the chance to discuss the market trends in power electronics and power supplies with Alexander Gerfer and Martin Haug from Würth Elektronik eiSos, and how the company is facing these trends with their active and passive component portfolio.

By Bodo Arlt, Founder, Bodo's Power Systems

Mr Gerfer, the German economy looks pretty bleak at the moment. What's your outlook concerning the development of the market in the area of power supply and power electronics?
Gerfer: I anticipate a very positive trend over the long term.

What makes you so confident?
Gerfer: The laws of physics are irrefutable, and the same goes for politics and economics: climate change is forcing us to radically reconsider our attitudes, in particular how to use the various energy sources at our disposal. We've got to get away from fossil energies, which is why electricity is becoming ever more important – and that's why we need efficient power electronics.

Alexander Gerfer, CTO, Würth Elektronik eiSos Group

(Image source: Würth Elektronik)

For example?
Gerfer: For example, in electric drivetrains: power electronics play a key role in the control of engines and in transforming battery current into mechanical energy. Or in the field of renewable energies. Wind and solar energy often generate direct current, and feeding this into the power grid requires efficient inverters. The same applies for power-grid stability, where power-frequency and voltage control play a role, and how to reinforce grid stability by reactive power compensation, as well as power electronics for battery storage systems. Another example is the heat pump, whose efficiency can be considerably enhanced using state-of-the-art power electronics. Regarding energy efficiency in general, power electronics can enhance energy-conversion processes to a substantial degree. All installations where electrical energy is used intelligently need an equally intelligent power-supply system – from the asynchronous motor to the data-processing centre.

Which products and strategies do you intend to use to exploit these potentials, Mr Haug?
Haug: Würth Elektronik has a constantly growing portfolio of passive and active power-electronics components to offer, encompassing storage inductances, power transformers, capacitors, and integrated power modules.

So do many other competitors.
Haug: True, but what makes Würth Elektronik so special is that we're much more than just a mere supplier of components. We proactively support our customers in turning their ideas into innovations and ultimately into market-ready products.

What specific form does that take?
Haug: Specifically this means a dedicated transfer of knowhow that comes free of charge for the customer. The wheel is constantly being reinvented, especially in the area of power supply. At a first glance, the problems may seem trivial, but the devil is in the detail – in the aspects of heat management, efficiency, or EMC safety. I know from my own experience that good ideas often fail due to trivial problems, ones that we here at Würth Elektronik have long since resolved. We share these solutions with our customers in the form of reference designs, design-in support, and targeted advice, but also by providing intelligent tools like REDEXPERT, Würth Elektronik's own online design and simulation platform. Developers can use this tool to measure the AC and DC losses for DC-DC converters, or to design an EMC filter based on specific applications, making the selection of the best-suited components much faster. Services like these are important, especially for SMEs, which don't always have the budgets for their own large R&D departments.

Martin Haug, Head of Product Management, MagI³C Power Modules

(Image source: Würth Elektronik)

Are you at Würth Elektronik set up well for the future?
Gerfer: We sure are. Comprehensive service has always been the basis for our success. We're continuing to invest in this area, for example in our new Hightech Innovation Center (HIC) in Munich-Freiham, which is basically a gigantic customer-service thinktank.

Which specific topics are on your agenda there?
Gerfer: Electromagnetic compatibility, for example. As a rule, power-supply systems still use DC voltage converters, which entails high-frequency technology. If you want to launch electrical and electronic devices onto the market, you have to prove their electromagnetic compatibility in an accredited test lab. These tests are time-consuming, and a negative result means additional development costs and delays in their launch. A major part of the floor space at the HIC, but also at our head office in Waldenburg, is taken up by EMC test facilities.
Here we offer our customers a special service to assist them in their development process: EMC pre-compliance measurements. If a product doesn't comply to the statutory provisions, we make dedicated suggestions based on our experience. This can make the customer's development process even more efficient. No matter which new concepts and technologies the future holds in store, nothing will move forward without power supplies and power electronics. This makes us the system partner of choice, thanks in no small part to our large FAE team: application engineers working in the field, providing customers with practical solutions in matters of EMC and power management – individually, locally, on the spot. We offer a comprehensive range of services, especially for SMEs.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What are Würth Elektronik's concrete plans in the power sector over the next five years? Do you foresee any revolutionary developments?
Gerfer: Power supplies will always be needed. More probable are evolutionary developments, a selective expansion of the product portfolio, of both passive and active components. We're going to continue our efforts in the key sectors, for example regarding efficiency and miniaturization, as well as integration and power density.

Which major trends do you foresee in the future, Mr Haug?
Haug: Interesting developments here include wide bandgap semiconductors, which are an improvement over conventional silicon chips. Made of silicon carbide or gallium nitride, these have many positive properties, for example a high electrical breakdown voltage and a high thermal conductivity, and they enable higher switching frequencies, making them ideally suited for high-frequency technology, power electronics, and high-speed communication technology. Thanks to their wider bandgap, these semiconductors have lower power losses at high switching frequencies and a greater resilience towards high temperatures and aggressive environments.
Another exciting trend is the transmission of power via data lines, the keywords being Power over Ethernet (PoE) and Power over Data Lines (PoDL). This renders the installation of several separate power cables redundant, which results in a substantial saving in costs when this technology is used in the right way. Both PoE and PoDL are subject to stringent standards and specifications to guarantee their safety and interoperability. The limits for the transmitted power, voltages, and currents must be meticulously adhered to, making it all the more important to use components that are economical in the utilization of the limited amount of energy available. This principle of "energy savings" also applies for the field of energy harvesting. This technology utilizes a variety of environmental energy resources in places where a normal power supply is not possible or economical. Most people here think only about photovoltaics, but energy can also be tapped from movements, differences in temperature, or radio waves using piezo generators, thermocouples, or antennas. This energy is stored in capacitors or batteries. While the yield isn't exactly vast, it may be enough to power entire electronic modules when these are optimally trimmed with energy efficiency in mind.

Mr Gerfer, so far you've not made any mention of Artificial Intelligence. What's your stance here – is AI a blessing or a curse?
Gerfer: That depends on what you make of it. But one thing is clear: AI is making rapid advances, and it'll incrementally change our lives. By the year 2035 at the latest there'll not be one job left that is not linked to AI applications, according to some forecasts1. There's currently a lot of speculation about the risks involved. I'd rather emphasize the opportunities it opens up, especially for SMEs. AI will speed up the development process without requiring more manpower.
Selectively supporting and accelerating development by means of services – that was and still is our recipe for success, as I've already said. AI will enable us to substantially expand these efforts. We'll not be tackling the issue of AI too naively, but we'll not be too pessimistic or restrictive either. It's up to us to tap the enormous potentialities this technology has to offer, to shape it proactively. We have to start out on this path here and today. We're still in the driver's seat, and this is where we must remain. The more we make AI our partner, the more successful we'll be in our best role: as human beings.

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Silicon Carbide for Sustainable Transportation

Powering industrial e-mobility across land, sky, water, and rail

Following closely behind the adoption of electric vehicles, new transportation markets are transitioning to electric mobility (or e-mobility) to achieve a sustainable, CO_2-neutral future. From commercial electric vehicles to advanced air mobility, long-haul ships, and high-speed trains, new electrified vehicle concepts are emerging all around the world. But what does it take to enable industrial e-mobility? The latest innovations in silicon carbide technology can provide reliable, efficient, and cost-effective energy conversion and delivery.

By Alexis Bryson, Ph.D., Marketing Communications Manager and Muzaffer Albayrak, Strategic Business Developer, Wolfspeed

The term e-mobility, also known as electric mobility or electro-mobility, refers to the use of electric propulsion to drive a vehicle. Wide bandgap semiconductors like silicon carbide are used in vehicle inverters to manage the transfer of power from the energy source (e.g. battery or hydrogen fuel cell) to the electric motor. Although most widely associated with passenger electric vehicles (EVs), Wolfspeed expands the term to "industrial e-mobility" to encompass the range of applications across land, sky, water, and railway that run on all types of electric platforms.

While some industrial e-mobility segments are emerging, such as electric vertical take-off and landing (eVTOL) aircraft, others, like electric railway, are well established. Manufacturers within each segment are working to transition from traditional mechanical solutions to electrified systems that can increase power, improve efficiency, and reduce carbon dioxide (CO_2) emissions from transportation.

The ratio of vehicle electrification is growing across all transportation segments. Currently, 19% of EVs[1], >10% of construction and agriculture vehicles[2], 1-2% of water vehicles[3], and 45% of aircraft[4] are fully and partially electrified. These segments are growing at CAGRs of 20% for EVs[5], 21.5% for construction and agriculture vehicles[6], 12.7% for water vehicles[7], and 13% for aircraft[8] from about 2023 to 2030.

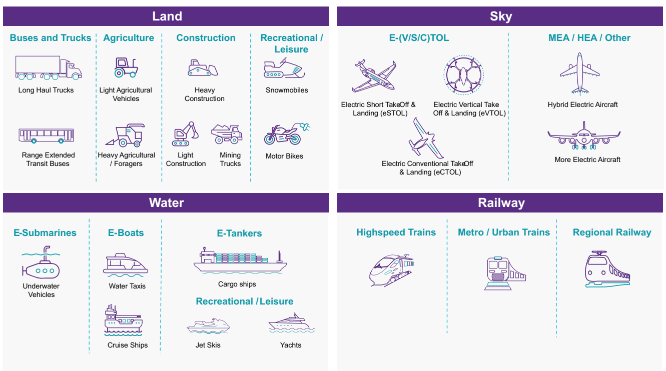

Figure 1: Examples of industrial e-mobility applications within land, sky, water, and railway markets.

Moving to Industrial E-Mobility

Two driving factors have prompted the rapid and widespread shift to vehicle electrification.

Driving Factor #1: Global Targets for Emissions Reduction

Transportation accounts for 20% of global carbon dioxide emissions, producing approximately 7.6 $GtCO_2$ a year[9]. This is primarily due to the burning of diesel and gasoline within internal combustion engine (ICE) vehicles. Although passenger cars and vans are the leading source of emissions, freight, shipping, aviation, and railway all contribute to the total environmental impact.

Therefore, governments worldwide are implementing increasingly stricter regulations (and offering new incentives) to curb emissions and accelerate the production of sustainable transportation. These regulations focus on reducing greenhouse gas emissions within given transportation segments. For example, the EPA Cleaner Trucks Initiative in the United States, PE-CONS 60/19 in the European Union, and VI Fuel Standards in China all set CO2 emissions performance standards for new light- and heavy-duty construction and agriculture vehicles.

Furthermore, the International Maritime Organization has implemented regulations to cut down greenhouse gas emissions from ships, including the Marine Environment Protection Committee (MEPC 80) session that targets a 40% reduction in CO2 emissions from international shipping[10]. The Energy Efficiency Design Index requires a maximum energy efficiency level for different ship types and size segments. This equates to a 30% CO2 reduction level for new builds in 2025 compared to the 2000-2010 average[11]. Other organizations including the International Civil Aviation Organization, European Union Aviation Safety Agency, Federal Aviation Administration, and Civil Aviation Administration of China all set emissions standards for aircraft.

In order to reduce emissions and adhere to these types of regulations, industrial e-mobility markets depend on the benefits of electrification: energy efficiency and zero emissions.

Driving Factor #2: Innovations in Power Semiconductors

Industrial e-mobility applications require reliable and efficient solutions to manage high voltages and currents under demanding environmental conditions. Compared to silicon, silicon carbide devices enable higher switching frequencies and greater power densities at much higher operating temperatures – which are all necessary for high-power industrial e-mobility applications.

Wolfspeed's release of automotive qualified (AEC-Q101) silicon carbide MOSFETs enabled manufacturers to begin the transition from ICE to electric vehicles. And starting in 2019, the release of higher power silicon carbide power modules, including the XM3 product family from Wolfspeed, enabled DC fast chargers to

Johannes Soldan, Stefanie Hagemann, Daniel Rückert, Steffen Knapp, GVA experts for development
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Product SKU	Configuration	Blocking Voltage	Current Rating	RDS(ON) at 25°C	Maximum Junction Temperature	Qualification
CAB320M17XM3	Half-Bridge	1700 V	320 A	3.5 mΩ	175 °C	Industrial
CAB400M12XM3	Half-Bridge	1200 V	400 A	4 mΩ	175 °C	Industrial
CAB425M12XM3	Half-Bridge	1200 V	425 A	3.2 mΩ	175 °C	Industrial
CAB450M12XM3	Half-Bridge	1200 V	450 A	2.6 mΩ	175 °C	Industrial
EAB450M12XM3	Half-Bridge	1200 V	450 A	2.6 mΩ	175 °C	Automotive

Table 1: Wolfspeed XM3 silicon carbide power module family

achieve a full charge in less than 4 minutes, making EV adoption more appealing and affordable for consumers. Automotive OEMs like General Motors, Lucid Motors, Jaguar Land Rover, Mercedes, and others continue to announce significant electrification plans for next generation EVs (including the transition from 400 V to 800 V power distribution architectures). State-of-the-art industrial e-mobility applications are following closely behind these developments, relying on technological innovations in silicon carbide to provide higher power density, higher system efficiency, and longer range, along with lower system cost and long-term reliability.

Industrial E-Mobility Case Study: Electric Water Vehicles

Let's take a closer look at how the benefits of silicon carbide can enable new developments in electric water vehicles ranging from jet skis and yachts to passenger ferries, water taxis, harbor craft, cargo ships, tankers, and submarines.

Half-Bridge Power Module Designed to Enable High Power Density

Wolfspeed developed the XM3 power module platform to maximize the benefits of silicon carbide while keeping the module and system design robust, simple, and cost effective. With half the weight and volume of a standard 62 mm module, the XM3 power module maximizes power density while minimizing loop inductance and enabling simple power bussing. The optimized packaging enables 175°C continuous junction operation, with a high reliability silicon nitride (Si3N4) power substrate to ensure mechanical robustness under extreme conditions. The XM3 is a perfect fit for demanding applications such as industrial e-mobility main inverters.

Within the main inverter of a water vehicle, XM3 power modules enable significant system-level optimization. Design engineers can increase power density without increasing system size by moving from a 200 kW [powered by the CAB400M12XM3] to 300 kW [powered by the CAB450M12XM3] inverter.

We used a 200 kW three-phase inverter reference design [200kW Three-Phase Inverter with XM3 Power Module | Wolfspeed] to compare silicon carbide power modules to silicon IGBTs.

This inverter design features a complete stack-up including modules, cooling, bussing, gate drivers, voltage / current sensors, and controller, and can be used in conjunction with Wolfspeed's SpeedFit Design Simulator tool [SiC and GaN Solutions SpeedFit Design Simulator | Wolfspeed] and Power Applications Forum [Wolfspeed Power Applications Forum].

a) Comparing efficiency vs output power using Wolfspeed's 200 kW three-phase inverter
b) Comparing inverter losses vs output power using Wolfspeed's 200 kW three-phase inverter

Overall, silicon carbide enables higher power, greater efficiency, lower switching losses, and higher switching frequency, within a lighter weight, smaller system.

The Electrification of Everything Inside Industrial E-Mobility

	Wolfspeed SiC 200 kW inverter CRD200DA12E-XM3	Wolfspeed SiC 300 kW inverter CRD300DA12E-XM3
Weight	6.2 kg	6.2 kg
Volumetric power density	21.7 kW/liter	32.25 kW/liter
Efficiency	98.28%	98.3%

Table 2: Comparing a 200 kW to 300 kW silicon carbide inverter.

Figure 2: Wolfspeed XM3 silicon carbide power module.

Figure 3: Wolfspeed 200 kW XM3 three-phase inverter.

In addition to main inverters for battery electric vehicles (BEVs) and fuel cell inverters for fuel cell electric vehicles (FCEVs), industrial e-mobility applications can integrate power electronics within battery management systems (BMS), auxiliary power supplies, auxiliary power drives, pump and fan actuators (HVAC systems), and onboard chargers. Each electrified system further reduces the number of mechanical components compared to ICE vehicles, enabling greater efficiency, lighter weight, and lower total cost of ownership.

These electrified systems conserve system-wide energy usage, reduce emissions, and extend lifetime through low losses, high power density, and high reliability and robustness. However, the operating environments of industrial e-mobility applications, including temperature fluctuations, vibration, high humidity, and harsh climates, impact which systems benefit most from electrification.

For example, water vehicles may integrate electric elevators, cranes, anchor winches, and automation systems, in addition to the main inverter.

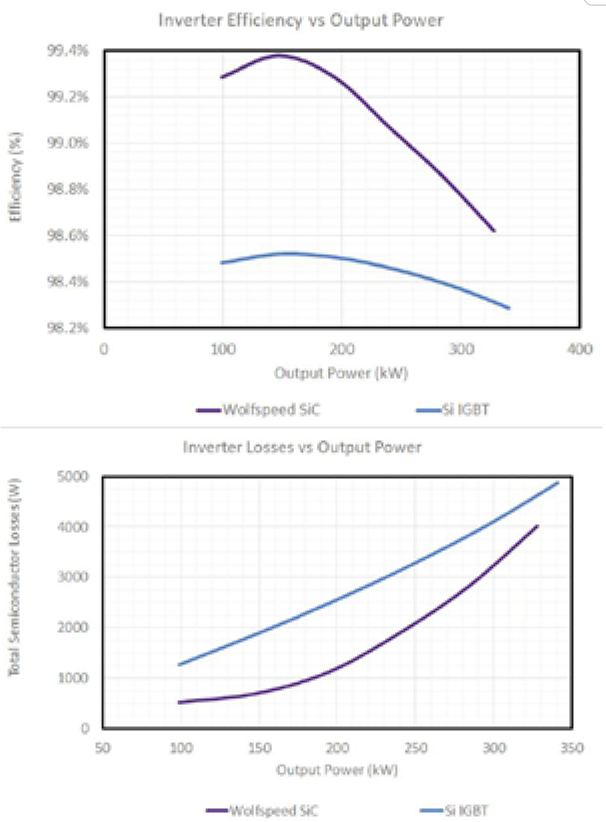

Figure 4: Comparing the simulated efficiency and switching losses between a Wolfspeed silicon carbide 200 kW power module [CAB-400M12XM3] and a silicon 200 kW IGBT for a water vehicle 800 V main inverter.

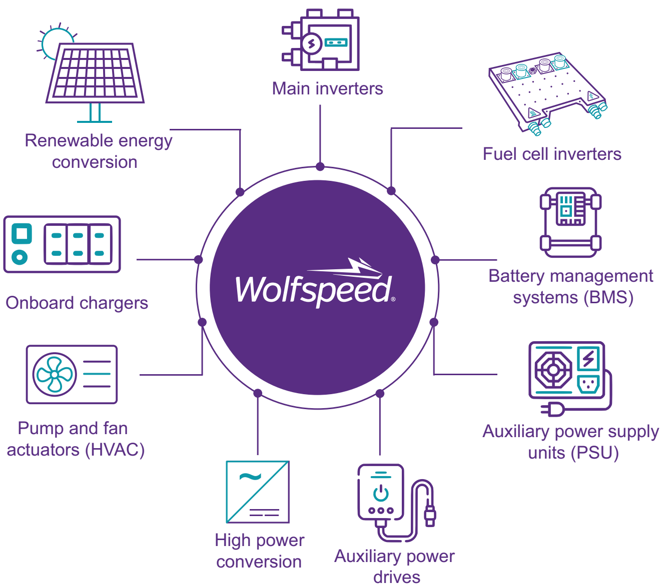

Figure 5: Power electronics systems within industrial e-mobility applications

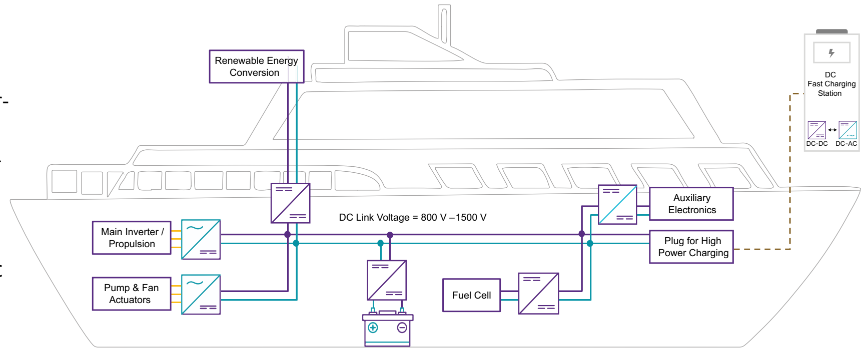

Figure 6: Example power electronics systems within water vehicles that can benefit from silicon carbide devices.

Numerous systems can also be electrified within off-highway land vehicles, which range from small forklifts to megawatt-consuming mining trucks. For example, electrical power take-off (ePTO) drives can lessen the load on the main inverter within heavy-duty construction and agriculture vehicles by harnessing and distributing power to auxiliary functions. And lower-power inverters can replace existing mechanically driven systems such as fans, pumps, actuators (HVAC) and thermal management systems.

Advanced air mobility applications can integrate a series of smaller, more efficient electronics systems that can lower weight and conserve space inside vehicles where size, weight, and power (SWaP) ratios matter most. Electric spoiler controls, solid state power controllers, circuit breakers, de-icing systems, and green taxing systems are key systems within these vehicles. The lighter weight and smaller size achieved by integrating power electronics within these auxiliary systems translates into extra range and/or extra cargo capacity.

Finally, regional, metro, and high-speed railway applications operate at high voltages, sourcing power that is distributed from a grid to overhead (or under rail) lines. Trains can also incorporate electric power systems for door control, braking, and energy recuperation within battery and grid designs. Each of these systems require reliable and efficient power semiconductors to supply and manage electrical switching. Silicon carbide is the best-in-class technology for the voltage classes required by not only the main inverter, but also the wide range of auxiliary power supplies and drives essential within industrial e-mobility applications.

Challenges Facing the Future of Industrial E-Mobility

Two of the biggest challenges for the future of industrial e-mobility are energy sources and infrastructure. All electric vehicles require an energy source—most commonly a battery or hydrogen fuel. Industries have already recognized the rising demand for both. According to the International Energy Agency, battery production will increase 400%[12] and hydrogen production will increase by >18%[13] from 2023 until 2030.

In addition to a larger quantity of batteries, industrial e-mobility will require more powerful batteries to get the required energy density within the same space (more watt hours per kilogram). Batteries with higher power density are better suited to vehicles with higher power inverters such as heavy-duty construction vehicles and cargo ships. These battery and hydrogen market developments are essential to the future of industrial e-mobility.

Infrastructure—high power charging stations, electric grid capacity, and hydrogen refueling stations—is also crucial.

Regional and local governments are investing in charging stations to boost EV adoption, but expanding, scaling, and maintaining efficient, fast, and high-power charging infrastructure is a substantial undertaking. For EVs, this means roadside superchargers.

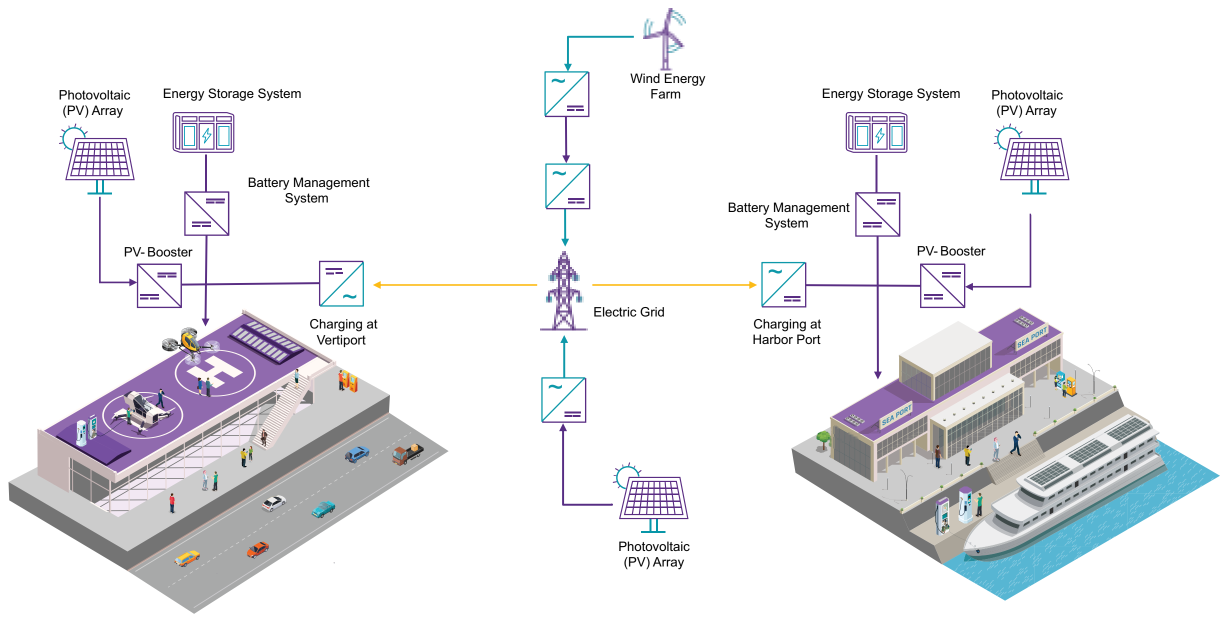

Figure 7: Renewable energy sources can support upcoming high-power charging infrastructure at vertiports and harbors.

For long-haul trucks, this means megawatt charging system (MCS) technology. For regional buses, this means depot charging. For ships, this means charging at harbor ports. For aircraft, this means charging at vertiports.

Wolfspeed's Long-Term Vision for the Industry

Wolfspeed is leading the transition from silicon to silicon carbide as we enable the industry through a growing number of product portfolios that scale from less than 2 kW up through the megawatt range and address a broad range of voltage, current, and isolation requirements.

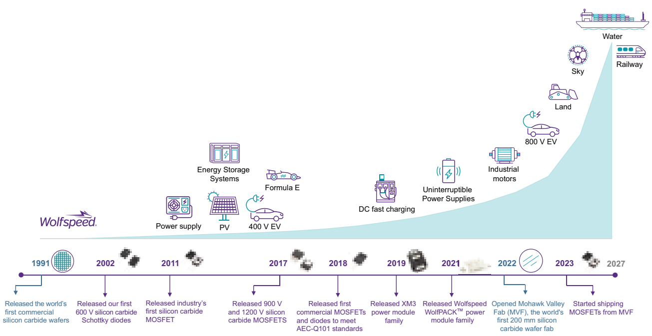

Figure 8: Wolfspeed's innovations in silicon carbide materials and devices have enabled many different markets, including advancements in industrial e-mobility.[14]

From now until 2027, we expect a significant percentage of the silicon carbide device market to come from industrial and energy applications, including industrial e-mobility.

For more than 35 years, Wolfspeed has focused on producing vertically integrated silicon carbide wafers and high-quality power devices in our mission to save the world energy. To-date, Wolfspeed has manufactured more than 60% of the world's silicon carbide. Our silicon carbide devices have surpassed 12 trillion field hours. We have a global footprint of support. And we can work directly with manufactures to develop high-performance silicon carbide products that are optimized for the specific requirements of industrial e-mobility applications.

Wolfspeed is scaling our capacity to meet the surge in demand for reliable and efficient energy conversion and power delivery solutions. In 2022, we opened the world's first and largest 200 mm silicon carbide fabrication facility in Marcy, New York. This state-of-the-art power wafer fab will be automotive-qualified and has already started shipping MOSFETS. It is complemented by our materials factory expansion at our Durham, North Carolina headquarters, our upcoming materials manufacturing facility in Siler City, North Carolina, and the world's most advanced silicon carbide device manufacturing facility planned for Saarland, Germany. These investments are necessary to support the rapid growth of industrial e-mobility applications, meet the climate goals of nations around the world, and achieve sustainable electrification.

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Powering Generative AI Platforms with TCO at the Core

The datacenter of the future – the AI factory – runs on thousands of AI accelerators, each of which consume over 1000 A. Creating a green AI factory starts with designing an efficient voltage regulator (VR) to provide such high currents to these AI accelerators with high power density and efficiency.

By Davood Yazdani, Senior Director Product Marketing, and Paul Yeaman, Director Power Module Design Engineering, Infineon Technologies

Artificial intelligence is driving exponential growth in global data generation, especially with the recent boom of generative AI queries. The energy demand of the chips supporting this enormous data growth have exponentially increased, with each chip approaching >1000 W of thermal design power. Datacenter utility power is reaching its limits as AI servers demand three times higher energy than traditional servers.

Datacenters consume more than two percent of global energy and will consume more. Power solutions and architecture innovations are critical for a measurable impact on global energy savings and better total cost of ownerships (TCOs) for datacenters.

Evolution of processor power requirements

Traditional servers have a processor (<200 A thermal design current, or TDC), coprocessor (<30 A), and memory DIMM (<40 A). The processor is in the board's center, with one side for power and three sides for signals and communication (to the memory and coprocessor).

As computers evolved and high-powered AI-compute applications emerged, CPU/GPU/FPGA vendors and AI start-ups designed faster, powerful ASIC and AI chips. Core-rail current levels doubled to 400 A TDC in 2016, and again four years later to 800 A TDC.

When core rail current increased beyond 200 A, single-sided entry became impractical due to excessive power distribution network (PDN) losses and vendors standardized double-sided entry. It halved the PDN resistance, but PDN losses still grew due to I2R. Vendors integrated the coprocessor and memory with the core processor to increase speed and performance. The coprocessor, instead of being a separate entity, was now located on the core silicon, and high-bandwidth memory (HBM) replaced memory DIMMs. All the power driving the AI processor was physically consolidated into the motherboard's main area. As power increased, the heat was concentrated in a small area.

Processors became larger as well. The industry standard form factor for AI applications is the OCP Accelerator Module (OAM), with typical AI server motherboards accommodating ≤8 OAM modules. An OAM's size (170 × 102 mm) became insufficient for larger AI chip sizes and total power requirements. New high-current AI chips were as large as 110 × 80 mm, leaving limited space for power components due to two large mezzanine bottom connectors. Cooling system design became challenging due to high PCB losses, higher heat density, and component height restrictions.

The challenge

With new AI systems requiring >1000 A concentrated within a small area at the OAM's center, double-sided entry led to multi-sided entry (figure 1), where the resistance scales down by 1/N, N being the number of sides with power. However, this reaches a ceiling, as there are only four sides to a processor and a limited perimeter from which to source current easily.

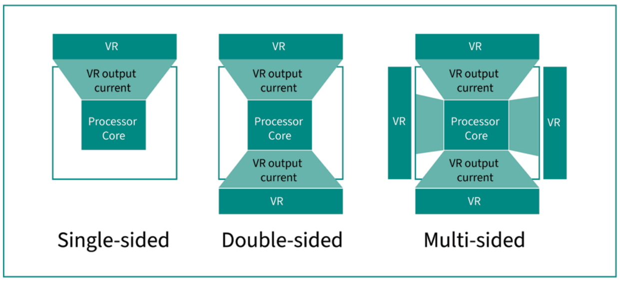

Figure 1: Different methods of voltage regulators (VR) supplying current to the processor core. Each additional side dedicated to supplying power results in more of a challenge for routing signals.

Arranging phases in multiple rows increases PDN resistance as high currents sourced from the back would be routed around the forward stages. Additionally, signal integrity becomes an issue with four-sided entry due to limited places to route sensitive signals while avoiding power planes, which tend to be noisy.

A >1000 A design requires a solution addressing three obstacles:

- increasing power density allowing more current to be sourced from a small space
- increased power integrity allowing power to coexist near high-speed signals
- a low profile enabling power to be sourced from underneath the processor

Modules

Dual-phase power modules incorporate the inductor, discrete capacitors, and power stages of two phases of a multiphase buck regulator onto a substrate to create a single device, deployed in an array as a multiphase system. By this integration of the voltage regulator (VR), a power module decreases a multiphase solution's footprint by 40 percent compared to an equivalent discrete solution.

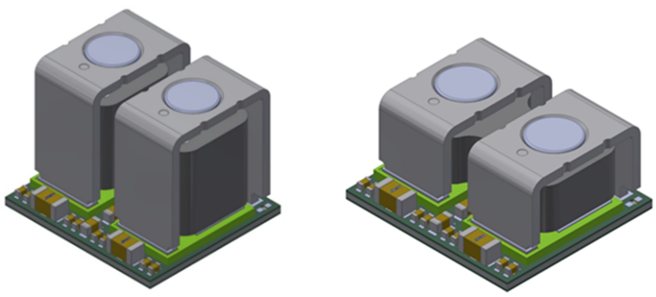

Figure 2: Infineon's dual-phase modules TDM22544D (8 mm tall) and TDM22545D (5 mm tall).

When integrating the inductor and power stage, what should be located on the surface closest to the heatsink?

Since the power stage causes most of the power loss, locating it on top, closest to the heat sink, minimizes the heat conduction path and improves thermal performance. However, a shorter heat conduction path is offset by a longer electrical conduction path, particularly on the input side, leading to additional losses and lower efficiency.

A better design keeps the power stage on the motherboard side of the module, minimizing both conduction and parasitic losses. In this configuration, the inductor is located between the power stage and the heatsink, but still able to effectively cool the power stage by thermally coupling it to the heatsink.

Infineon's dual-phase modules (figure 2) utilize a proprietary inductor-on-top design for improved thermal performance with better efficiency (figure 3). This design maximizes heat-conduction to the top surface from the key heat-generating areas of the power stage below it, through the inductor.

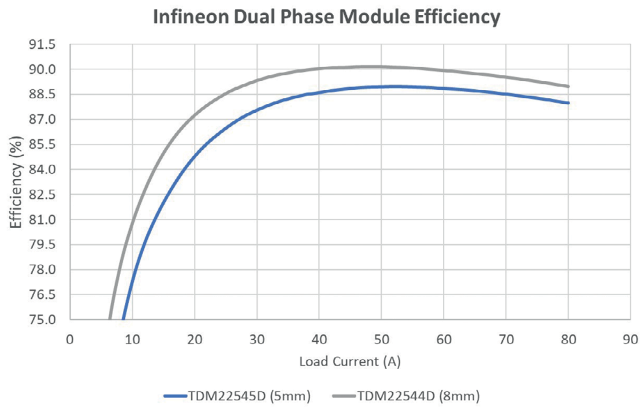

Figure 3: Infineon dual-phase module efficiency at 13.5 V input, 0.8 V output, 800 kHz.

The power module also adds a vital electrical component to the VR: the substrate. The substrate isolates the switch-node from the motherboard, rendering all input and output currents into the module at a constant DC voltage. This improves signal integrity by eliminating switching voltages from the motherboard and protecting sensitive signals from noise-coupling.

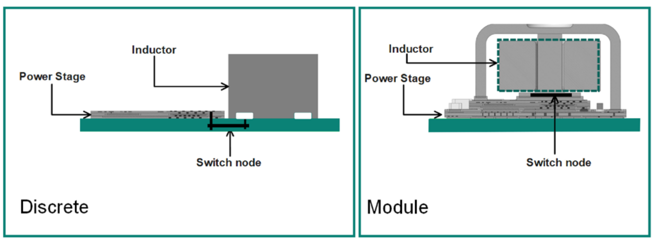

Figure 4: Implementing the switch-node inside the module reduces impedance as well as parasitics that cause noise and limit performance.

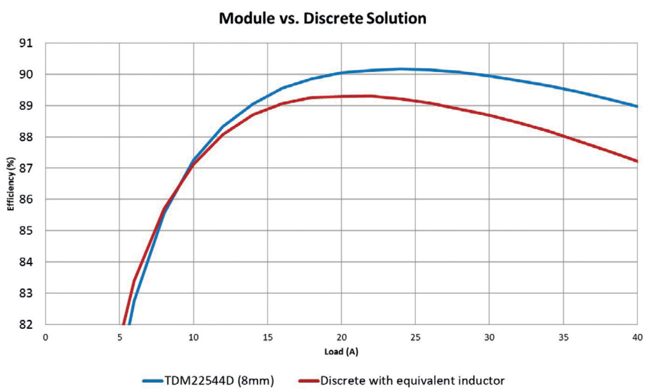

Figure 5: Efficiency comparison between a single phase of a module and a single phase of a discrete solution at 13.5 V input, 0.8 V output, 800 kHz.

At higher switching frequencies, switch-node parasitics limit efficient switching of the VR. Integrating the switch-node into the module (figure 4) minimizes its parasitic impedances for a more efficient operation at higher switching frequencies (figure 5). High switching frequency VRs use smaller inductors and less output capacitance, increasing power density.

Once the switch-node is off the motherboard, the module can now be located under the processor. This minimizes PDN losses as the high current flows vertically through the thickness of the motherboard, instead of laterally traversing the package to the core. This reduces the current path by ~30 times, significantly reducing power losses.

PDN study

Dual-phase power modules are critical to high-power GPU systems due to effective power density and signal integrity management without reducing system efficiency. Locating modules closest to the processor and utilizing all the available mounting area, achieving >2000 A becomes feasible by reducing PDN losses.

Assume a 2000 A OAM with 90 μΩ resistance from the north and south sides of the processor core. Sourcing 100 percent of the current from both sides yields 180 W of PDN loss, or >10 percent of the total processor loss (assuming 0.8 V core voltage). Sourcing 60 percent of that current from underneath the processor at 18 μΩ, PDN losses drop by 70 percent to 50 W, or ~3.1 percent of the total processor loss.

Since typical large-scale deployments consist of ~100,000 processors, saving 130 W/processor translates into megawatts for a datacenter. This means millions of dollars saved over the system's lifetime.

Improving power efficiency at the core yields significant energy savings. Leveraging decarbonization-based technology improves each power conversion stage starting with AC power entry. Service providers can leverage Infineon's XDP™ controllers, dual-phase power modules, combine them with AI capabilities in datacenters, to deliver superior power-conversion efficiency, enhanced flexibility and energy-efficiency in system-design, and the best TCO for datacenters.

Conclusion

Increasing power density without compromising on efficiency is key to presenting a path to an efficient and green 2000 A GPU system and beyond. Modules enable this path and open new avenues for being able to further integrate the multiphase VR while also moving it closer to the processor. Infineon's patented inductor technology carries both output current and heat from the module and enables best-in-class system performance with simpler construction. Combining Infineon's Trench device technology with this patented magnetic technology paves the way for true Vertical Power Delivery (VPD) architectures that enable AI processors to achieve the best possible performance and lowest TCO.

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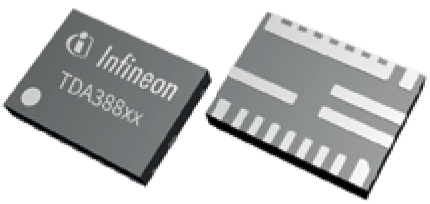

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GaN Technology Exhibits Extreme Robustness for Space Missions

In this article, we delve into the reasons why GaN power devices are the ultimate choice for power conversion applications in space and how their resistance to radiation makes them an extremely robust solution for space missions.

By Max Zafrani, Chief Technology Officer, EPC Space

Space exploration has always demanded cutting-edge technology, reliability, and resilience. The latest breakthrough in power electronics, gallium nitride (GaN) technology, has emerged as a game-changer for space-based systems, offering superior radiation tolerance and unmatched electrical performance compared to traditional silicon MOSFETs.

GaN's Resilience to Radiation

Space is a harsh environment in which semiconductors can experience various forms of radiation, including gamma radiation, neutron radiation, and heavy ion bombardment. GaN devices have showcased exceptional radiation tolerance, setting them apart from the silicon MOSFETs traditionally used.

An energetic particle can cause damage to a semiconductor in three primary ways; it can cause traps in non-conducting layers, it can cause physical damage to the crystal – also called displacement damage, or it can generate a cloud of electron-hole pairs that will cause the device to momentarily conduct, and possibly burn out in the process. In enhancement-mode GaN (eGaN®) devices, energetic particles cannot generate momentary short-circuit conditions because mobile hole-electron pairs cannot be generated.

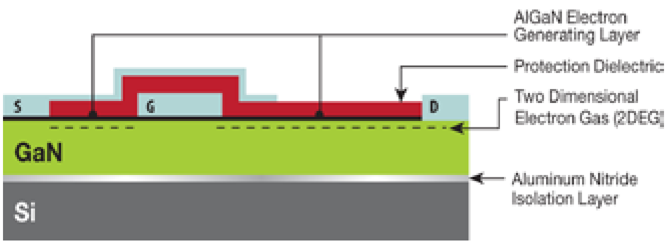

Figure 1: Cross section of a typical enhancement mode GaN (eGaN®) device

Gamma Radiation

GaN's unique construction and intrinsic material properties make it highly resistant to gamma radiation. eGaN devices are built very differently from a silicon MOSFET. All three terminals; gate, source, and drain, are located on the top surface. In figure 1, you can see that the gate is separated from the underlying channel by an aluminum gallium nitride layer. This layer does not accumulate charge when subjected to gamma radiation. This ensures that GaN devices maintain their performance even in the presence of high-energy photons.

Neutron Radiation

Neutron radiation primarily causes displacement damage to semiconductor devices, affecting parameters like $R_{DS(on)}$. GaN devices exhibit minimal degradation even at high neutron exposure levels (up to 4x10^15 fluence) due to their significantly higher displacement threshold energy compared to silicon as seen in figure 2.

Heavy Ion Bombardment

Heavy ion radiation can lead to single-event effects (SEE) like single event gate rupture (SEGR) and single event burnout (SEB) in silicon MOSFETs. Single event gate rupture is caused by the energetic atom causing such a high transient electric field across the gate oxide that the gate oxide ruptures. Single event burnout is caused when the energetic particle transverses the drift region of the device where there are relatively high electric fields. The energetic particle loses its energy while generating many hole electron pairs. These hole electron pairs crossing the drift region cause the device to momentarily short circuit between drain and source. This short circuit can either destroy the device, called a single event burnout, or the device can survive, appearing as a momentary short circuit that can cause damage to other components in the system. The absence of a gate oxide in GaN devices makes them immune to gate rupture. Moreover, heavy ion bombardment only slightly increases the drain-source leakage current in GaN devices, well below the defect limit, as confirmed through extensive testing.

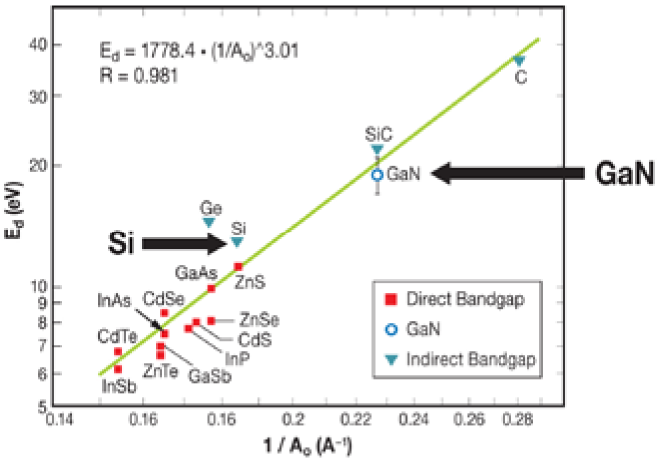

Figure 2: Displacement energy compared with the inverse of the lattice constant for various crystals(1)

Published reliability reports, see https://epc-co.com/epc/design-support/gan-fet-reliability,explain the failure mechanisms for GaN devices, as well as establish predictive models so designers can estimate the lifetime of devices in their specific mission profile.

Superior Electrical Performance of GaN

Beyond radiation resilience, GaN devices offer unmatched electrical performance compared to silicon MOSFETs. GaN devices enable power converters to operate at higher frequencies, resulting in greater efficiency and power density. For space applications like satellites and lunar habitats, this translates to smaller, lighter, and more efficient power supplies. GaN devices are significantly smaller and lighter, making them ideal for applications where space is at a premium. Their size reductions contribute to cost savings by optimizing space utilization in satellite payloads.

Applications Transforming Space Missions

The advantages of GaN technology extend to various spaceborne systems:

DC-DC Converters: GaN-based DC-DC converters, such as those used in satellite power supplies, offer peak efficiencies of up to 96%, outperforming silicon alternatives and contributing to increased energy efficiency in space missions.

Lidar Systems: GaN's speed and efficiency enhance lidar systems, providing higher resolution and more precise navigation for autonomous space missions and docking.

Reaction Wheels: Critical for satellite orientation, GaN-powered reaction wheels offer precision control, reduced weight, and reliability in harsh space environments.

Ion Thrusters: GaN enables smaller, lighter, and more efficient power supplies for ion thrusters, crucial for spacecraft propulsion and positioning.

Collaboration with Space Agencies

GaN technology's adoption in space missions has gained momentum, with collaborations between industry leaders like EPC Space and space agencies such as NASA, DLA, and ESA. These partnerships aim to standardize GaN technology testing and screening procedures, further validating its suitability for space applications.

Cost Savings and Sustainability

The cost-saving potential of GaN technology is significant. Smaller power converters optimize space utilization providing cost savings for satellite payloads. The efficiency improvements capable with GaN translate to reduced power consumption and longer mission life. Additionally, GaN's robustness in harsh environments minimizes component failures and replacements, contributing to sustainability by reducing electronic waste generated by space missions.

EPC Space: Rad-Hard GaN Transistors

EPC Space offers a family of Rad-Hard GaN transistors that have been designed for radiation hardness, and every wafer is radiation sample tested prior to shipping to the customer. These rad-hard GaN transistors offer ultra-low on-resistance and high current capability. These devices offer cost-effective, efficient, mission-critical components with a superior figure of merit, substantially smaller size, and lower cost than alternative rad hard silicon solutions for satellite power supplies, robotic motor drives, instrumentation, reaction wheels, and deep space probes. EPC Space's GaN devices have proven themselves with over 130,000 deployments in LEO and GEO orbits since 2017, solidifying their space heritage and reliability.

Conclusion

Gallium nitride (GaN) technology has ushered in a new era of power electronics in the space industry. Its resilience to radiation, superior electrical performance, cost-saving opportunities, and sustainability makes it the go-to choice for space missions.

Graph of displacement threshold energy vs. the invers of the lattice constant for different materials taken from S.J.Pearton, F.Ren, E.Patrick, M.E.Lawand, A.Y.Polyakov, "Review – Ionizing Radiation Damage Effects on GaN Devices", ECS Journal of Solid State Science and Technology, 5 (2) Q35-Q60, 2016.

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What Are the Most Important Timing Factors for Low Power Precision Signal Chain Applications? Part 2

This article explains timing factors and solutions for reducing power while maintaining precision in low power systems, as required for measurement and monitoring applications. It explains the factors that influence timing when the ADC of choice is a successive approximation register (SAR) ADC. It explores signal chain considerations in analog front-end timing, ADC timing, and digital interface timing. For sigma-delta (∑-Δ) architectures, the timing considerations differ (see Part 1 of this article series).

By Padraic O'Reilly, Product Applications Engineer, Analog Devices

Analog Front-End Timing Considerations

These three blocks in Figure 1 can be viewed independently starting with the analog front end (AFE). The type of signal chain will change the AFE but there are some common aspects that can apply to most circuits.

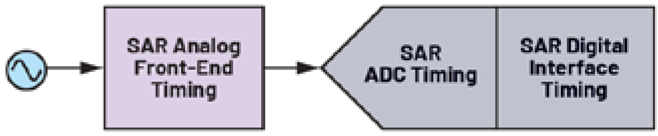

Figure 1: AFE timing considerations with a multiplexed SAR ADC.

Figure 2 shows the AD4696 SAR ADC, the external amplifier, and a low-pass filter that make up the AFE. The AD4696 is a 16-bit, 1 MSPS multiplexed SAR ADC with Easy Drive™ features. While external amplifiers and circuitry are required to interface with external sensors, Easy Drive features such as analog input high-Z mode and reference input high-Z mode reduce the analog input and reference drive requirements. In higher power applications, the SAR ADC's antialiasing filter design needs to be aggressive, but for sampling lower bandwidth signals, typical of low power applications, the filter design is less demanding. The benefit to a sigma-delta architecture is that we can rely on the digital filter to determine frequency response and use the external antialiasing filter to filter at the modulator frequency. In the absence of oversampling and the inherent filtering qualities, an external analog low-pass filter is required to prevent any higher frequency signals present above the sample rate aliasing into the passband. The low-pass filter also acts to reduce wideband noise from the analog front-end circuitry, reduce the nonlinear voltage kickbacks that occur at the analog inputs, and protect the analog inputs from overvoltage events. The same principle applies to the timing considerations. See the antialiasing filter section in the article "What Are the Most Important Timing Factors for Low Power Precision Signal Chain Applications? Part 1."

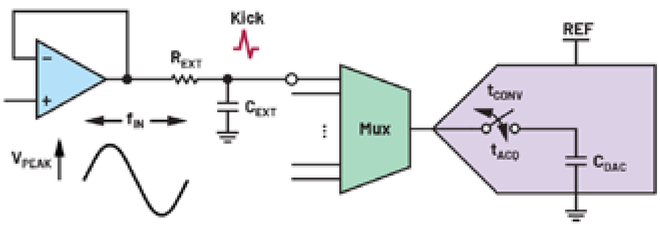

Figure 2: The AD4696 SAR ADC with an external kickback RC filter and a driver amplifier.

The SAR ADCs, while sampling, incorporate a sample-and-hold mechanism, which is a switch and a capacitor that captures the input signal until a conversion is gathered.

The design of the amplifier stage is a two-step process. The first step is to select the signal conditioning amplifier and external antialiasing stage similar to what is discussed in Part 1 of this article series. The next step is to choose an external driver amplifier (which has a bandwidth dictated by the gain; remember there is a power vs. bandwidth trade-off) that will buffer the signal conditioning antialiasing filters output and drive the ADC input. The next step is to design the kickback filter taking the total capacitance C_{EXT} + C_{DAC} as the total capacitance of our filter.

Multiplexed SAR ADCs suffer from the issue of kickback when switching between analog input channels. Each time the switch is closed, the internal capacitor voltage (C_{DAC}) may be different from the voltage previously stored on the sampling capacitor (C_{EXT}). A voltage glitch occurs when these switches close due to the difference. The energy will be shared between them, and the voltage measured between the capacitor terminals will be halved. The C_{EXT} and C_{DAC} values will impact filter designs and need to be considered when designing a circuit. The kickback and the choice of the ADC driver are described in detail in the AD4696 data sheet. ADC driver tools in conjunction with helpful training videos are also available.

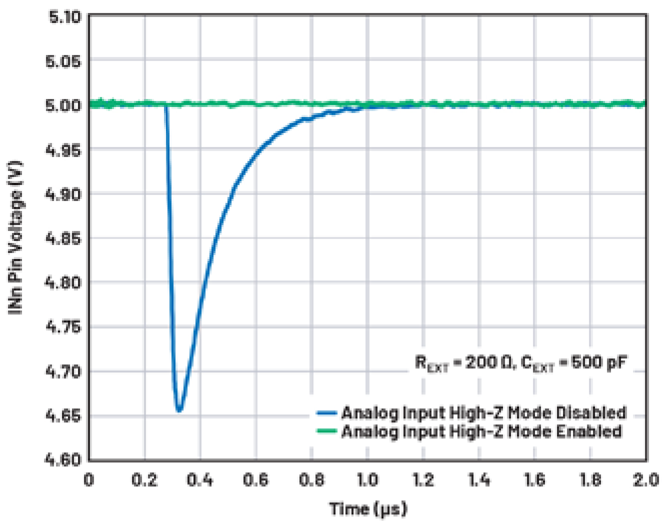

Figure 3: High-Z mode's impact on kickback.

The AD4696 contains an analog input high-Z mode. This significantly reduces the magnitude of the voltage kickback as seen in Figure 3. The analog input high-Z mode also reduces performance degradation caused by series resistance between the front-end amplifiers and the AD4696 analog inputs, which allows the resistor in the external RC filter to be larger compared to traditional multiplexed SAR ADCs. Using larger R_{EXT} with smaller C_{EXT} alleviates amplifier stability concerns without significantly impacting distortion performance, although C_{EXT} = 500 pF minimum is recommended if an internal overvoltage protection clamp is enabled to avoid stability issues. Figure 3 shows us that we can sample the required signal quicker, speeding up our system timing.

ADC Timing Considerations

The ADC that is chosen will depend on what is important in your system. There are numerous articles that touch the subject of which is a better fit in terms of performance and that compare SAR and sigma-deltas technology. In the low power space, there is plenty of overlap between SAR and sigma-deltas measuring similar signals. One thing that is clear, SAR timing is more straightforward to understand.

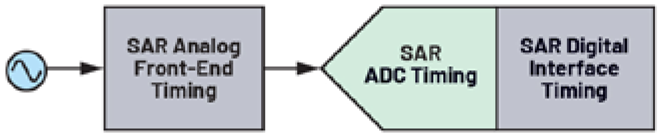

Figure 4: The AFE SAR timing considerations.

SAR ADCs sample the input at a point in time and consist of an acquisition phase and a conversion phase. In the acquisition phase, the sample-and-hold network or the internal capacitive network is being charged (Figure 2). In the conversion phase, the capacitor array is switched to a comparator network and a weighting on the DAC is modified until a code corresponding to the analog input is reached.

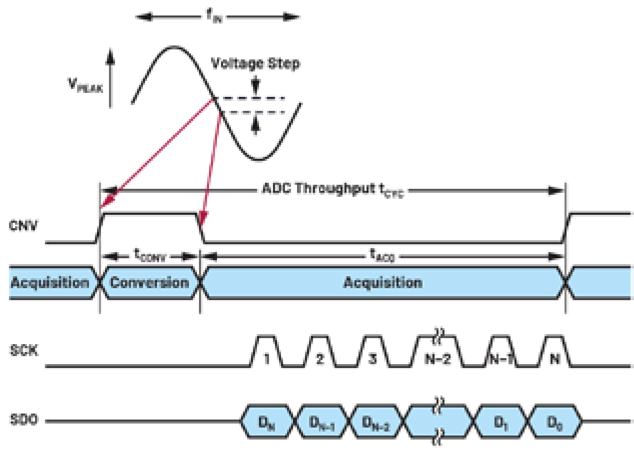

Figure 5: A typical SAR ADC timing.

The maximum conversion time is specified in the data sheet and is 415 ns for the AD4696. The minimum conversion time to acquire the signal is 1715 ns, which is the acquisition time for the AD4696 while operating at 500 kSPS. The time between conversions is the throughput rate.

In terms of timing, the main trade-off in relation to the SAR ADCs is the power consumption vs. the ADC sample rate. SAR ADCs have the advantage of having a direct linear relationship between the sample rate and supply current, which means that it can scale depending on the bandwidth of the signal of interest. The internal ADC core powers down between conversions, so when operating at lower sample rates, 10 kSPS for example, the AD4696 typically consumes 0.17 mW vs. 8 mW at 1 MSPS making the devices suitable for battery-powered applications at lower sample rates.

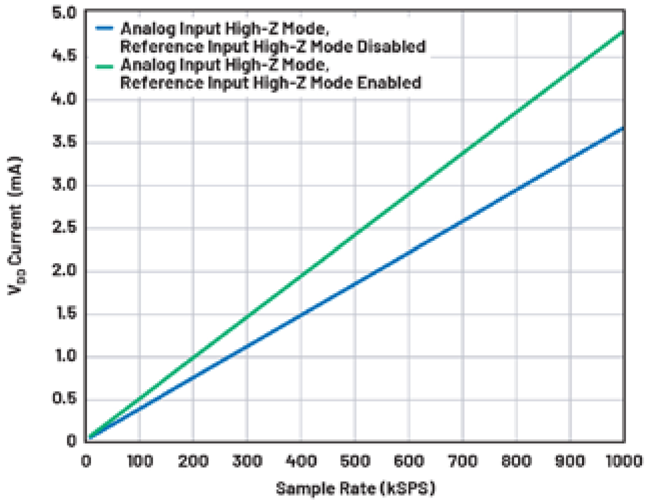

Figure 6: VDD current vs. sample rate.

Figure 6 shows the V_{DD} current. If we reduce the sample rate of the AD4696 to work in the sub 100 kSPS range vs. at 500 kSPS, our I_{DD} current drops from almost 2.5 mA to 0.5 mA. If we reduce the current further to 10 kSPS, our typical I_{DD} current reduces to 42 μA. The rate of increase in current is linear. All digital and analog supply currents scale in a similar linear fashion, making the SAR ADC an attractive proposition for measurement of DC-to-AC signals using the same part.

Digital Interface Timing Considerations

There are several features associated with the AD4696 that would not be traditionally associated with SAR ADCs that can help low power signal chain designers achieve additional power savings but with timing implications.

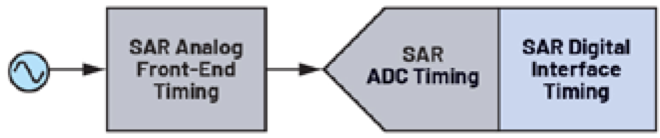

Figure 7: SAR digital interface timing considerations.

A SAR ADC's throughput rate in comparison to the sigma-delta architecture is easier to calculate as filter latency does not need to be considered:

$$Throughput\ Rate\ (SPS) = \frac{1}{t_{CYC}} \div CHs \qquad (1)$$

CHs = the number of channels enabled.

The cycle time is the time between CNV rising edge transitions and consists of a combination of the acquisition and conversion phase but there can be overlap. The ADC can begin acquiring a signal while the conversion phase is still taking place. The time between samples on a SAR ADC can be described as cycle time t_{CYC} or sample rate time t_{SR}.

$t_{CONVERT}$ = conversion time t_{ACQ} = acquisition time

t_{CYC} = t_{SR} = inverse of the sample frequency, the time between samples

The sample instant of when the conversion takes place is controlled by the CNV signal rising edge. In most modes, this is provided by an external signal. The AD4696 also has an on-chip autocycle mode that can generate the convert start signal internally. This signal kick starts the conversion. There are a number of sequencer modes available on the AD4696 allowing the user to choose the order and configuration of conversions in a predefined fashion or control the

next channel in the sequence on-the-fly without interrupting conversions.

The digital host must read back the data before the start of the next conversion. With higher speed signals, the SCK frequency must therefore be fast enough to read back the data from the AD4696 SPI before the next CNV rising edge (or internal convert start signal when in autocycle mode). Faster sample rates require faster SCK frequencies because the time between conversions is shorter.

The minimum required SCK frequency is a function of the sample rate, the length of the SPI frame (in bits), and the serial data output mode in use. Conversion results for a given sample are available until the start of the next conversion phase. The SCK frequency must therefore be fast enough to read the data from the AD4696 SPI before the following CNV rising edge (or internal convert start signal when autocycle mode is enabled).

Multiple SDO Digital Outputs
The AD4696 family also includes dual-SDO and quad-SDO modes. In these modes, ADC results are shifted out on SDO and additional GPIO pins in parallel. These modes significantly reduce the required SCK frequency for a given sample rate by doubling or quadrupling the number of bits output on the SPI per SCK period. This reduces the requirement on the microcontroller, which reduces the required clock from 32 MHz SPI clock to 16 MHz SPI clock when converting at 1 MSPS.

The number of SCK periods required per conversion mode frame (NSCK) is a function of the number of bits per frame (NBITS) and the number of serial data outputs (NSDO):

$$N_{SCK} = \frac{N_{BITS}}{N_{SDO}} \tag{2}$$

Where N_{SDO} is 1 for single-SDO mode, 2 for dual-SDO mode, and 4 for quad-SDO mode.

The start of the conversion mode SPI frame must not occur before the $t_{CONVERT}$ time has elapsed and must complete early enough to adhere to the minimum t_{SCKCNV} specification. The amount of time given to complete an SPI frame in conversion mode (t_{FRAME}) is calculated as follows:

$t_{FRAME} = t_{CYC} - t_{CONVERT\_max} - t_{SCKCNV}$

Where t_{CYC} is the sample period, $t_{CONVERT\_max}$ is the maximum, $t_{CONVERT}$ is the specification, and t_{SCKCNV} is the SCK to CNV rising edge delay specification.

The f_{SCK} is a function of t_{FRAME} and N_{SCK}.

$$f_{SCK} > \frac{N_{SCK}}{t_{FRAME}} \tag{3}$$

The AD4696 data sheet includes a table that gives examples of minimum SCLK frequencies vs. several sample rates.

Autocycle Mode
For voltage or current level monitoring applications traditionally, SAR ADCs require a host controller to issue a convert signal continually for conversions to take place. The system needs to examine the data for thresholds and to make decisions based on these levels. This is not power efficient because it means the host needs to continually convert. The AD4696 can be configured to convert autonomously on a user programmed channel sequence.

Autocycle mode is a great mode to use for monitoring analog inputs. There are several options for the conversion period ranging from 10 µs (100 kSPS sample rate) to 800 µs (1.25 kSPS sample rate). This mode can be used in conjunction with threshold and hysteresis detection alerts that are configurable on a per channel basis to reduce overhead for the digital host system. In this scenario, the host controller can enter a low power state and only power up when it receives an interrupt from the AD4696 when a level is triggered.

Oversampling
Oversampling and decimation are inherent to sigma-delta architecture as seen in Part 1 of this article series. The AD4696 SAR ADC includes an oversampling and decimation engine to allow for further noise reduction. It effectively averages consecutive ADC samples to generate an oversampled result with higher effective resolution and lower noise. The effective number of bits increases by 1 bit every time the oversampling ratio (OSR) is increased by a factor of 4 on the AD4696.

This is especially useful in measuring a slower moving signal found in a low power signal chain application, such as temperature, that requires higher precision.

$$t_{SAMPLE} = t_{CYC} \times OSR \tag{4}$$

Where t_{SAMPLE} = the sample period, t_{CYC} = cycle time (1/sample rate), and OSR = oversampling ratio (a programmable value of between 4 and 64).

The trade-off, similar to sigma-delta ADCs, is between performance and speed.

Topic	Timing Considerations	Low Power Signal Chain Impact
Antialiasing Filter	Delays can exist that impact the first conversion result(s)	Less aggressive filtering needed compared to higher speed signal chains
High-Z Mode	The kickback time is reduced when switching channels	Power scales with sample rate; less external circuitry
Current vs. Sample Rate	Reducing power reduces your sample rate	Reducing your sample rate reduces power
Autocycle Mode	Software configurable internal convert start	Host controller can enter a low power state
Dual-SDO and Quad-SDO	At higher sample rates, read back of all data not possible with single SDO	Trade-off between extra circuitry and data speeds
Oversampling	The interval between samples increases as the oversampling increases	Increasing OSR improves noise and resolution performance

Table 1: SAR Summary

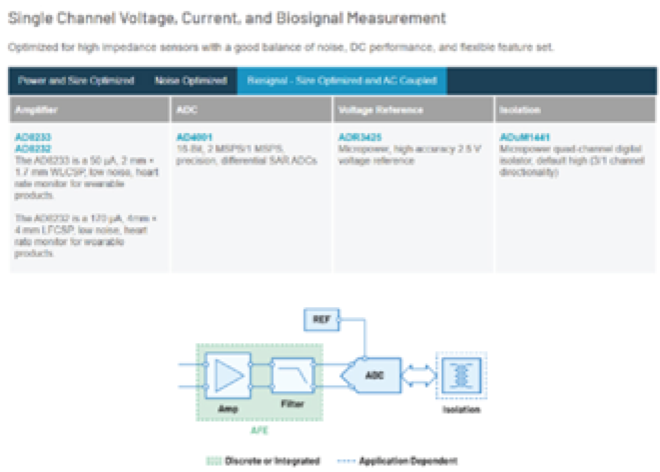

Figure 8: The precision low power signal chains webpage.


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Low Power Precision Platforms

As the trend in energy cost increases globally and we learn about the impact of our energy usage on the natural world, system designers are working to achieve precision with reduced power budgets. It can be difficult to research and find the lowest power components available. Analog Devices is simplifying the design process by taking our lowest power precision components and providing a one stop shop with ready-to-go signal chains and circuits that supply system designers with the most up-to-date precision low power offerings.

Example: Low Power SAR Signal Chain

Many applications require the measurement of a small signal on top of a large DC offset or common-mode voltage. If the aim of a system is to monitor flow in an industrial environment or make a biopotential measurement, there is overlap in the approach. These signals typically need AC coupling to remove the large offset as well as biasing and gain to maximize the dynamic range of the ADC.

Our low power precision signal chains include suggestions on which devices to choose for this type of application.

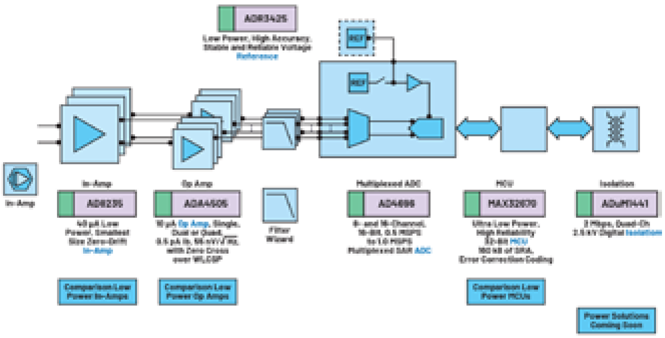

Figure 9: A signal chain example.

In addition, know-how with integrated knowledge (KWIK) circuits provide a more in-depth analysis of circuits as well as the latest suggestions on up-to-date components to choose.

Flow Signal Chain Example

Take an example where we want to design a large multimeasurement system that includes flow measurement using the KWIK circuit shown in Figure 10.

(A) I want to run 10 flow sensors at 1 kSPS. Is the SAR or sigma-delta the better option?

(B) What are the AFE timing considerations?

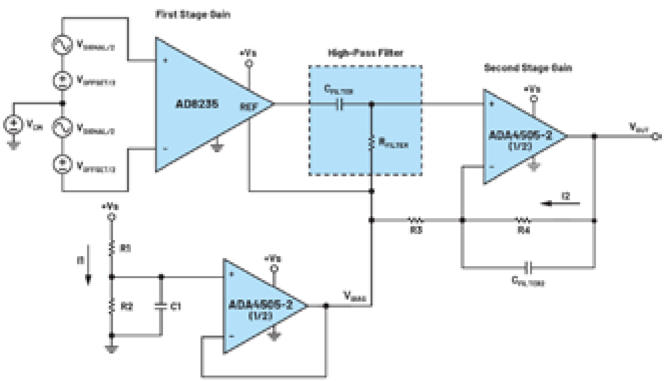

Figure 10: The flow measurement signal chain KWIK circuit.

The SAR (AD4696) in conjunction with the AD8235 and ADA4505-2 amplifiers needed for signal conditioning are the best options as we can run 10 channels at 10 kSPS using an external convert signal or auto cycle mode.

In this case, the response vs. gain of the AD4505-2 amplifier will dictate the BW of the signal under measurement rather than the antialiasing filter response. The high-Z mode will take the pressure off the performance of the input amplifier, enabling designers to choose lower power amplifiers. The components in Figure 10 are chosen for their ultra low power performance.

Conclusion

When designing high resolution low power data acquisition systems, it can be difficult to find the lowest power components available and ADI's precision low power signal chains act as a starting point for low power designs. Care must be taken in understanding the trade-offs and differences in timing when forming signal chains that incorporate sigma-delta and SAR architectures as their core ADC.

When interfacing with sensors or signals of interest, the analog front-end timing needs to account for chip level startup, sensor biasing, external filtering, and component choice. Antialiasing filters are needed with stricter requirements on SAR ADCs because sigma-delta ADCs have inherent sampling associated with their design. On the AFE, sigma-delta ADCs are incorporating PGAs while SAR technology like high-Z mode is easing the drive requirements on external amplifier circuitry.

When we consider sigma-delta ADC architecture, oversampling and decimation as well as filter latency have an impact on the throughput rate especially while converting on more than one channel. SAR throughput, on the other hand, is more straightforward to calculate because of the successive approximation approach, with the added benefit that the slower you sample, the lower the current drawn while converting.

The complexity of the sigma-delta AD4130-8 digital timing has led to the development of ACE software timing tools. These are available to simplify the understanding and aid in calculating the channel throughput rate. The same device has timing features like duty cycling, FIFO, and a standby mode to help conserve battery life, but care is necessary when looking at the achievable effective resolution when targeting a particular throughput rate.

When we examine a SAR ADC like the AD4696, we can sample at higher sample frequencies. This has its advantages but it means the digital timeframe, tFRAME, in which you need to read back is smaller, meaning faster SPI clock speeds are needed.

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www.analog.com

Ultra-High-Speed Gate Driver IC

ROHM has developed a gate driver IC - the BD2311NVX-LB. It is optimized for GaN devices and achieves gate drive speeds on the order of nanoseconds (ns) - ideal for high-speed GaN switching. This was facilitated through a deep understanding of GaN technology and the continuing pursuit of gate driver performance. The result: fast switching with a minimum gate input pulse width of 1.25ns that contributes to smaller, more energy efficient, higher performance applications.

In recent years, improving power conversion efficiency while reducing the size of power supply units in server systems have become important factors as the number of IoT devices continues to grow. This requires further advancements in the power device sector. At the same time, LiDAR, which is used not only for autonomous driving but also for monitoring industrial equipment and social infrastructure, demands high-speed pulsed laser light to further increase recognition accuracy.

As these applications require the use of high-speed switching devices, in conjunction with the release of GaN devices, ROHM developed an ultra-high-speed gate driver IC that maximizes GaN performance. Going forward, ROHM continues to release smaller WLCSP products to support greater miniaturization.

www.rohm.com

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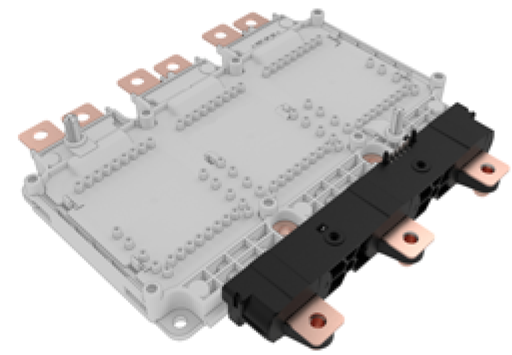
Current Sensor for Three Phase Automotive Traction Inverter Power Modules Battery Systems

LEM has launched the HAH3DR S07/SP42, a compact current sensor designed for 800V three-phase power modules. Developers of automotive traction inverters are increasingly using three-phase power modules such as the popular and widely proven Hybridpack Drive from Infineon. These modules are now adopting the more efficient SiC MOSFET technology, allowing vehicles to use 800V battery systems that offer faster charging and longer driving range.

The HAH3DR S07/SP42 three-phase sensor has been designed to fit these 800V power modules. Fully calibrated over temperature and stable over the unit's lifetime, they enable a quick time to market with little R&D effort. This makes them ideal for companies developing small passenger vehicle platforms, trucks and buses while restrained by limited R&D resources. The current sensor offers a wide selection of current measuring ranges from 700A to 1200A, and compared to existing units in the HAH3DR family, the package isolation characteristics have been upgraded to cope with the challenge of 800V power modules. As well as the sensor, LEM also offers a large choice of packages and current measuring range options. The HAH3DR S07/SP42 features an enlarged aperture that can accommodate busbars up to 1.5mm thick, making it compatible with newest generation of power modules. It is also compatible with power modules from various other suppliers, such as the Acepak Drive from ST Microelectronics, the SSDC from ON Semi, and others such as Starpower and CRRC.



www.lem.com

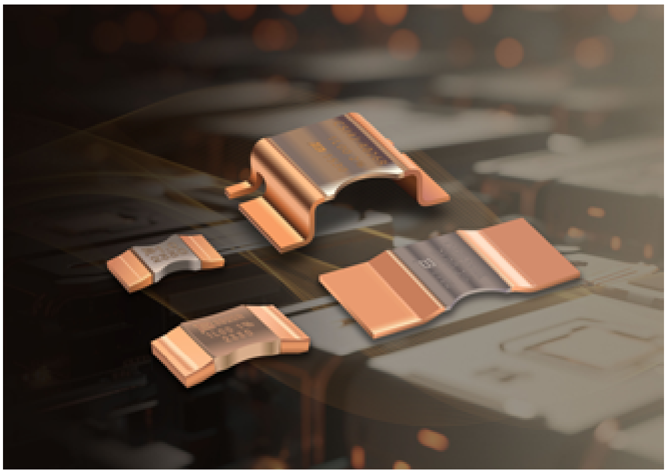
12V Output 2040W 3-Phase Industrial Power Supply

TDK Corporation announces the addition of the TDK-Lambda brand TPS4000-12 power supply, further extending the existing 3kW to 4kW rated TPS series. Delivering up to 2040W output power (12V at 170A) in a 2U high package, the TPS4000 series operates from a wide range Delta or Wye 350 - 528Vac three phase input. These industrial power supplies are ideal for use in many applications including test and measurement equipment, semiconductor fabrication, additive manufacturing, printers, lasers and RF power amplifiers. The high voltage, three-phase input avoids the requirement for costly step-down transformers and assists phase load current balancing.

The TPS4000 series is fully featured with isolated AC Fail, DC Good and dropped phase signals, remote on/off, remote sense, and a 12V 0.3A standby supply. A PMBus™ communications interface allows remote monitoring of the output voltage, output current, internal temperature, status signals and fan speed. In addition, the output voltage, over current limit and the remote on/off can be programmed by the PMBus™. The output voltage can also be adjusted from 9.6 to 14.1V and the current limit point by 70-105% using front panel potentiometers or an analog 0-5Vdc voltage. Up to eight units can be connected in parallel for higher power and internal ORing FETs allow redundant operation.

www.emea.lambda.tdk.com

High Power Current Sense Resistor Series Provides Accurate Measurement



Bourns introduced four high power, ultra-low ohmic current sense resistor series. The latest current measurement devices from Bourns are designed to help save energy while maximizing sensing performance in power electronics designs. The four CSI Model Series feature low Temperature Coefficient of Resistance (TCR) for operating accuracy over a wide temperature range and excellent long-term stability. Their very low resistance levels, low thermal electromagnetic force (EMF) and high power handling capabilities make them ideal solutions for a variety of industrial and consumer applications and power electronics including Battery Management Systems (BMS), Switched-Mode Power Supplies (SMPS) and motor drives.

Current sense resistors are increasingly being used in higher power applications due to their precise measurement accuracy and relatively low cost compared to other technologies. Bourns developed this new family to help designers meet the monitoring accuracy necessary to provide a current reading that assists in the efficient operation of the circuit.

Bourns' Model CSI Series are constructed with Electron Beam Welded (EBW) resistive and copper alloy terminals, and are available in both two and four-terminal options. The two-terminal models are offered in three different footprint sizes: 5930, 3920 and 2512. The four-terminal devices, in footprint size 4026, allow for very precise four-wire Kelvin (K) resistance measurement. The metal alloy current sensing element supports low thermal EMF and low TCRs of ±50 PPM/°C in the 20 °C to 60 °C temperature range. All four models supply resistance values as low as 0.2 milliohms, and customers can select from a range of low resistance options and power ratings of up to 15 W.

www.bourns.com

GaN Portfolio Compatible with Common Topologies in AC/DC Power Conversion

Texas Instruments announced the expansion of its low-power gallium nitride (GaN) portfolio, designed to help improve power density, maximize system efficiency, and shrink the size of AC/DC consumer power electronics and industrial systems. TI's overall portfolio of GaN field-effect transistors (FETs) with integrated gate drivers addresses common thermal design challenges, keeping adapters cooler while pushing more power in a smaller footprint.

The portfolio of GaN FETs with integrated gate drivers, which includes the LMG3622, LMG3624 and LMG3626, offers accurate integrated current sensing. This functionality helps designers achieve maximum efficiency by eliminating the need for an external shunt resistor and reducing associated power losses by as much as 94% when compared to traditional current-sensing circuits used with discrete GaN and silicon FETs. TI's GaN FETs with integrated gate drivers enable faster switching speeds, which helps keep adapters from overheating. Designers can reach up to 94% system efficiency for <75-W AC/DC applications or above 95% system efficiency for >75-W AC/DC applications. The new devices help designers reduce the solution size of a typical 67-W power adapter by as much as 50% compared to silicon-based solutions. The portfolio is also optimized for the most common topologies in AC/DC power conversion, such as quasi-resonant flyback, asymmetrical half bridge flyback, inductor-inductor-converter, totem-pole power factor correction and active clamp flyback.

www.ti.com

SiC MOSFETs for Power Switching in Industrial Applications

Nexperia announced its first silicon carbide (SiC) MOSFETs with the release of two 1200 V discrete devices in 3-pin TO-247 packaging with $R_{DS(on)}$ values of 40 mΩ and 80 mΩ. NSF040120L3A0 and NSF080120L3A0 are the first in a series of planned releases which will see Nexperia's SiC MOSFET portfolio quickly expand to include devices with a variety of $R_{DS(on)}$ values in a choice of through-hole and surface mounted packages. This release addresses the market demand for the increased availability of high performance SiC MOSFETs in industrial applications including electric vehicle (EV) charging piles, uninterruptible power supplies (UPS) and inverters for solar and energy storage systems (ESS). $R_{DS(on)}$ is a critical performance parameter for SiC MOSFETs as it impacts conduction power losses. Nexperia identified this as a limiting factor in the performance of many currently available SiC devices and used its innovative process technology to ensure its SiC MOSFETs offer temperature stability, with the nominal value of $R_{DS(on)}$ increasing by only 38% over an operating temperature range from 25°C to 175°C. Unlike other many currently available SiC devices in the market. Nexperia's SiC MOSFETs also exhibit the very low total gate charge (Q_G), which brings the advantage of lower gate drive losses. Furthermore, Nexperia balanced gate charge to have an exceptionally low ratio of Q_{GD} to Q_{GS}, a characteristic which increases device immunity against parasitic turn-on.

www.nexperia.com

Datasheets Enable Engineers to Calculate Different Technical Values

Danisense is updating all datasheets for its broad product range of current sense transducers to include formulas and examples to make it quick and easy for design engineers to calculate different values, e.g. current and voltage, linearity error, etc.

Comments Loic Moreau, Sales & Marketing Director at Danisense: "One of our development engineers thought it would be a good idea to include more technical data and also formulas for calculating certain values on our datasheets to make life for design engineers easier when selecting the right current sense transducer for their respective new application. Now we are in the process of updating all of our datasheets with a lot of examples of technical data for our products and all necessary formulas for engineers to calculate the most important technical values themselves where required." "We hope design engineers will make good use of our new datasheets and find them helpful in their daily work life," Moreau adds.

https://danisense.com

Common-Drain MOSFET Offers Bi-Directional Power within USB Applications

Toshiba Electronics Europe has launched their first 30V N-channel common-drain MOSFET. The SSM10N961L device offers low-loss operation and is specifically intended for use within devices with USB interfaces. Additionally, it may be used for protecting battery packs within mobile applications.

With the ubiquity of USB interfaces, many components and devices have been developed to support USB standards. The USB Power Delivery (USB PD) standard supports higher power levels from 15W (5V / 3A) to a maximum of 240W (48V / 5A) and allows swapping of the power supply and receiving side. This requires devices with USB charging to support bi-directional power and this is the use case that the SSM10N961L N-channel common drain MOSFET has been designed for.

Until now, Toshiba's N-channel common-drain MOSFETs have been 12V products primarily intended for the protection of lithium-ion (Li-ion) battery packs within smartphones. The 30V product can be used for applications requiring voltages higher than 12V such as load switching for power lines of USB charging devices and the protection of Li-ion battery packs for battery powered appliances.

The SSM10N961L combines two N-channels in a common drain configuration which is the feature that allows for bi-directional operation. The source-source breakdown voltage ($V_{(BR)SSS}$) is 30V for use in higher voltage applications such as those found in laptops and tablets. To reduce losses in all applications, the source-source on-resistance ($R_{SS(ON)}$) is typically 9.9mΩ.

https://toshiba.semicon-storage.com

62mm Package Helps Engineers to Achieve Higher Efficiency and Power Density

Infineon Technologies announced the expansion of its CoolSiC 1200 V and 2000 V MOSFET module families with an industry-standard package. The proven 62mm device is designed in half-bridge topology and is based on the recently introduced and advanced M1H silicon carbide (SiC) MOSFET technology. The package enables the use of SiC for mid-power applications from 250 kW – where silicon reaches the limits of power density with IGBT technology. Compared to a 62mm IGBT module, the list of applications now additionally includes solar, server, energy storage, EV charger, traction, commercial induction cooking and power conversion systems.

The M1H technology enables a wider gate voltage window, ensuring high robustness to driver and layout-induced voltage spikes at the gate without any restrictions even at high switching frequencies. In addition to that, very low switching and transmission losses minimize cooling requirements. Combined with a high reverse voltage, these devices meet another requirement of modern system design. By using Infineon's CoolSiC chip technology, converter designs can be made more efficient, the nominal power per inverter can be increased and system costs can be reduced.

With baseplate and screw connections, the package features a very rugged mechanical design optimized for highest system availability, minimum service costs and downtime losses. Rreliability is achieved through high thermal cycling capability and a continuous operating temperature (T_{vjop}) of 150°C. The symmetrical internal package design provides identical switching conditions for the upper and lower switches. Optionally, the thermal performance of the module can be further enhanced with pre-applied thermal interface material (TIM).

www.infineon.com

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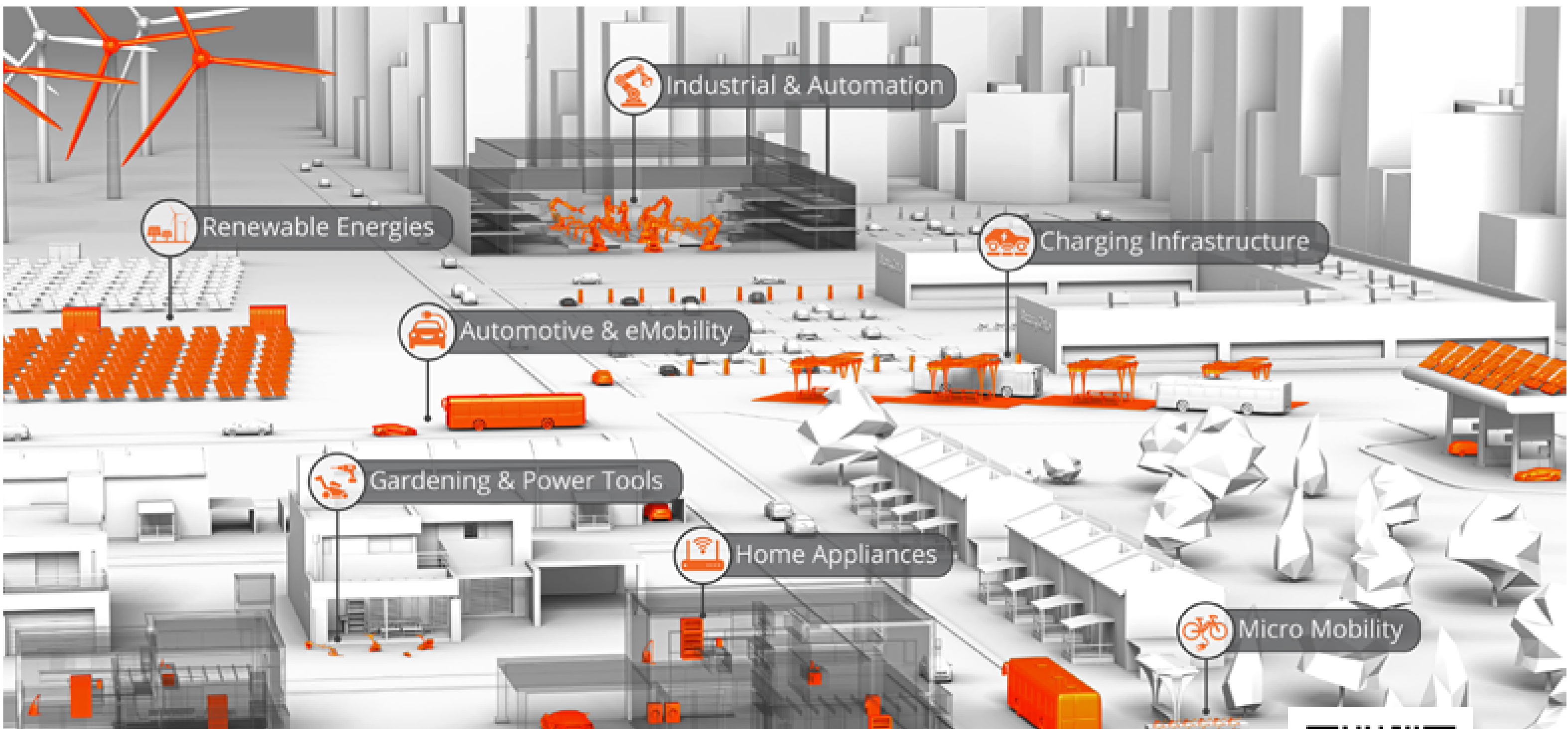

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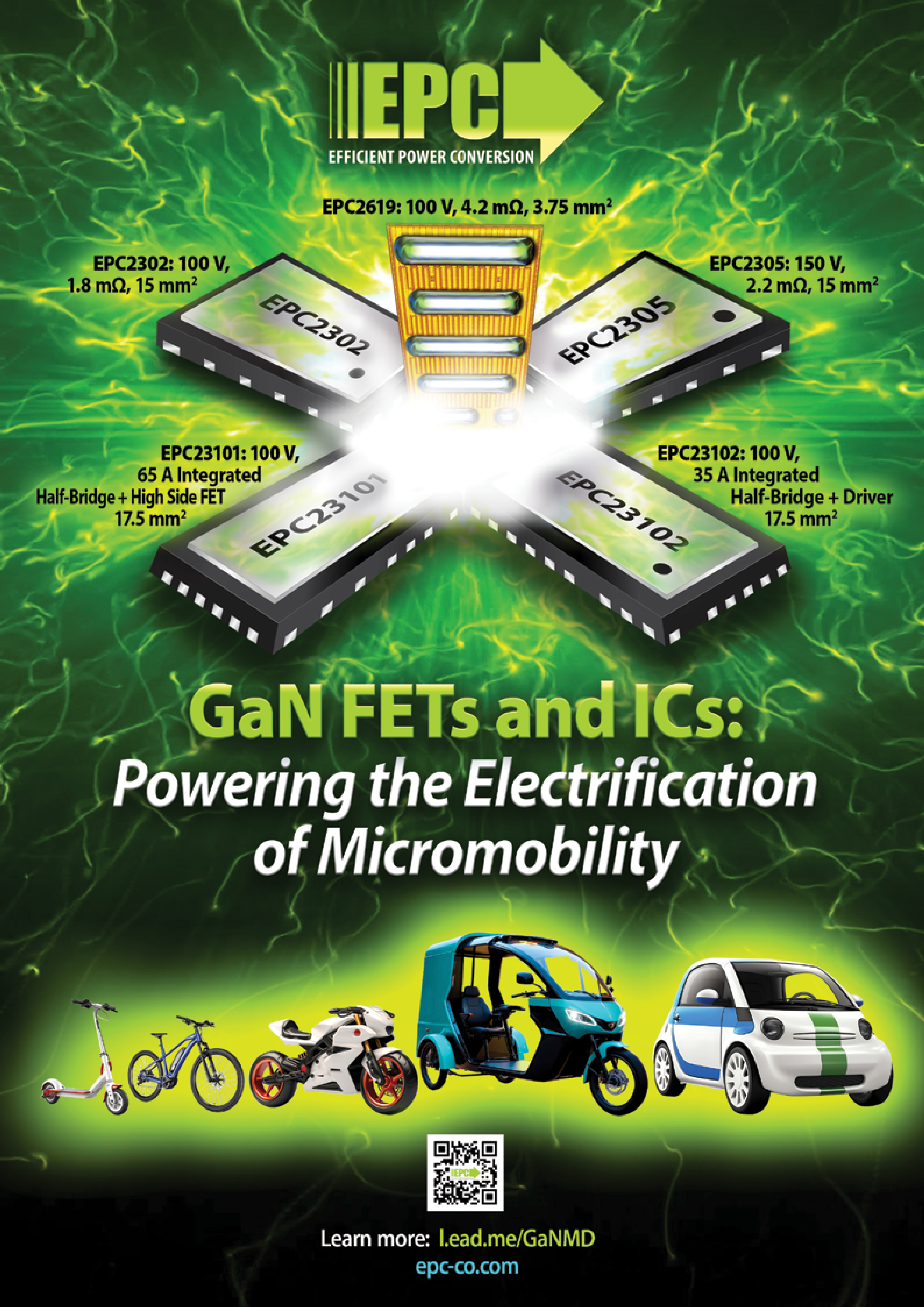
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