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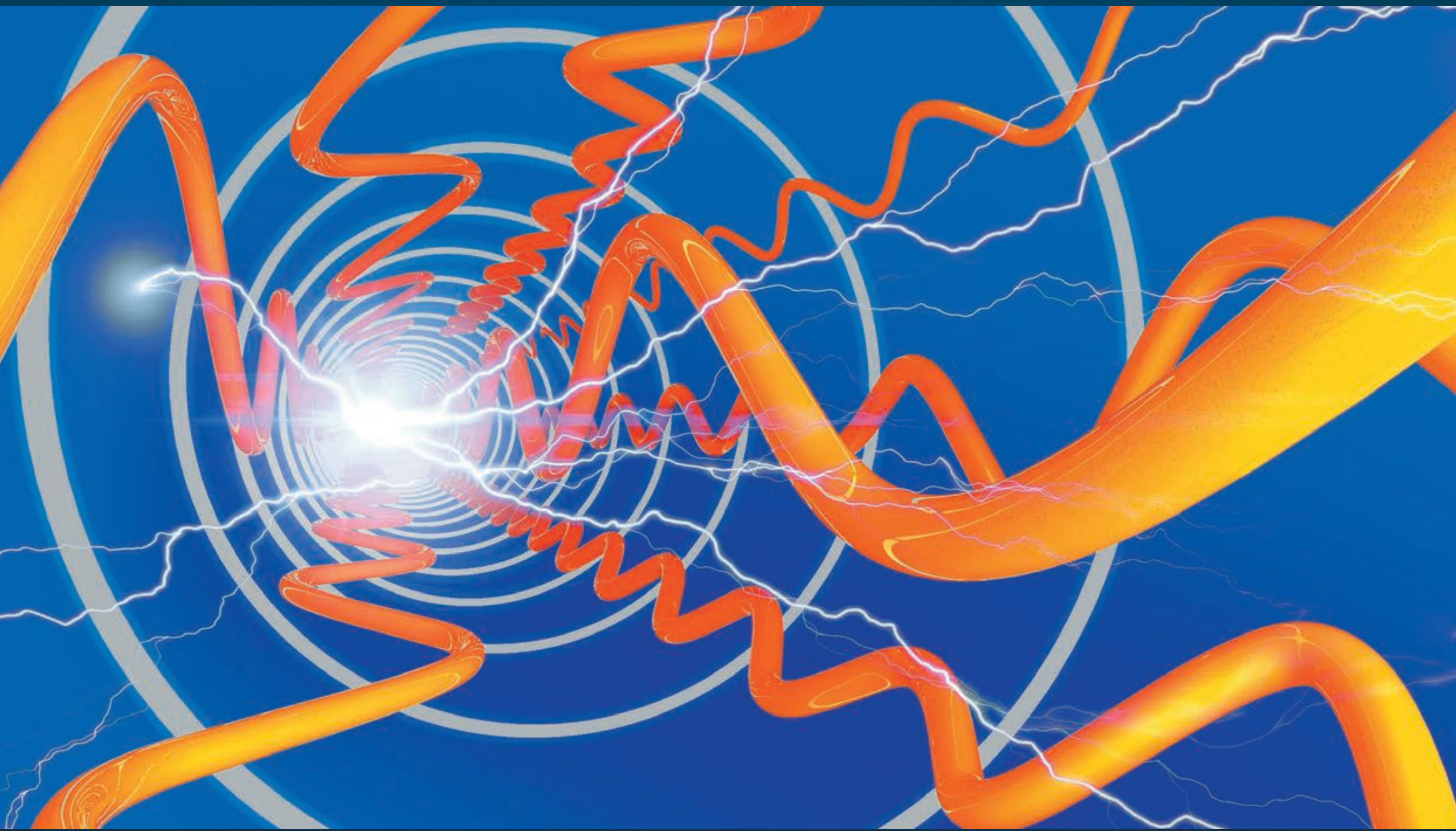

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Editor Achim Scharf
Tel: +49 (0)892865 9794
Fax: +49 (0)892800 132
Email: PowerElectronicsEurope@t-online.de

Production Editor Chris Davis
Tel: +44 (0)1732 370340

Financial Manager Joanne Morgan
Tel: +44 (0)1732 370340
Fax: +44 (0)1732 360034
Email: accounts@dfamedia.co.uk

Reader/Circulation Enquiries
Perception
Tel: +44 (0) 1825 701520
Email: dfamedia@dmags.co.uk

INTERNATIONAL SALES OFFICES
Mainland Europe:
Victoria Hufmann
Norbert Hufmann
Tel: +49 911 9397 643
Fax: +49 911 9397 6459
Email: pee@hufmann.info

Eastern US
Ian Atkinson
Tel: +44 (0)1732 370340
Fax: +44 (0)1732 360034
Email: ian@dfamedia.co.uk

Western US and Canada
Ian Atkinson
Tel: +44 (0)1732 370340
Fax: +44 (0)1732 360034
Email: ian@dfamedia.co.uk

Japan:
Yoshinori Ikeda,
Pacific Business Inc
Tel: 81-(0)3-3661-6138
Fax: 81-(0)3-3661-6139
Email: pbi2010@gol.com

Taiwan
Prisco Ind. Service Corp.
Tel: 886 2 2322 5266 Fax: 886 2 2322 2205

Publisher & UK Sales Ian Atkinson
Tel: +44 (0)1732 370340
Fax: +44 (0)1732 360034
Email: ian@dfamedia.co.uk
www.power-mag.com

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FEATURE STORY

Solving the Challenges of Increasing Power Density By Reducing Number of Power Rails

By Andy Wang, Business Line Director, High-Voltage Power Business Unit Allegro MicroSystems

More details on page 12.

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What were 2022's key power electronics industry trends and events?

Power electronics devices are found across multiple industries – some of which have seen disruptive or even traumatic changes during 2022. This article looks at what has been happening, and how the chip manufacturers have been responding.

The power electronics industry is a dynamic arena which is constantly being modified by numerous trends and events - a situation which is as true in 2022 as in any other year. And these change factors can be widely disparate, as power electronic devices and systems are found across the entire electricity supply chain, from the generating station, across the grid, and to the items that consume the electricity. All very different environments, and subject to different influences.

Such change factors range from a shift in demand caused by political or economic events, to suppliers introducing new technologies that create better opportunities in the marketplace. Yet supply and demand cannot be neatly compartmentalized. For example, a green-driven growth in demand for EVs will stimulate suppliers to innovate new technology – yet, equally, the appearance of innovative products such as lower-cost or higher-capacity batteries will accelerate demand.

And events in one sector of the power electronics marketplace can ripple through to other areas. Growing numbers of EVs, for example, will put increasing pressure on power stations generating the electricity they need.

With these considerations in mind, let's look at what has been happening in the power electronics industry during 2022.

PCIM Europe 2023: Conference program published

The PCIM Europe Conference is setting a new record for this year's conference with more than 400 oral and poster presentations. From 9 - 11 May 2023, speakers from industry and academia will present the latest research results and innovations in power electronics.

In addition to qualified keynotes at the beginning of each conference day, participants can expect three special sessions. These focus on highly relevant topics for the industry: "Solutions for Future Medium Voltage Grids", "Power Electronics for E-Mobility" and "Understanding Losses in WBG Power Devices".

The three keynotes will provide a further highlight at the conference. Franz Musil, Power Electronics Engineer from Fronius International will open the conference presentations on the first day with the question "How Life Cycle Analyses are Influencing Power Electronics Converter Design". On Wednesday, Holger Borcherding, Scientific Director at the University of Applied Sciences and Arts Ostwestfalen-Lippe will present the topic "On the Way to the DC Factory – The Open Industrial DC Grid for Sustainable Production Sites is Entering the Dissemination Phase". Munaf Rahimo, President and Founder, MTAL will present the keynote "HV Silicon and SiC Power Semiconductors; Key Components for Sustainable Energy Solutions" on Thursday.

First-hand knowledge

"The PCIM Europe 2023 offers technical highlights on disruptive new technologies in silicon and wide bandgap power semiconductors paired with innovative materials for packaging and interconnection technologies with the goal of longer and more application-specific lifetimes for components and systems," explains Prof. Dr. Leo Lorenz, General Conference Director ECPE. "The range of topics at the conference extends to AI-based smart power electronic energy converters for a successful transformation to e-mobility and renewable energy technologies."

In addition to the oral presentations in five conference rooms, the poster sessions in the entrance area NCC Mitte also promise a platform for exclusive 1:1 exchange between presenters and interested participants. For the first time, there will also be poster presentations on the last day of the conference.

Direct exchange with industry experts

The user-oriented seminars and tutorials on the two days prior to the conference complete the PCIM Europe program. In small groups, participants can directly exchange ideas with renowned experts and gain first-hand, practice-oriented know-how. Special topics such as "Power Electronics in Electric Vehicles", "Drives", "WBG Devices" and "Reliability" will be presented in 12 half-day seminars and 6 full-day tutorials.

Further information about the conference and social program as well as the exhibition, which will be taking place at the same time, can be found at:

pcim-europe.com

MANUFACTURING + ENGINEERING WEEK 2023

Drives & Controls Show joins 'Glastonbury of industrial sector' line-up

THE NINETEEN GROUP, the exhibition organiser which recently acquired the Drives & Controls Show and its sister events AirTech and Fluid Power & Systems from DFA Media, has announced that they will appear as "zones" at the Manufacturing & Engineering Week event at the NEC in June 2023, before returning as standalone exhibitions in 2024.

The week-long event – which Nineteen is promoting as "the Glastonbury of the industrial sector" – will combine live and digital events. It will include the Design & Engineering Expo and Maintec exhibitions as well as events that Nineteen acquired when it bought The Hennik Group, publisher of The Manufacturer, earlier this year. These include the Smart Factory Expo, the SME Growth Summit, the Sustainable Manufacturing Digitalisation Summit and the Manufacturing Top 100 Awards.

"We launched the first Manufacturing & Engineering Week this year and I referred to our ambition as being about building a Hannover Messe type event," says Nineteen Group CEO, Peter Jones. "However, in 2023, with the incredible additions we have made, I think Glastonbury is a more relevant reference point – something uniquely British that celebrates creativity and original thinking both on a large scale on our 'main stages', the centrepiece exhibitions, or on smaller stages, or virtually, where cutting-edge technology can be demonstrated, or industry thought-leaders can inspire through a series of topical sessions."

The main exhibitions will take place at the Birmingham NEC on 7 and 8 June 2023. The zone dedicated to Drives & Controls and the other former DFA Media events will provide educational content, including an Automation and Robotics Theatre.

"We are so pleased to have the addition of Smart Factory Expo and Drives and Controls, and its sister events incorporated within Manufacturing & Engineering Week 2023" says Haf Cennydd, who is overseeing the Manufacturing & Engineering Week portfolio for Nineteen. "The sheer scale of our ambition for Manufacturing & Engineering Week means that it will produce a momentum and a focus on the industrial sector that will benefit all."

www.mandeweek.co.uk

Peter Jones, CEO Nineteen Group

Farnell offers infrastructure products from onsemi

Designed to shorten development times while exceeding power density norms and reducing power loss the SiC (silicon carbide) EliteSiC products have reduced switching losses under real-world conditions compared to products from competitors, says Farnell.

As the industry moves to accelerate the transition to decarbonisation, there is a shift in demand towards installing energy infrastructure systems featuring DC fast chargers (DCFC), solar inverters and battery energy storage systems (BESS).

Adopting SiC-based power stages is critical in reducing power losses, increasing power density and reducing cooling costs, advises the distributor.

Typical applications for onsemi EliteSiC devices include UPS, DC/DC converters, boost inverters, solar inverters, electric vehicle charging stations and industrial power systems. These devices are Pb?free, halide free and RoHS-compliant.

Farnell now stocks the EliteSiC Power, single N-channel with typical low gate charge of 56nC and low effective output capacitance (typically 79pF) and a junction temperature of 175°C.

There is also the EliteSiC MOSFET NXH006P120MNF2 which consists of a 6m /1200V SiC MOSFET half bridge and a thermistor in an F2 package. It is available with or without pre?applied thermal interface material (TIM) and solderable or press?fit pins.

Adrian Cotterill, global product segment leader, transistors and WBG at Farnell, said: "This is a key addition to Farnell's portfolio that will ensure energy infrastructure systems are developed using the highest calibre, best-of-breed components . . . highly optimised SiC products [which] meet the latest performance requirements of energy infrastructure end applications."

URL: https://uk.farnell.com/

PTX30W integrates power management and li-ion battery chargers

Fabless semiconductor company, Panthronics is sampling the PTX30W, claimed to be the only single-chip solution for the listener circuit in NFC wireless charging systems.

It combines a rectifier, NFC tag, battery charger and power management as well as protocol handling. The NFC tag supports bi-directional data communication in NFC Type A mode. This enables the transfer of data between the charging cradle and the charged device, such as the battery's state of charge or fault indicators, as well as enabling firmware upgrades of both devices.

The device's power management unit supplies the chip from RF power when available, or from the battery. A battery charger circuit regulates the input voltage from the antenna to match the voltage profile of the constant current/constant voltage charge supplied to the li-ion battery. This minimises power losses in the charger to improve thermal management in sealed, space-constrained enclosures.

The device is supplied in a compact 3.2mm2 WL-CSP which enables manufacturers of small battery-powered products to implement NFC wireless charging with a board which is around four times smaller than existing designs which are based on multiple discrete components. It is also easier to implement than a circuit made of multiple discrete components, says the company.

The autonomous PTX30W runs an NFC Forum-derived wireless charging protocol which supports power negotiation. As a result, the device can operate in standalone mode without an external microcontroller to run NFC wireless charging operations.

Paired with an NFC poller, such as the PTX130W in the charging cradle, the PTX30W can supply up to 1W to charge the li-ion battery in fitness trackers, smart watches, earbuds, hearing aids, smart glasses, smart rings, styluses and medical sensors.

The company also provides a software development kit to accelerate integration into end product designs.

The PTX30W is available now for sampling, with volume production orders due to start shipping in Q2 2023.

https://www.panthronics.com/

Rad-tolerant power management for LEO is based on plastic COTS device

The idea behind the design is for space system developers to quickly develop prototypes and final designs for a power management system with a radiation-tolerant device based on a familiar plastic commercial-off-the-shelf (COTS) product.

It is the company's first commercial-off-the-shelf (COTS) rad-tolerant power device and is a high current, low voltage is a power management chip, available for prototype sampling in both plastic and hermetic ceramic according to the satellite mission requirements.

Using proven COTS devices makes it easier to conduct preliminary evaluation and early development, says Microchip. The MIC69303RT operates from a single low voltage supply of 1.65 to 5.5V and can supply output voltages as low as 0.5V at high currents, offering high precision and low dropout voltages of 500mV under extreme conditions. The MIC69303RT is a companion power source the company's radiation-tolerant space-qualified microcontrollers such as the SAM71Q21RT and PolarFire FPGAs including the RTPF500TLS.

The MIC69303RT operates from -55 to 125 degrees C. It is offered in eight- and 10-pin package configurations with radiation tolerance up to 50Krad total dose robustness. The low noise of the output is critical to sensitive RF circuits, post regulation of switching power supplies and industrial power applications.

The MIC69303RT is manufactured in compliance with the following MIL Class Q or Class V requirements: screening testing, qualification testing and TCI/QCI specifications. The plastic MIC69303RT is compliant with high reliability plastic quality flow derived from AEC-Q100 automotive requirements with specific additional tests necessary for space applications.

A MIC69303RT plastic evaluation board is available to evaluate the performance of the plastic engineering IC version. The four-layer PCB allows the user to easily change and measure the electric parameters of the device at different input and output conditions.

The MIC69303RT is available in limited sampling upon request.

http://support.microchip.com

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Event Running Order

	Panel Discussions	Seminars		Workshops	
8:30 Arrival, Registration & Breakfast					
9:30 - 10:15 Keynote Speaker - TBC					
10:30 MTC Tour	10:30 - 11:15 Robotics & Automation	10:30 - 11:15 Seminar 1 TBC	10:30 - 11:15 IFM Electronic Why Condition Monitoring? Why not?	RITTAL EPLAN 10:30 - 12:30 Smarter Panel Building	EUCHNER More than safety. 10:30 - 12:30 Managing Equipment Safety & Cyber Security in The Modern Factory
	11:30 - 12:15 Increasing OEE/ Digital Manufacturing	11:30 - 12:15 Seminar 2 TBC	11:30 - 12:15 KUKA Mobile Robotics: Mobile, flexible & resilient – The factory of the future.		
12:30-13:30 Lunch					
15:00 MTC Tour	14:00 - 15:15 Industrial Data and AI	14:00 - 15:15 OMRON Collaborative Automation: Solving the UK Productivity Puzzle.	14:00 - 15:15 AI Build/ KUKA Additive Manufacturing: Automated 3D Printing – Exponential Manufacturing Possibilities.	13:30 - 15:30 Smarter Panel Building	13:30 - 15:30 Managing Equipment Safety & Cyber Security in The Modern Factory
15:30- 16:30 Networking					
16:30 Close					

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1 Panel Discussions

Hosted in the auditorium. There will be three panel discussions throughout the day. Audience participation and questions will be taken throughout the discussions.

Topics for discussion:

1. Robotics & Automation
2. Increasing OEE / Digital Manufacturing
3. Industrial Data and AI

2 In depth Workshops

Provided by our content partners in meeting rooms 7 & 8. Places are limited to 40 per session so pre-registration via the website is advised.

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3 Demonstrators/Exhibitors

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4 Seminars

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5 MTC Tours, Networking & Luncheon

There will be two technology tours of the MTC provided throughout the day. Networking opportunities with peers, partners and exhibitors will be created through out.

Solving the Challenges of Increasing Power Density By Reducing Number of Power Rails

By Andy Wang, Business Line Director, High-Voltage Power Business Unit Allegro MicroSystems

The world continues to become increasingly electrified, and both the demand for energy and the requirements placed on that energy continue to expand. Between automobile electrification, internet traffic, and renewable energy, a global need has developed for high-power-density technologies that can deliver more power output from the same or less amount of space as legacy solutions. In electrical vehicles, particularly in on-board charger applications, higher power density equates to a smaller, lighter-weight form factor that allows faster charging and frees more space for the battery. This ultimately leads to more driving distance per charge. In data centers, government regulations are driving the need to improve power density. For example, beginning in 2023, the power supply of a European data center must achieve a Titanium Plus efficiency rating (greater than 96 percent efficiency), which effectively doubles power density requirements compared to legacy systems. In microinverters for solar panels, the market continues to push for smaller system size with an increase in power level. This article overviews some of the challenges associated with high-power-density solutions and some of the technologies that can best enable the desired outcome. An innovative technology is then presented that simplifies power-system design for all these markets, with cascading benefits.

Overview of power transistor choices

Common applications today demand high-density power conversion in high-current, high-temperature, high-voltage environments. Achieving the market demand necessitates use of technologies that can support higher switching frequency with reduced conduction losses at much higher temperatures than conventional silicon insulated-gate bipolar transistors (IGBTs) and silicon MOSFETs. The latest trend that allows engineers to achieve the goal of increasing power output while reducing solution size is the adoption of wide-bandgap semiconductors. Wide-bandgap devices—such as silicon carbide (SiC) and gallium nitride (GaN)—have better on-state resistance per specific area than conventional silicon IGBTs and silicon MOSFETs. This performance improvement allows a wide-bandgap power device to enable high-frequency operation and leads to system size reduction.

As described in "Why gate drivers are key to successful electric vehicle designs," Power Electronics Europe, 2022, Issue 4, for applications that require voltages up to 1700 V, the required high-voltage, high-current, high-temperature performance is better achieved by SiC transistors than silicon IGBTs. Many common applications also demand a small system design with switching speed as fast as 2 MHz. This reduced-size, high-speed switching performance is better served by GaN devices.

Regardless of semiconductor selection—GaN or SiC—achieving the desired performance often requires use of many power devices that must adhere to the strict safety standards established for electric vehicles and various industrial and data-center applications. Meeting these standards requires careful selection of system components. One of the most critical components among these devices is the isolated gate driver, which is used to turn on and turn off the selected transistor.

Understanding the importance of gate drivers and switch-matching

The success of a power conversion system is heavily influenced by the isolated gate driver. Isolated gate drivers enable the transfer of data and power between the high-voltage and low-voltage domains, while providing system and human protection from hazardous direct current. Each gate driver must provide a specific control voltage for each of the power switches within the design. The voltage needed for one switch typically differs from the voltage needed for another. Because device switching speed and output quality greatly affect the power conversion, matching the requirements of the switches to the gate drivers is crucial to achieving the desired system performance.

Before selecting a gate driver, the cost, size, weight, reliability, and efficiency of the power-conversion system must be weighed with consideration for the influencing factors, including the environmental conditions presented at the location where the gate driver is placed, component count, and design complexity. The wide variety of conditions that a gate driver will face heavily influence performance. These conditions vary depending on where the gate driver is located—on the high-voltage side of a bridge, on the low-voltage side of a bridge, in the hostile environment of an inverter, or in a charger. In power-conversion circuitry, component count and design complexity also heavily influence device performance. Larger designs result in longer signal paths, which adds parasitics, so smaller gate drives can improve performance. Also, because every component is a potential point of failure, gate drives with reduced component count can improve reliability.

With the vast selection of gate drivers available on the market today, designers have a plethora of options. However, the choice of gate driver is only a starting point. In many applications, it can be challenging to identify a suitable source of power to enable the gate driver to drive the gates of the switches at the required speeds, as discussed next. To meet requirements, power-conversion designs often include multiple bias power supplies that are isolated from the control ground. For a solution that includes multiple tradeoffs in performance, the design challenges that arise from these architectures can consume a significant amount of valuable engineering time, which makes it critical to choose the right gate driver technology early in the design process: The right gate driver can have a big impact on the success of a system.

Understanding the tradeoffs of power rails, auxiliary supplies, and bootstrap circuitry

In conventional designs, external DC-DC bias supplies are used to drive the gates of the power transistors. Sometimes, application requirements can force the addition of eight or nine separate bias supplies, with each supply adding transformers and other bulky components that degrade reliability and increase solution size. Although the load and stress added by these components can be minimized by design, including these components hinders reliability because every component is a potential point of failure. The added bias supplies not only bring new points of potential for failure, but they must also be sized for the highest operational switching frequency, which results in less-efficient operation at lower frequencies. All things considered, the many complex components and circuitries used in conventional designs add to system cost, size, and weight and reduce reliability.

The task of adding an extra power rail to a design is often more complicated than it first seems. Use of any power supply adds stray capacitance between the control ground and the source terminal of the semiconductor power switch that the gate driver is controlling. For a switch located in the high side of a full bridge, the additional stray capacitance is likely to create common-mode and electromagnetic interference, which brings new design challenges. Also, stray capacitance can allow for the flow of high-voltage current spikes, which can interfere with correct functional operation. These issues are likely to occur even if the power device is driven across an isolation barrier or if the extra power rail is derived from an additional winding on the main system transformer. Furthermore, using an additional winding complicates the design of the main system transformer and can have negative implications when it comes to safety compliance.

A lower-cost alternative method of providing an additional power rail to serve as the external bias supply for the isolated gate driver is to use bootstrap circuitry. The essential components of the bootstrap circuit are a diode, a capacitor, and—in some cases—a resistor. A bootstrap circuit is arranged so that, when the low-side switch is turned on, the capacitor is charged via the diode almost to the level of the supply voltage (Vdd). The capacitor subsequently provides the drive power for the high-side switch. Although this process may seem straightforward, it brings a fresh set of challenges. The diode requires a reverse voltage rating that is higher than the high-voltage bus. In designs with high-frequency switching, this diode must also be rated for fast recovery. The capacitor must be small enough to recharge quickly, but large enough to supply the required gate charge for the switch without becoming discharged too quickly. The resistor, if required, must limit the spikes of charging current flowing into the bootstrap capacitor. This is because all bootstrap designs have the potential for false overcurrent tripping, which would occur if the charging current in the low-side current sense signal to the controller were to spike with sufficient amplitude at the capacitor. To prevent false overcurrent tripping, the amplitudes of such potential spikes must be limited. For that purpose, a resistor is often added in series with the diode. This resistor comes with difficult tradeoffs. Increasing resistor values requires a larger capacitor, which takes more time to charge at startup and thereby delays the availability of high-side drives; yet, if the capacitor is too small, supplying the required gate charge to the high-side switch will come with too much droop in the gate voltage. Together, these requirements typically result in a need that can only be filled by large and relatively expensive components.

Considering the tradeoffs, there is no such thing as an ideal bootstrap circuit. At best, a bootstrap circuit provides a workable tradeoff between multiple design variables. Although this workaround has often been accepted as a required means to an end, it does not satisfy today's top-notch power-conversion requirements.

The ideal solution for the electrification needs of today might lie in finding a way to eliminate the need for bootstrap circuits and separate power supplies. However, most industry resources have not been devoted to research and development of gate drive systems but rather to wide-bandgap power switches. Driving these switches requires gate drive systems that can fully leverage the potential advantages of these new technologies, including the tremendous benefits that come with the elimination of bootstrap circuits and separate power supplies.

New approach—Embedding the bias supply system within the driver

A new approach to driving wide-bandgap power switches is to simplify the way the power switches are driven. Some devices now embed the bias supply system within the driver. These devices need no external auxiliary supply as the bias supply system replaces the need for the external auxiliary supply, eliminating the additional components and design resources associated with auxiliary supplies. In one such approach, the

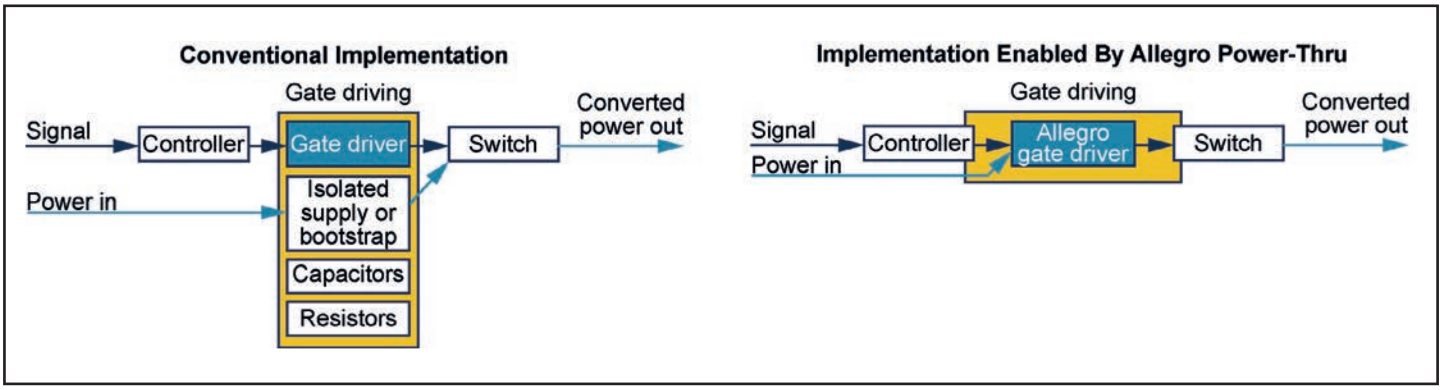

Figure 1: Simplified functional block diagrams of conventional implementation (left) and an implementation enabled by Allegro Power-Thru (right). The Allegro solution reduces system size and component count to deliver benefits that can improve most all aspects of bringing a power product to market.

Power-Thru technology from Allegro MicroSystems, power is transferred to the gate drivers using a fully integrated system-in-package (SiP) gate drive (see Figure 1).

The key subcomponents of the Power-Thru technology are two gate drive ICs and a tiny magnetic-based isolation structure that enables efficient power transfer across the boundary from the low-voltage signal to the high-voltage system. At first, this may seem like an ordinary solution. Compared to the wide range of isolated gate drive ICs on the market, the real and significant novelty is located inside the IC: The Power-Thru technology includes a clever and patented circuit design that allows the IC to manage both the gate drive signal and the transfer of energy from the primary IC to the secondary gate driver IC across the magnetic isolation barrier. This novel technology enables the isolation boundary to carry the drive power required to drive both the external FET switch and the gate drive signal data. Because complete electrical isolation is provided by the magnetic coupling, Power-Thru drivers are equally suitable for use in high-side, low-side, and isolated applications.

The Power-Thru devices remove the need for a bootstrap circuit or an external

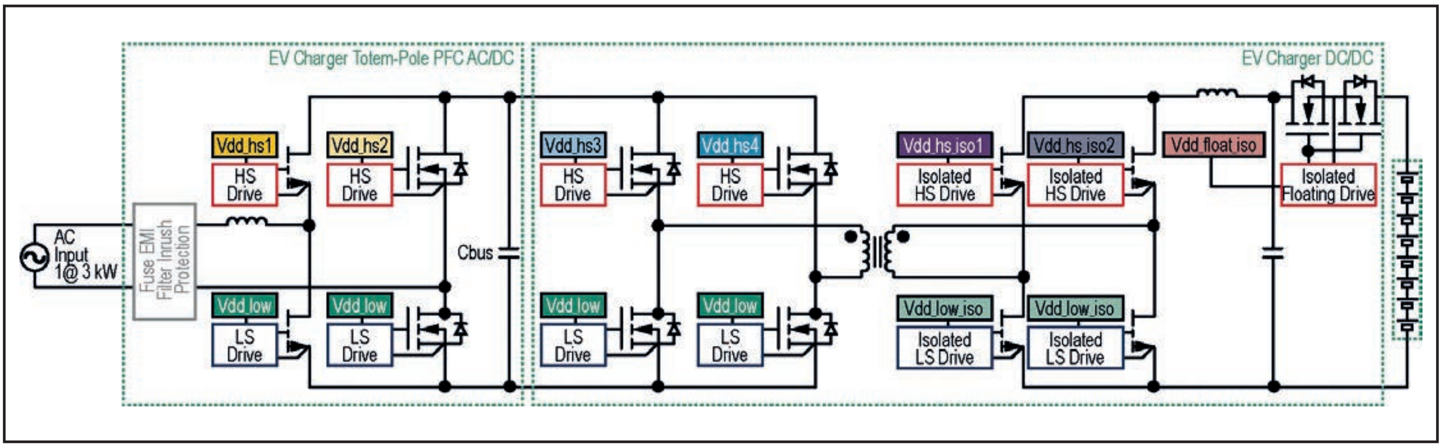

Figure 2: When all phases are considered, dozens of power rails can be required in conventional on-board charger designs.

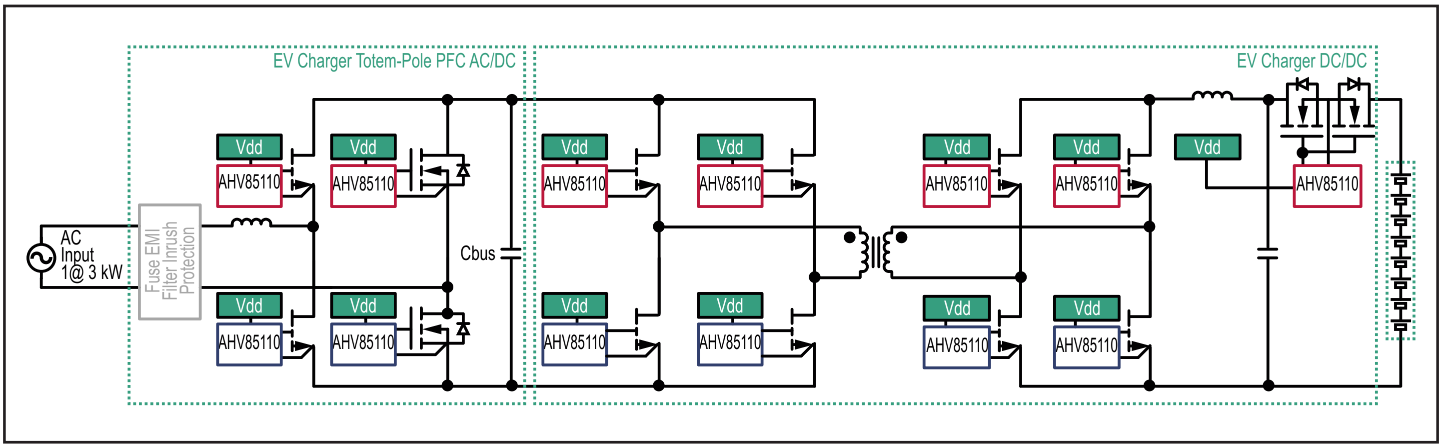

Figure 3: The design of an EV on-board charger can be simplified and accelerated using Power-Thru technology from Allegro. Allegro Power-Thru technology can allow an on-board charger design with as few as one power rail per phase. The Allegro AHV85110 isolated gate driver shown in this example is optimized for driving GaN FETs in multiple applications and topologies. (Additional information about the AHV85110 isolated gate driver is available at https://www.allegromicro.com/en/products/motor-drivers/gate-drivers/ahv85110)

isolated DC-DC source to create the floating voltage required for controlling the high-side switches. The benefits cascade from there. By eliminating the need to provide an external bias power supply, all the tradeoffs and complexity in choosing the optimal combination of components vanish. The reduced component count/complexity amounts to fewer potential points of failure, which delivers greater reliability, leading to fewer potential warranty claims and enhanced product reputation. The reduced component count also results in smaller gate driver assemblies with shorter signal paths. The shorter signal path inherently results in reduced parasitic capacitance and inductance. As a result, the risk of damage caused by ringing and voltage spikes is significantly reduced and more space is available for the power stages, enabling the use of more-efficient designs. This solution also allows the gate driver to track the power consumption of the gate control with the switching frequency, enabling automatic optimization of efficiency.

By enabling the elimination of auxiliary power supplies, Power-Thru gate drivers ultimately make design and qualification easier while lessening strain on engineering resources and accelerating research and development cycles.

Simplifying power-conversion design by applying Power-Thru solutions

Cost, design time, and unexpected problems: These are three of the most significant issues on the minds of project managers who are involved with the design of power conversion systems, and the innovative Power-Thru technology from Allegro can help to minimize all of them. The following example of an on-board charger illustrates the significant impact of the Power-Thru technology.

This example uses a multilevel topology, which is known to enable high-efficiency power conversion. However, the design of a multilevel topology is very complex—particularly the gate driver. Each wide-bandgap power transistor of the on-board charger used in this example requires one gate driver to switch the power device. While the primary and secondary low-side switches share the respective power rail, each of the seven high-side switches requires its own isolated bias supply. This can result in nine separate bias rails for the system, which is extremely complex, as shown in Figure 2. When designing the same on-board charger with isolated gate drivers enabled by the Allegro Power-Thru technology, the nine power rails per phase can be merged into a single rail, as illustrated in Figure 3. This break-through system design and build simplification allows significantly reduced component count. All power stages can be implemented in a single board, only requiring a single capacitor and two resistors on the output, which speeds design time and improves the likelihood of early design success. Furthermore, the reduced component count reduces bill of material (BOM) costs and system size, and also unlocks new levels of build simplification.

By reducing complexity, early success in testing and validation is more likely, and application of the technology can be more reliable because use of fewer parts equates to less opportunity for a failure. More importantly, the reduction of system size enables an increase in power density as the same amount of power can be delivered with smaller form factor.

Unlocking new levels of conversion performance and simplification with Power-Thru

In summary, power conversion systems need to be ever more efficient, compact, reliable and, ideally, less expensive. Wide-bandgap power switches allow for significant advances in achieving higher efficiency and higher power density, but they add system complexity and cost. Reducing system complexity can be achieved by focusing on another critical part of the power conversion system—the driving of the power FETs. The approach used to drive a power switch can have great impact on the solution as a whole, and drivers that enable the elimination of multiple power rails and bootstrap circuits have cascading benefits to the system.

The new paradigm in power conversion—created by the Power-Thru technology inside Allegro high-voltage isolated gate drivers—uses a novel SiP gate drive that includes a magnetic coupling device placed in between the primary and secondary gate driver integrated circuits, which eliminates the need for bias supplies. The power needed to drive the gate of the switch is transferred with the gate on/off logic signals, thus completely eliminating the external auxiliary power required by conventional solutions. The Power-Thru technology enables shorter signal paths that reduce parasitics and voltage spikes, increase reliability, free up space, and lead to more-efficient designs. The embedded bias eliminates bootstrap circuitry, separate power supplies, and other complicated design tradeoffs.

Considered as whole, the Power-thru technology provides advantages in all relevant system dimensions, unlocking significant system and design simplification, higher efficiency, and reduced component count leading to higher power density and reliability.

https://www.allegromicro.com/en

Wolfspeed grows to meet supply challenge and launches high performance Gen 3+ die

Silicon Carbide (SiC), known for long as the ideal semiconductor technology for power devices, has with design and manufacturing innovation not only increased its share of the existing market but enabled new applications, such as electric vehicles (EVs), by offering higher power density, better high-speed switching performance, higher breakdown field, higher thermal conductivity, higher chip temperatures, and lower leakage currents than are possible with Silicon (Si). **Anri Mikirtichev, Product Marketing Engineer, Wolfspeed, Amy Romero, Power Die Applications Engineer, Wolfspeed**

Wolfspeed has led the SiC industry with the first commercial wafers in 1991, diodes in 2001, and MOSFETs in 2011. The company's technology development has supported its relentless march toward larger wafer diameters and lower costs, higher quality, and greater device performance. The company has more than 35 years of SiC development experience and over 7 trillion device field hours.

This widely recognized success is evident from its recent selection by General Motors (GM) as their strategic SiC power device supplier [1]. GM is participating in the Wolfspeed Assurance of Supply Program (WS AoSP) for domestic, sustainable, and scalable materials in EV production.

It comes as no surprise that the same success was recently responsible for a rapid, wafer-shortfall-inducing growth in SiC demand from EV, solar and datacenter applications.

Yole Devéloppement forecasts the EV market the biggest opportunity for SiC, worth over $5 billion in 2027, while the charging infrastructure market continues growing at 90% CAGR through 2025. Yole expects SiC to gain market share in the long term as companies like Wolfspeed overcome all challenges, including those related to supply, cost, and performance (Figure 1).

Resolving supply & cost challenges

Commanding nearly 60% of the N-type SiC substrate market in 2018-2019 as estimated by Yole, Wolfspeed is naturally the supplier to resolve supply challenges due to growing market confidence in SiC. The company is investing $1 billion in a new 200-mm wafer-capable Mohawk Valley Fab (MVF) [2] and converting its existing facility into a materials mega-factory.

While competitors are still using 150-mm fabs, Wolfspeed is leveraging vertical integration and internal "cycles of learning" to address demand and cost with 200-mm wafers from the new automotive-qualified automated facility.

The MVF construction is complete, the first 200-mm wafers demonstrated, and the fab is undergoing qualification for mass production.

Figure 2: Wolfspeed is leading the industry in taking 200-mm Silicon Carbide

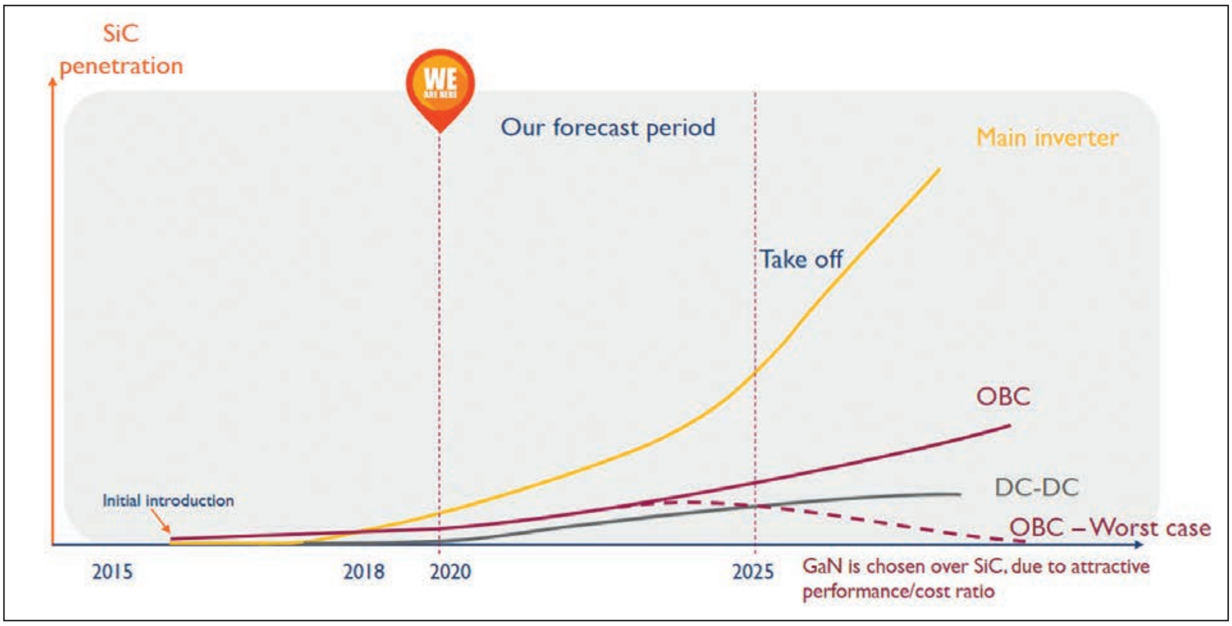

Figure 1: EV/HEV market outlook to 2030. Source: Power SiC Materials, Devices and Applications, Yole Devéloppement

Figure 2: Wolfspeed is leading the industry in taking 200-mm Silicon Carbide wafers from prototype to production. The new Mohawk Valley Factory fabrication facility is shown above.

wafers from prototype to production. The new Mohawk Valley Factory fabrication facility is shown above.

Upping the performance ante

Among key performance parameters that help meet EV requirements are the SiC MOSFET drain-to-source ON resistance, RDS(ON), and rated junction temperature, T_j, with the former responsible for conduction losses and thermal waste and the latter the device reliability and its ability to withstand heat.

Wolfspeed has continued innovation to address these concerns with a new Gen 3+ 750 V bare-die MOSFET (Figure 3) that has already won several contracts. Coming

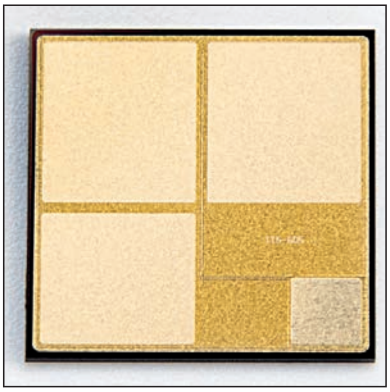

Figure 3: The Gen 3+ 750 V MOSFET sets new standards for low R_{DSON} and temperature qualification.

in a 5mm x 5mm-layout and 180-µm thickness, it features low internal gate resistance R_g to optimize current rise-time and switching losses. Importantly, the new device boasts low on-state resistance ($R_{DS(ON)}$) and high maximum junction temperature (T_J).

Gen 3+ 750 V Characteristics

Compared with Wolfspeed's 650 V, 15 mΩ MOSFET die with T_j rated to 175°C, the Gen 3+ product improves on $R_{DS(ON)}$ per unit area as well as total area to reach 10 m . The 750 V rating improves the FIT rate and the MOSFET also elevates the T_j rating to above 175°C (200°C data shown) for peak condition operation during the vehicle mission profile. The temperature-stable $R_{DS(ON)}$ increases overall efficiency as well as system temperature limits (Figure 4).

Gen 3+ technology offers similar stability for the gate threshold voltage, V_{th}, giving designers enough headroom to switch aggressively while avoiding spurious turn-on (Figure 5). Combined with a high capacitance ratio, the stable V_{th} allows for safe operation without shoot-through concerns at elevated temperatures.

Moreover, Wolfspeed uses an Ni/Pd/Au metallization stack-up on both die sides to allow double-sided soldering/sintering. This new metallization used on Wolfspeed's automotive die opens the option for more advanced packaging solutions that can lead to better performance from the die and better reliability of the package. Examples of this include sintering copper clips or films to the top of the die and using copper wire bonds for higher current

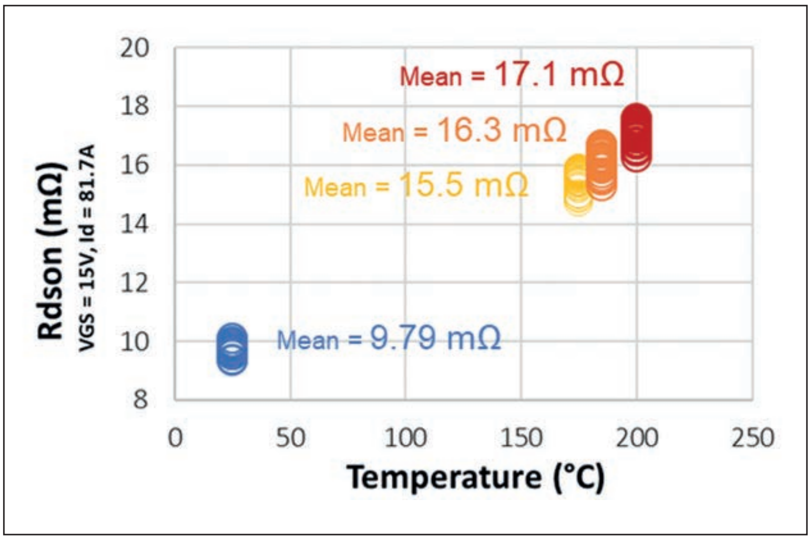

Figure 4: The Gen 3+ 750 V MOSFET $R_{DS(ON)}$ (blue) remains low and stable over 25°C-to 200°C range against the competition.

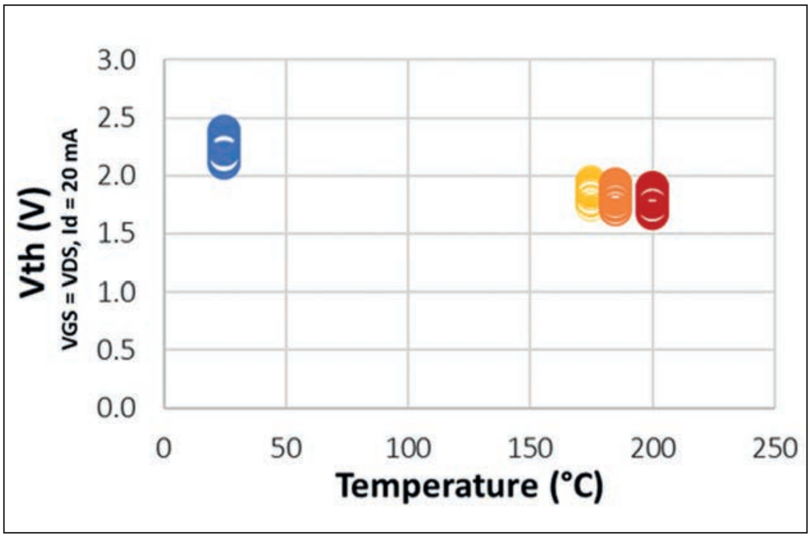

Figure 5: The new device offers a temperature-stable V_{th} (blue) for greater freedom in avoiding spurious turn ONs.

carrying and thermal capabilities (Figure 6).

Figure 6: The double-sided Ni/Pd/Au plated metal stack-up double-sided copper soldering/sintering for higher current and thermal performance.

Robust performance for automotive apps

The AEC-Q101-qualified MOSFETs are robust enough to withstand failure modes like short circuit and surge, which are important factors to consider in automotive applications where high robustness is necessary. [3]

This die has high energy capabilities of 1.2 J in short circuit conditions and >2.6µs withstand time at a junction temperature of 175°C. This short circuit withstand time (tested under worst case conditions) offers an adequate safety margin for gate driver technology to handle the fault. The devices have also been tested to withstand surge currents of up to 340 A or, depending on application conditions, >3x rated current. This surge current capability is important for active short circuit modes or other high current events.

The die is also capable of withstanding high temperature excursion events up to 200°C for a limited time without affecting device reliability. This functionality was demonstrated with extended high temperature AEC-Q101 tests at 200°C for 168 hours.

Switching performance tests under standard conditions demonstrated 30 V/ns and 4 A/ns switching speeds, without exceeding the voltage rating during transients. The device also exhibited consistent switching losses over temperature, with only a 150 µJ increase in total switching losses in a device tested from 25°C to 175°C. The fast switching capability of these devices and stable operation over temperature leads to overall lower switching losses in the system.

Summary

Wolfspeed has shared new details of its 200 mm expansion and new automotive-qualified 750 V MOSFETs designed for use in electric vehicle powertrain applications. Robust operation to 200°C, strong short-circuit energy (1.2 J) and time (> 2.6 µs) capabilities, surge currents up to 340 A, and low (10 m) conduction losses have enabled the 750 V, 10 m SiC MOSFETs to be successfully designed into new battery electric vehicles.

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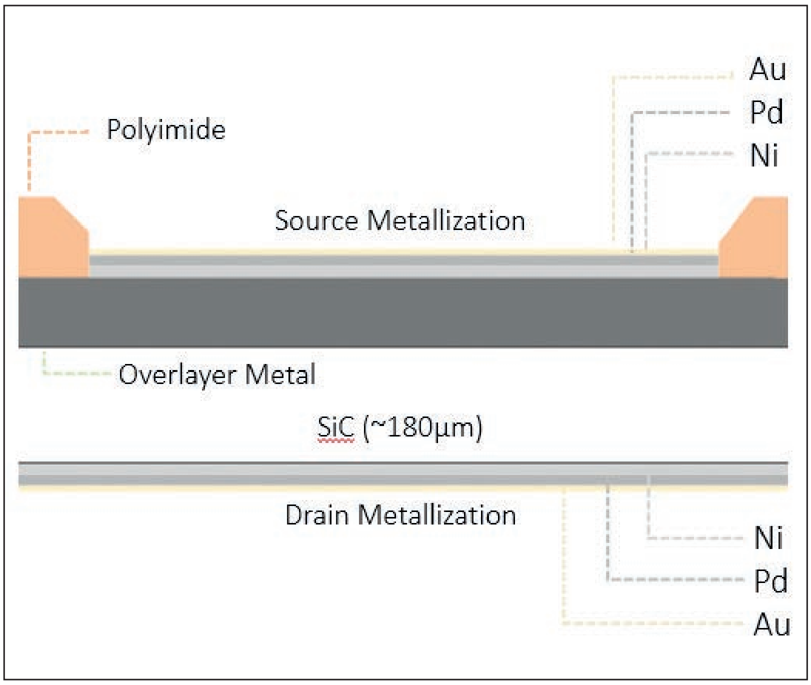


Figure 6: The double-sided Ni/Pd/Au plated metal stack-up double-sided copper soldering/sintering for higher current and thermal performance.

eGaN FETs enable more than 4 kW/in³ power density for 48 V to 12 V power conversion

GaN transistors in Chip Scale Package (CSP) enable higher than 4 kW/in3 power density for 48V to 12V power conversion using an LLC resonant converter with up to 1 kW capability. **Alejandro Pozo.**

Introduction

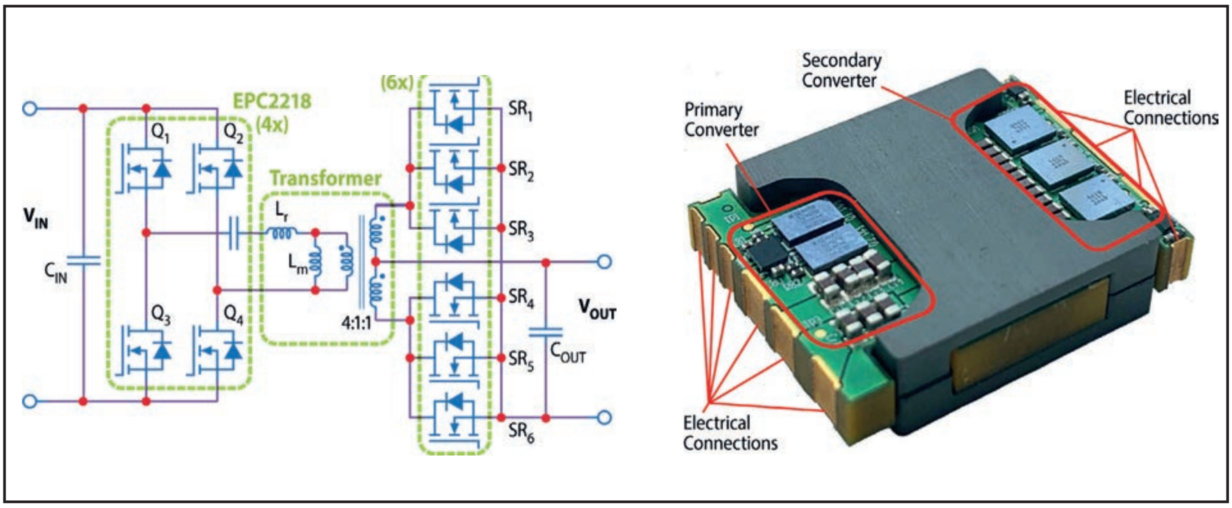
Growing computational power and miniaturization of electronics in computing and datacenters is increasingly putting pressure in 48 V power delivery and conversion systems. High efficiency and high-power density converters enable a reduction in power losses at the system level while allowing smaller form factors. In this context, LLC resonant topologies combined with GaN technology succeed to deliver outstanding performance, as it has been demonstrated with multiple examples [1-4]. This article will show the key design parameters and components to achieve beyond 4 kW/in3 of power density in a 48 V to 12 V LLC converter using eGaN FETs. This work is an evolution of [2] and it was first introduced in [1], demonstrating 96.3% peak efficiency and 93.8% when delivering 1 kW into a 12 V load and with module dimensions of 17.5 x 22.8 x 7.7 mm.

Converter Overview

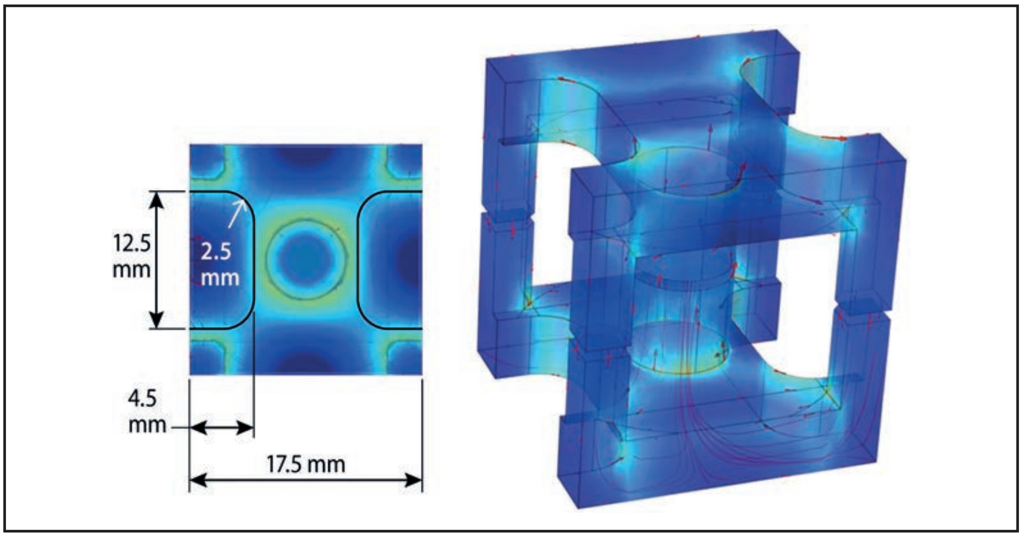
The LLC resonant converter presented here features a primary full bridge and a center-tapped full wave synchronous rectifier for the secondary as shown in Fig 1 (left). Both are coupled with a planar transformer having a 4:1 turns ratio. The power FETs used in the primary and secondary, together with the transformer and printed circuit boards are the key components of the module. Figure 1 (right) shows a photo of the overall module assembled

Power Transistors and Gate Drivers

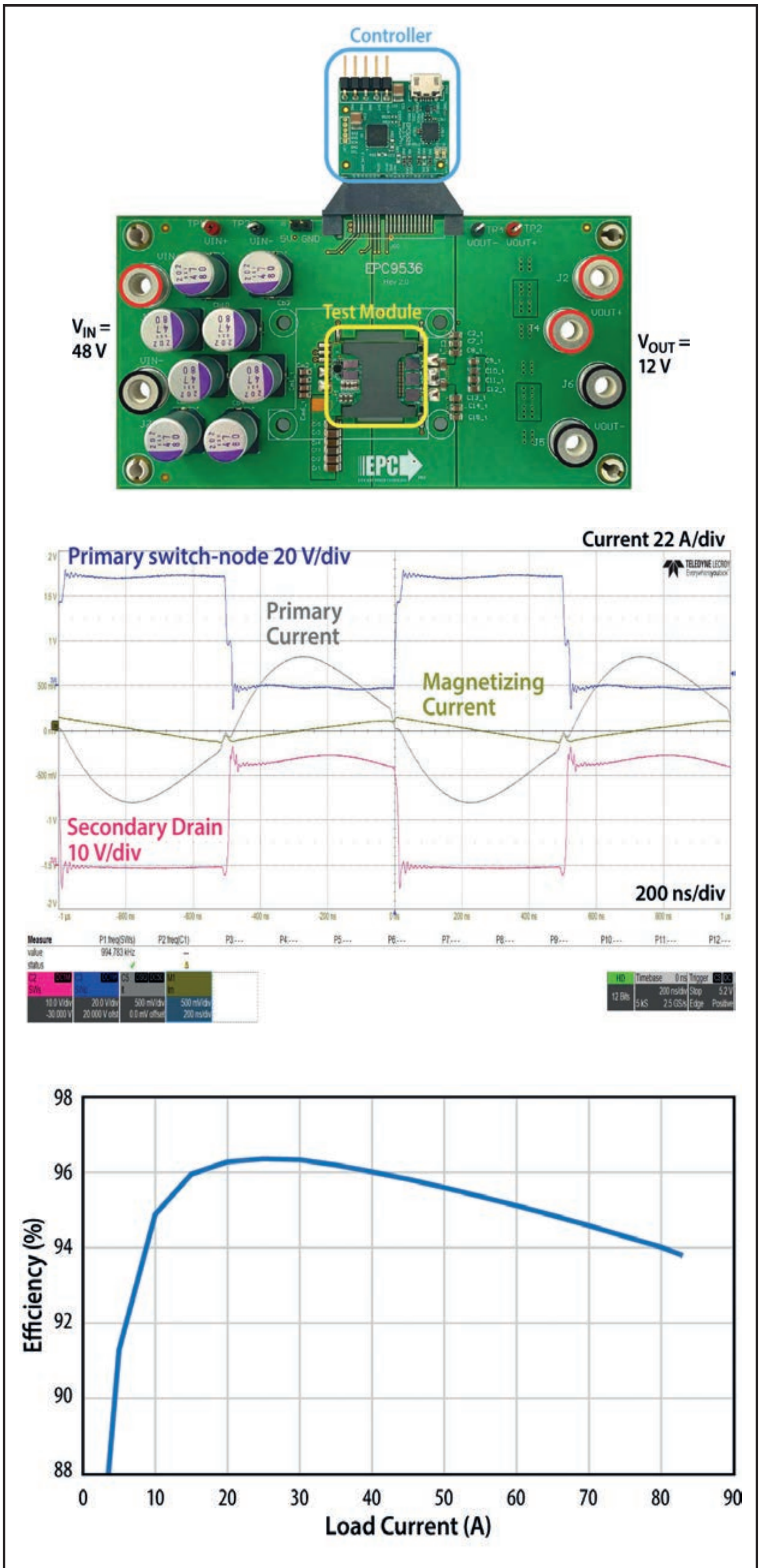
For the primary circuit, four 100 V rated



ABOVE: Fig. 1 (left) Topology of the LLC converter, (right) photo of the assembled LLC power converter module



RIGHT: Fig. 2 (left) top view and dimensions of optimised core (right) full FEA model of the core showing the flux density throughout the core



LEFT: Fig. 3 (top) Photo of the test system assembled, (centre) measured waveforms, (bottom) measured efficiency at V_{in} = 48 V

3.2 mΩ EPC2218 [5] are used in conjunction with two uP1966E [6], a half-bridge gate driver ICs. For the secondary rectifier, a total of six 40 V rated 1.55 mΩ EPC2067 [7] are used as synchronous rectifiers. These six transistors are divided into two branches, where each branch consists of an LMG1020 [8] low side gate driver controlling a parallel array of three EPC2067s. All power transistors and gate drivers are in CSP format for minimum size and lowest parasitic elements.

The choice of eGaN transistors is especially advantageous in the primary given the low RDS(on) * COSS figure of merit compared to equivalent Si MOSFETs. This is because for a similar RDS(on) and voltage rating, GaN transistors offer lower COSS, therefore minimizing the magnetizing current needed to achieve ZVS in as short transition time as possible. As a result, the frequency can be increased to the 1 MHz range enabling size reductions in the passive components while maintaining high efficiency.

The uP1966E half-bridge gate drivers used for the primary are an ideal match for this application where a minimum of 80V rating and minimum size and external components are key features. Similarly, the LMG1020 offers a tailored solution for this socket, given its minimum footprint and supporting circuitry required, as well as sufficient strength capable of driving the three paralleled EPC2067 FETs without compromising speed.

While the components listed above enable very high operating frequencies in a very compact form, some challenges arise from the different propagation delays between primary and secondary gate drivers. To overcome these mismatches, 3 unique PWM generators with independent dual edge control are used to align the desired synchronization between primary and secondary circuits. Such configuration provides the programmable flexibility needed to ensure a balanced square waveform in the primary, with control of the dead time to realize ZVS in the primary and maintain ZVS/ZCS in the rectifier transistors and minimize circulating energy.

Transformer Design

The transformer design and choice of core material are driven by the converter requirements, input/output voltage ratio of

4:1, desired output power of 1 kW at 1 MHz resonant frequency, and maximum size of 17.5 mm x 23 mm. Building on the experience from previous work [1,2] and aided by Finite Element Simulations a core shape with a single 6 mm diameter center post and four satellite flux return legs was designed and shown in Figure 2 (right). The 6 mm diameter for the center post was found to be the optimal dimension considering conduction losses in the copper windings and core losses, as analyzed in [1]. The final dimensions of the top and bottom side caps of the core shown in Figure 2 (left) are a compromise between flux density and magnetic core utilization, to open areas for placing components without increasing core losses. Note that the PCB real state close to the transformer windings is of utmost interest to minimizing parasitic inductance. As reported in the literature, this parasitic inductance in the secondary is detrimental to the performance by as much as 30% [4].

ML91S [9], the same soft-ferrite material used in prior work [2], was used for the transformer core. It provides good stability over temperature and frequency, even beyond 1 MHz, as well as less than 200 kW/m3 of flux density volumetric power loss. The airgap between the two core halves was tuned to realize a magnetizing inductance of approximately 1.8 μH.

PCB Design

With the transformer core dimensions defined, the primary and secondary windings were distributed over 16 layers routing the current around the center post of the transformer core. A single 3oz per layer was dedicated to each primary turn and three 3oz layers and one 2oz layer were paralleled for each branch of the secondary. The inner twelve layers are fabricated with standard PCB technology, whereas HDI technology was utilized for the outer layers. This way the primary and secondary components can be placed on the top and bottom sides of the board and the current efficiently routed down into the transformer windings.

Testing Results and Next Steps

To test the converter described in the previous sections, a motherboard was developed to provide input/output connections for the module, additional bus capacitance, housekeeping power supplies, sense connections for accurate efficiency measurements, and a connector for the controller board. A photo of the setup is provided in Fig. 3 (left), along with waveforms at full load (center) and the efficiency curve (right). Peak efficiency of 96.3% could be measured at 25 A and 93.8% at 84 A (1 kW).

In the next iteration of the converter, the controller and housekeeping power supplies will be integrated in the module while maintaining the same overall size. Moreover, a small resonant inductor will be added in series with the transformer to increase the Q factor while maintaining the same resonant frequency. The PCB will also experience changes as the 16-layer board will be replaced with a two-PCB solution to reduce copper losses and improve manufacturability of the overall system.

Conclusions

The module presented in this article demonstrates that GaN FETs can enable unprecedented levels of power density (>4 kW/in3) in 48 V to 12 V power converters, such as those needed in datacenters with a 48 V architecture. In particular, the combination of GaN technology featuring chip-scale packaging like those of eGaN transistors, and carefully designed magnetics, allow 1 kW load capability at 1 MHz frequency with peak efficiencies and full load efficiency of 96.3% and 93.8% respectively.

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AC/DC power factor correction module offers up to 1,512W

The power supply has a 0.98 power factor and delivers a regulated 360V DC non-isolated voltage from an AC input. The PF1500B-360 can be used to drive isolated high voltage input DC/DC modules in a distributed power architecture configuration, or loads requiring a high voltage DC input. Applications include semiconductor fabrication, LED lighting and custom power supplies using power modules.

With an input of 170 to 265V AC, the PF1500B-360 provides 1,512 and 1,008W when operated from 85 to 265V AC. Efficiency of 96.5% efficiency ensures reliable operation with baseplate temperatures of up to 100°C and in ambient temperatures of -40 to 85°C.

The industry standard full brick package measures 116.8 x 61 x 12.7mm high for low profile applications.

The module provides a 10 to 16V 10mA auxiliary voltage and has a remote on/off and an inverter good signal. An enable function is available to activate isolated DC/DC converters when the output voltage is greater than 360V DC to synchronise output rise times. Parallel connection with current sharing of up to three modules is possible for additional output power.

Input and output to baseplate isolation is 2,500V AC.

The module is certified to the IEC/EN/CSA/UL 62368-1 standards and is CE / UKCA marked to the low voltage, EMC and RoHS EU Directives and UK regulations. With external circuitry, the module will meet radiated and conducted emissions and comply with the IEC 61000-4 immunity standards.

https://product.tdk.com/en/products/power/index.html

Smart power device manages safe power distribution

The RAJ2810024H12HPD is available in the TO-252-7 package which reduces the mounting area by about 40% compared to the conventional TO-263 package product. It measures 6.10 x 6.50mm, excluding pins.

Intended for use in vehicles equipped with next-generation E/E (electrical/electronic) architectures, it has a current detection function for abnormal currents such as overcurrent and detects abnormal currents even at low loads, says the company, for precise power control system design that can detect even the smallest abnormalities.

Other features are built-in charge pump, self-diagnostic feedback by load current sense and load short circuit, overheat detection, sense current output and GND open protection.

The single channel, high side IPD has low Ron of of 2.3mΩ at 25°C (typical). The intelligent power device (IPD) addresses E/E architectures as they evolve in automotive design. In a conventional distributed E/E architecture, power supply from the battery is distributed to each electronic control unit (ECU) via long, thick wires from a power box consisting of mechanical relays and fuses. IPDs have a longer life and are maintenance-free compared to mechanical relays, so they can be placed anywhere in the vehicle. As the automotive industry moves toward centralised or zoned E/E architectures, IPDs offer flexible power supply networks using shorter, thinner wires.

The RAJ2810024H12HPD supports 3.3/5.0V logic interface and complies with AEC-Q100 and RoHS automotive standards.

The RAJ2810024H12HPD is available today in sample quantities with mass production scheduled in Q1 2024.

https://www.renesas.com/eu/en/products/automotive-products/automotive-power-devices/automotive-protected-and-intelligent-power-devices

Miniature DC/DC convert by Advanced Energy are programmable

Miniature isolated single and dual-output high voltage DC/DC converters from Advanced Energy in the AEQ series supply up to 600V DC at 0.5W from 5V DC input.

The UltraVolt AEQ series are designed for power conversion in a range of ISM (industrial, scientific, medical), life science and semiconductor equipment applications.

They are housed in a 0.5 x 0.5 x 0.5 inch / 127 x 127 x 127mm (cube) solid vacuum encapsulated package and are protected against shock and vibration.

Benefits include an output that is proportional to the control pin voltage, giving complete programmability from zero to the maximum rated value. Output stability is within 5% at maximum Vout and full load. A high input-to-output isolation rating of ?1500V DC supports precise output voltage control and meets safety levels required for handheld equipment. They also support compliance in medical and life science applications.

The small form factor make them suitable for use in high voltage products where space and weight are critical application requirements. Conor Duffy, vice president of marketing, medical power products at Advanced Energy, says: "The series is particularly well-suited for hand-held and portable devices ranging from silicon detectors and avalanche photo diodes to MEMS devices and ultrasonic transducers. Its programmable control enhances flexibility, precision and reliability to address specific application needs."

The AEQ series comprises unipolar 100 to 600V models and bipolar versions from ?50 to ?300V. Higher power and voltage levels are planned for later releases.

All devices have UL/cUL and IEC-62368-1 safety approvals.

URL: https://www.advancedenergy.com/

Toshiba releases two automotive-grade N-channel MOSFETs

The automotive-grade 40V N-channel power MOSFETs use the large transistor outline gull-wing leads package format, the L-TOGL.

The L-TOGL packages and its resulting heat dissipation characteristics mean that the MOSFETs are highly optimised for handling large currents, says the company. They each feature high drain current ratings (400A for the XPQR3004PB and 200A for the XPQ1R004PB), with what are claimed to be industry-leading on-resistance values (0.3mΩ for the XPQR3004PB and 1mΩ for the XPQ1R004PB).

There is no internal post structure (solder connection) because the source and outer leads are connected via a copper clip. A multi-pin structure used for the source leads reduces the package resistance (and associated losses) by about 70%, compared with the existing TO-220SM(W) package. The drain current (ID) rating of the XPQR3004PB, represents a 60% increase over the existing TKR74F04PB, housed in the TO-220SM(W) package. The thick copper frame reduces junction-to-case thermal impedance to 0.2°C/W for the XPQR3004PB and 0.65°C/W for the XPQ1R004PB to ease heat dissipation, lower operating temperatures and enhance reliability.

The AEC-Q101-qualified MOSFETs operate in automotive applications at temperatures up to 175°C. The gull-wing leads reduce mounting stress and allow easy visual inspection to help improve the solder joint reliability.

When used in high current automotive applications, such as semiconductor relays or integrated starter generators (ISGs), the MOSFETs can simplify designs and reduce the number of MOSFETs required, says Toshiba, contributing to size, weight and cost reductions.

Both MOSFETs are shipping in volume now.

https://toshiba.semicon-storage.com/eu/top.html

Diodes unveil AL5887 is dual digital interface, multi-channel LED driver

The latest linear current LED driver from Diodes drives multiple LEDs for complex colour mixing and different lighting patterns. The LL5887 integrates both I2C and serial peripheral interface (SPI) options. It delivers a wide colour range and an extensive dynamic range of brightness levels, says the company.

There are 36 independent programmable channels which can drive up to 12 RGB LED modules or 36 single colour emitters. It features an internal 12-bit pulse width modulation (PWM) for colour and six-bit analogue brightness control, which can be accessed through either interface.

There are three programmable banks for software control of each colour, making it easier to programme and set RGB lighting module patterns. An independent colour-mixing and brightness register per channel enables better colour-mixing schemes, explains the company. The dimming function relies on a PWM duty cycle from three to 100%. Once the duty cycle goes below 3%, internal circuitry converts the output to analogue dimming, maintaining linearity. By combining PWM and analogue dimming functions, a dimming ratio greater than 100K to 1 can be achieved.

There are also advanced diagnostics with fault-reporting functions. There are built-in protection capabilities for continued operation, including both short circuit and open-LED protection, as well as over-temperature shutdown. For earlier detection, there is also a pre-event over-temperature shutdown warning function.

Two external hardware address pins enable up to four devices to be connected in I2C mode. An internal 16MHz oscillator avoids the need for an external high-precision clock, reducing the overall bill of materials (BoM) cost.

The AL5887 LED driver is supplied in a 52-pin wettable QFN package, with exposed pad for heat dissipation.

Typical applications that are suitable for the LED driver are in smart home appliances, electric vehicle charging stations, infotainment displays, IoT information indicators, and computing hardware.

URL: https://www.diodes.com/part/view/AL5887/

EPC develops 80V laser driver IC for higher density lidar systems

Efficient Power Conversion (EPC) has designed the monolithic IC with an 80V, 40A FET with gate driver and 3.3 logic level input. It is a single chip for time-of-flight lidar systems used in robotics, surveillance systems and vacuum cleaners and for lidar systems for gesture recognition, ToF measurement, robotic vision or industrial safety.

The laser driver uses 5V supply voltage and is controlled using 3.3V logic. It is capable of frequencies greater than 50 MHz and super short pulses down to 2ns to modulate laser driving currents up to 15A. Voltage switching time is less than 1ns and delay time from input to output is less than 3.6ns.

The single chip driver plus GaN FET based on EPC's proprietary GaN IC technology in a chip-scale BGA form factor that measures 1.7 x 1.0 x 0.68mm. The wafer level packaging is characterised by low inductance and the level of integration means that the overall solution is 36% smaller on the PCB compared to an equivalent multi-chip discrete implementation.

The EPC21701 complements the ToF driver IC family in CSP (chip-scale package) that also includes the 40V, 15A EPC21601 and the 40V, 10A EPC21603.

This family of products will enable faster adoption and increased ubiquity of ToF solutions across a wider array of end-user applications, believes EPC. They dramatically improve the performance while reducing size and cost for time-of-

flight lidar systems, said Alex Lidow, CEO, and co-founder of EPC. "Integrating a GaN FET with driver on one chip generates an extremely powerful and fast IC and reduces size and cost for wider adoption in consumer and industrial applications," he added. The company also plans to extend the family soon to 100V and 125A models.

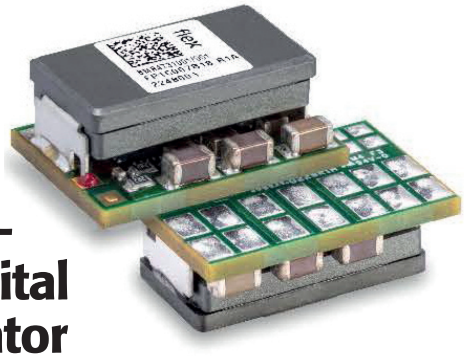
A development board is also available. The EPC9172 features the EPC21701 eToF laser driver IC and is primarily intended to drive laser diodes with short, high current pulses. Capabilities include minimum pulse widths of <2 ns, 15A peak currents and bus voltage rating of 40V.

The EPC21701 and EPC9172 are available for immediate delivery from Digi-Key.

Designers interested in replacing their silicon MOSFETs with a GaN solution can visit the EPC website to access the EPC GaN Power Bench's cross-reference tool to find a suggested replacement based on a project's specific operating conditions.

https://epc-co.com/epc/design-support/assemblybasics

Power Modules adds SMD horizontal-mount digital PoL regulator



It is also suitable for reverse mounting during reflow-soldering.

The mechanical module measures 19 x 13 x 7.5mm and operates from 6.0 to 15V input. Regulated output is adjustable from 0.6 to 5.0V at up to 40A. Up to four units can be paralleled with synchronisation and phase-spreading for a maximum of 160A output.

The single phase power module has efficiency up to 96.2% at 12Vin and 5Vout at full load. Minimal temperature derating is required due to thermal management and a 125°C maximum hot spot temperature, advises Flex.

Remote control, a power good signal and configuration and monitoring via PMBus are included and the module is compatible with the Flex Power Designer GUI.

There is also input under- and over-voltage, over-temperature and output over-voltage, over-current and short-circuit protection. In addition, there is tight regulation, low output noise and fast load transient response and over 30M hrs MTBF, according to Telcordia SR-332 standard.

The surface mount version of the BMR473 PoL regulator will be useful to customers in telecomms and datacomms sectors who require automated placement and a low profile in the final form facto

https://flexpowermodules.com/

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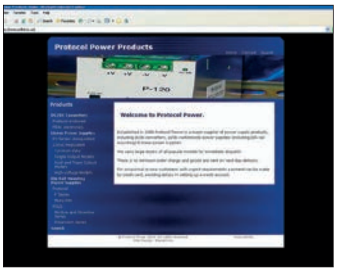

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