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Bodo´s Power Systems®

Electronics in Motion and Conversion

February 2021

PULSED INDUCTANCE MEASUREMENT

POWER CHOKE TESTER DPG10/20 SERIES

Inductance measurement from 0.1 A to 10 kA

KEY FEATURES

Measurement of the
- **Incremental inductance** $L_{inc}(i)$ and $L_{inc}(\int Udt)$
- **Secant inductance** $L_{sec}(i)$ and $L_{sec}(\int Udt)$
- **Flux linkage** $\psi(i)$
- **Magnetic co-energy** $W_{co}(i)$
- **Flux density** $B(i)$
- **DC resistance**

Also suitable for 3-phase inductors

APPLICATIONS

Suitable for all inductive components from **small SMD inductors** to **very large power reactors in the MVA range**
- **Development, research** and **quality inspection**
- **Routine tests** of small batch series and mass production

KEY BENEFITS

- Very **easy and fast** measurement
- **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

AVAILABLE MODELS

Model	max. test current	max. pulse energy
DPG10-100B	0.1 to 100A	1350J
DPG10-1000B	1 to 1000A	1350J
DPG10-1500B	1 to 1500A	1350J
DPG10-1500B/E	1 to 1500A	2750J
DPG10-3000B/E	3 to 3000A	2750J
DPG10-4000B/F	4 to 4000A	7700J
DPG20-10000B/G	10 to 10000A	15000J

Technological leader in pulsed inductance measurement for 18 years

www.ed-k.de

CONTENT


ADVENTURES OF OHM
QUID PRO QUO
ELECTRON TRADING POST
6 ft. APART
MASK REQUIRED
©2020 RIDLEY ENGINEERING INC.

The Gallery

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Electrical Times in Automotive

Electric vehicles are becoming more and more of an option. The number of newly registered electric cars in Germany in 2020 increased threefold compared to 2019. In Norway, 60% of all newly registered cars today are electric and another 15% are hybrids. The UK has announced plans to ban cars with internal combustion engines from 2030. But what is most impressive to me is seeing how quickly work is progressing on Elon's Gigafactory. Especially when you consider how long other projects have taken in the Berlin/Brandenburg area, for instance, the new airport. I am very sure that this additional (now not so new) player will help speed up other processes in Europe. Competition leads to more motivation!

This is all good news for our industry, but as we are still at the early stages of this next phase in personal transportation - there is still a lot to do. For example, the charging infrastructure needs to be rethought. The only reasonable way forward, in my opinion, would be a standardized solution. Many manufacturers are still doing their own designs, which is not very helpful. Anyway, EVs are becoming more and more visible on the roads. Hopefully, manufacturers will soon realize that it is the small cars that are best suited for electric drive. It really upset me when I recently looked at the portfolio of a very, very, large German automotive manufacturer. The smallest version of its electric models is no longer available at all from its subsidiary brands, and it has a delivery time of 16 months from the main brand. Sure, small car - small profit, but a 2.5-ton SUV with an electric range of less than 50 kilometers? Surely that cannot be the way to go! Just my opinion...

It took a little longer than expected, but the live sessions from the WBG-event in December are now available on our website. Together with all the presentations, it makes a nice compilation of the latest trends in Wide Bandgap Technology. And best of all, the material is not expiring, it is free and easy to access. And while you are at the website, www.bodospower.com/wbg.aspx, why not check out the presentations from last year's digital PCIM. That playlist is still available - together they give you enough video content for one of those awful lockdown evenings.

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 North America efficiently. If you are using any kind of tablet or smart phone, you will find all our content on the website www.eepower.com. If you speak the language, or just want to have a look, do not miss our Chinese version: www.bodospowerchina.com

My Green Power Tip for the Month:
Home delivery is like the public transport of groceries. Instead of having 20 odd cars make their way to the supermarket – one van drives around delivering to everyone in the area. More and more shops are offering it.

Kind regards

Events

embedded world 2021
Online March 1-5
www.embedded-world.de

IPC APEX 2021
Online March 8-12
www.ipcapexexpo.org

CWIEME Shanghai 2021
Shanghai, China March 10-12
www.coilwindingexpo.com

SEMICON CHINA 2021
Shanghai, China March 17-19
www.semiconchina.org

SEMI THERM 2021
Online March 22-26
www.semi-therm.org

emv 2021
Online March 22-26
www.e-emc.com

Hannover Messe 2021
Online April 12-16
www.hannovermesse.de

DesignCon 2021
San Jose, CA, USA April 13-15
www.designcon.com

IEEE-PEMC 2021
Gliwice, Poland April 25-29
www.ieee-pemc2020.org

Donation in Lieu of Sending Gifts

Vincotech has pledged to continue its holiday tradition of donating to a good cause in lieu of sending Christmas gifts to customers. The company's partner in philanthropy is again Plan International Germany. This aid organization will receive a €12,000 grant, provided in the name of the company and its customers, to fund vocational training

for disadvantaged young Bolivians. The youth unemployment rate in Bolivia is high with 30 percent of 20-to-24-year-olds lacking any sort of gainful employment. Some work on family farms, but inequality is an issue. Young women are likely to have fewer educational and job opportunities, which are particularly scarce in rural regions. And the few jobs available are often exploitative, paying less than minimum wage and subjecting workers to harsh conditions. Many of the young seek work abroad, leaving their families behind. This project affords this younger generation, and women especially, the opportunity to acquire marketable job skills and set up businesses of their own. An education in agriculture, tourism or catering is the first step towards a steady income that will enable youngsters to support their families and contribute to their communities.

"Fund-raising is hard for charities when times are tough," says Vincotech CEO Eckart Seitter. "We don't want to be a fair-weather friend to a partner we've worked with for nearly ten years. This is why Vincotech is very happy to be supporting Plan International Germany's initiative to help these young people to a brighter future. What a wonderful project."

www.vincotech.com

Capacitor Division Acquired

Cornell Dubilier Electronics announced that its subsidiary, CD Snow Hill, LLC, has acquired the capacitor producing assets of NWL, Inc. Now possessing greater capabilities in custom high-voltage film capacitors for pulsed power and power conversion applications, the company is poised to expand its solutions for industrial, military, and medical customers. "NWL has long been an industry leader in the design and manufacture of high voltage AC and DC film capacitors for applications where we see opportunities for growth.", says Jim Kaplan, CEO of Cornell Dubilier. "This acquisition greatly expands our capabilities in custom capacitors needed for high-power lasers, military propulsion systems, inverters and more.", continued Kaplan. According to Robert Seitz, President of NWL, the sale of their capacitor operations will allow NWL to focus on its other core

business segments: transformers, electrostatic precipitators, and power supplies. Cornell Dubilier plans to assume operations at NWL's former plant in Snow Hill, NC. Employees of the Snow Hill operation, many of them highly experienced, will be employed by Cornell Dubilier, ensuring the same high-level of service enjoyed by NWL's customers over many decades. With the addition of custom, high-voltage DC and AC film capacitors, CDE now offers one of the most extensive portfolios of power capacitors available to the global marketplace. The added capabilities complement the company's core strength in power capacitors across multiple dielectric technologies including aluminum electrolytic, film, mica, and supercapacitors.

www.cde.com

Reseller in Netherlands, Belgium and Luxembourg

Danisense has announced that AR Benelux has been appointed as a reseller covering the Netherlands, Belgium and Luxembourg. Part of the AR Europe group of companies, AR Benelux is a provider of test and measurement equipment covering AC and DC power, electrical safety, EMC, oscilloscopes, RF and microwave and SatCom equipment. The company is stocking Danisense's wide range of high-quality AC/DC current sensors ranging up to 3000A and beyond. Comments Loic Moreau, VP marketing at Danisense: "AR Benelux is an excellent partner for the 'Measure To Analyze' market sector. Now, our customers in the Netherlands, Belgium and Luxembourg will be serviced by an experienced, local company that is able to support our products technically and commercially. AR Benelux is already actively selling instrumentation and laboratory equipment that is complementary to our current sense transducers." Mark Vloemans, business manager of AR Benelux' Test & Measurement division also sees good synergies with existing and new customers. "Danisense's current sensors fit very well with solutions we currently offer in the field of power supplies, power analyzers and high-power AC/DC (bidirectional) testing systems. Innovative Zero Flux technology and sturdy metal enclosures ensure that Danisense's current sensors the most stable and accurate devices currently available on the market", he adds.

www.danisense.com

SMALLER
STRONGER
FASTER

ROHM
SEMICONDUCTOR

REDUCES STANDBY POWER
FOR ALWAYS-ON CONSUMER PRODUCTS

ROHM's BM1ZxxxFJ integrated zero cross detection IC series is optimized for home appliances such as vacuum cleaners, washing machines, and air conditioners. The device provides designers a turn-key zero cross detector without the need for a complex design using discrete components. Additionally, this integrated solution does not use a photo-coupler typically used in other solutions, and therefore, it further reduces standby current consumption and increases long-term reliability.

KEY FEATURES

- Breakthrough photocoupler-less zero cross detection circuit design minimizes application standby power consumption
- Contributes to improved reliability and efficiency in home appliances in a variety of countries and regions
- Easily replace conventional zero cross detection circuits
- Integrated voltage clamp function protects the downstream MCU

CONSUMER

www.rohm.com

Demystifying EMC Conference Goes Virtual in 2021

Rohde & Schwarz announced that the seventh edition of its Demystifying EMC conference will go virtual, offering participants the opportunity to engage with industry experts through Europe and beyond. In an expanded three-day digital event running from 9th to 11th February 2021, the conference will feature a mix of live, educational and interactive events, with a virtual exhibition running alongside. Originally a one-day seminar, Rohde & Schwarz has established Demystifying EMC as one of the premier industry events on EMC in the UK over the past seven years, and has previously attracted around 500 attendees. With the number of new and repeat delegates increasing year on year, the event's maximum capacity has continuously been raised to meet high demand thanks to the event's focus on knowledge sharing and providing an industry wide perspective. Demystifying EMC offers insightful presentations by experts from independent training partners and industrial partners, as well as by Rohde & Schwarz specialists. Each day of the online conference will start with an EMC fundamentals session from Lee Hill of Silent Solutions, who shares his 30 years of EMC teaching, problem-solving and electronic design experience. The afternoons will feature a wide range of live keynotes from Rohde & Schwarz experts in addition to educational streams throughout the three days covering the trends in the EMC industry, including aspects of product design, test, simulations, and regulations and standards from leading EMC partners.

www.rohde-schwarz.com

Joint Laboratory on SiC Technology

ROHM, together with Chinese Tier 1 comprehensive automotive manufacturer United Automotive Electronic Systems Co., Ltd (UAES), held an opening ceremony announcing the establishment of a joint laboratory on SiC technology at UAES headquarters in Shanghai, China (Shanghai). Since 2015, UAES and ROHM have been collaborating and carrying out detailed technical exchanges on automotive applications utilizing SiC power devices. Finally, automotive products incorporating ROHM SiC power devices have been released earlier this year. The joint laboratory contains a number of important equipment required for device and application evaluation in automotive such as onboard chargers and DC/DC converters. This will allow to strengthen the partnership and accelerate the development of innovative power solutions centered on SiC.

Says Dr. Kazuhide Ino, CSO and Senior Director of Power Device Business, ROHM Co., Ltd.:

"We are pleased to have established a joint laboratory with UAES, a leading manufacturer of automotive applications. As a leading supplier of SiC power devices, ROHM develops industry-leading devices and has a proven track record of providing power solutions that combine peripheral components such as driver ICs. And in the rapidly expanding automotive sector, as research tailored to customer needs and market trends becomes an important factor, we will continue to strengthen our partnership through this joint research lab and contribute to technical innovation in the automotive sector with power solutions centered on SiC."

www.rohm.com/eu

Vice President Engineering for EMEA Components Business

Arrow Electronics has announced the appointment of Margit Tischler as vice president engineering of its components business for Europe, Middle East and Africa (EMEA). In her new role, Tischler will be responsible for Arrow's engineering teams in EMEA. Engineering services are a core part of Arrow's business and deliver expertise that enables customers to accelerate product development and deployment. Arrow has built on its strong technology relationships with suppliers by establishing an ecosystem of companies with whom it can deliver additional engineering support. This support includes development boards and tools, which can kickstart a development project, through to bespoke services and solutions that help customers to reduce time-to-market significantly.

Margit Tischler brings with her over 20 years' experience in technical sales and marketing roles in the high technology sector. She joins from Intel where she was director, corporate and worldwide channel sales for PSG (Programmable Solutions Group). She spent seven years with Altera and managed the EMEA channel teams prior to its acquisition by Intel in 2015. Before this, Tischler spent almost 15 years with Xilinx and led a team of account managers and field application engineers (FAEs).

www.arrow.com

Workshop on Wide Bandgap Power Devices and Applications

The organizing committee for the 8th Annual IEEE / PMSA Workshop on Wide Bandgap Power Devices and Applications (WiPDA) is cautiously optimistic that the conference will be permitted to be held as an in-person event November 7 – 9, 2021. The organizing committee remains committed to provide engineers and scientists with opportunities to share their expertise in wide bandgap (WBG) semiconductor technology. The workshop will feature tutorials as well as keynote sessions, panel sessions, technical sessions, and a poster session that covers four technical tracks: silicon carbide (SiC) power devices, SiC applications, gallium nitride (GaN) power devices, GaN applications, and new this year, Gallium Nitride (GaN) RF devices and applications and International Technology Roadmap for Wide Bandgap Power Semiconductors) (ITRW). Topics in emerging WBG materials will also be solicited. The workshop is brought to you by the IEEE Power Electronics Society (PELS), the Power Sources Manufacturers Association (PSMA), and the IEEE Electron Devices Society (EDS). The General Chair is Sameh Khalil, Senior Principal Engineer, GaN Device Reliability and Product Engineering Management at

Infineon Technologies. The abstract submission portal will open mid spring to accept authors' manuscripts. Researchers are encouraged to submit their latest findings on the design and fabrication of WBG power devices, their insertion in power electronics circuits/systems, and on technology of SiC, GaN, their reliability and other emerging, high performance WBG power semiconductors.

www.psma.com

Design Expertise to Produce Converters for eMotorsport Vehicles

BrightLoop Converters has reduced the size, cost and improved reliability of its latest BB SP DC-DC buck converters thanks to Efficient Power Conversion Corporation’s (EPC) EPC2029 enhancement-

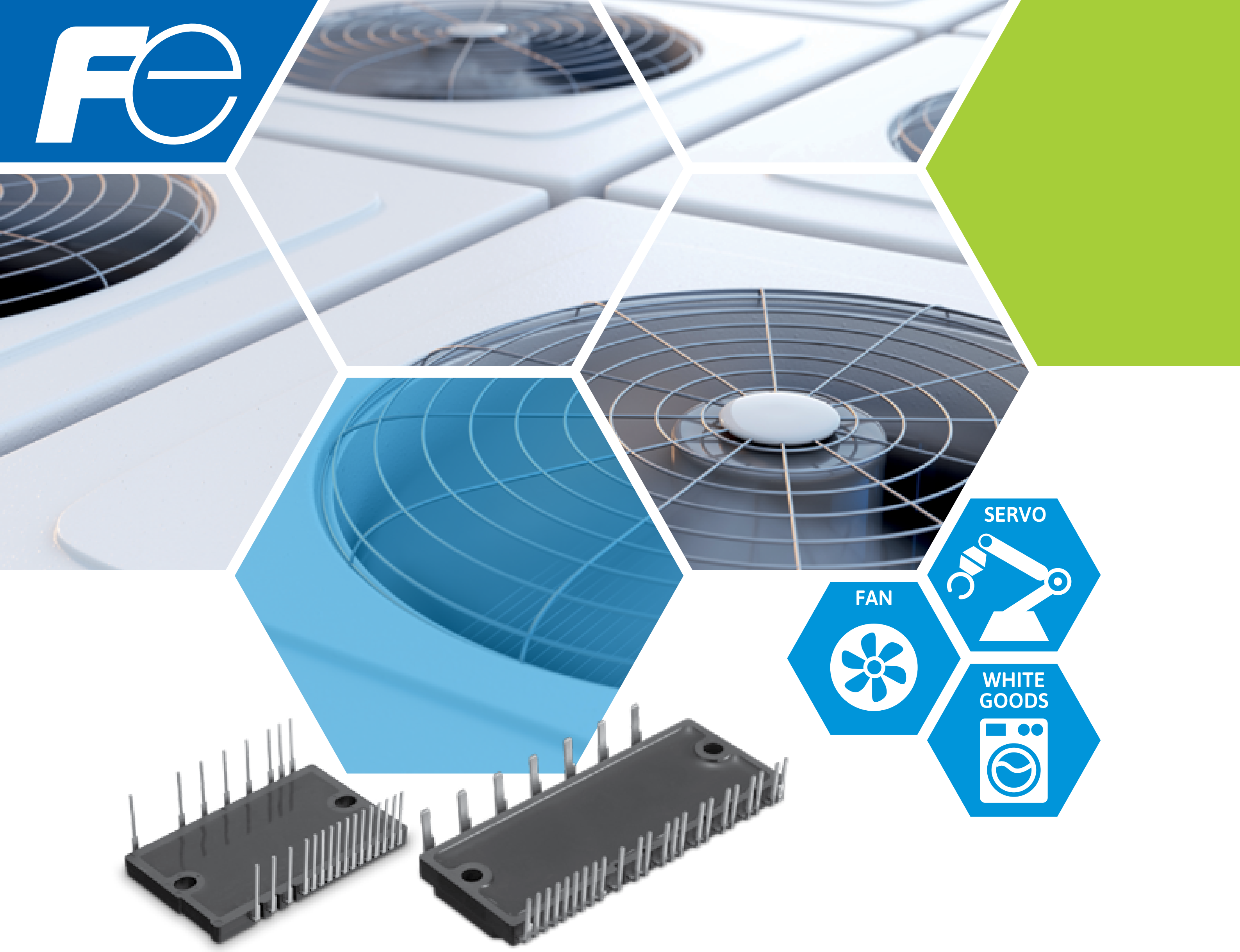
mode gallium nitride (eGaN®) FET transistors. By switching from silicon (Si) transistors to gallium nitride (GaN), BrightLoop was able to increase the switching frequency of their design from 200 kHz to 600 kHz, while keeping the same efficiency. This design change increased the power density of the solution by a factor of approximately two and this resulted in lower cost by enabling the implementation of a smaller enclosure. BrightLoop’s converters are used primarily in motorsports and supercars with other applications including commercial and off-highway vehicles. Future higher power versions are coming next year to address the mild hybrid applications such as electrical starting assistance. The BB SP is relevant in any dual voltage architecture (14 V / 48 V or 14 V / 24 V), or where a certain load is available only with a voltage that is different from the regular network (for example a 48 V pump on a 14V car), in which case the conversion can be done by the BB SP locally, just in front of the load. To make the use of BB SP interesting, it needs to have negligible losses and weight compared with the rest of the system. This is possible thanks to EPC’s eGaN FETs. For example, a 48V actuator plus BB SP using GaN can be lighter weight than the equivalent 12 V actuator.

www.epc-co.com

Maximizing Power Resilience for Uninterrupted Operations

Silicon Power Corporation announces the installation of an Innova STS sub-cycle transfer switch at the National Institute of Standards and Technology (NIST) in Boulder, CO. The Innova STS monitors the power quality of two distinct and redundant feeders to the NIST facility, and provides sub-cycle transfer from the utility preferred source to the utility alternate source in the event of a momentary interruption or disruption in power quality. This effectively protects NIST’s critical systems and keeps uninterrupted operations in the event of a disturbance. “We are excited to be part of a more intelligent and resilient electric grid solution connecting critical facilities with utilities,” said Perry Schugart, Sr. Vice President, Marketing and Business Development, Silicon Power. “Our Innova STS quickly transfers power (in less than a quarter cycle) from multiple feeds to the load when the power supporting the load fails or has insufficient power quality. Mechanical transfer switches are too slow for many power sensitive loads.”

www.siliconpower.com



Small-IPM Series – 2nd Generation

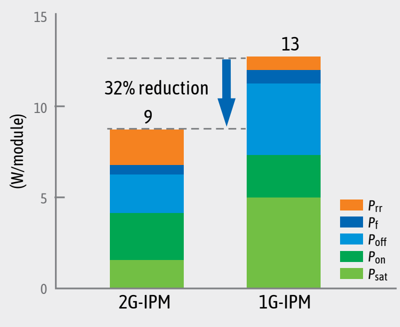
Ideal for Air Conditioners, Inverters and Servo Systems

MAIN FEATURES

- Reduction of losses and improvement of energy efficiency by utilizing 7th generation IGBT technology
- Built-in gate driver IC for optimum switching conditions
- Expansion of permissible operating area by improving the accuracy of overcurrent and overheating protection functions
- Utilizes an ultra-small DIP package with high heat dissipation aluminium insulating substrate

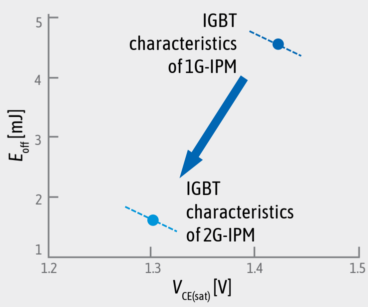
An IPM is a module which include three-phase inverter bridge circuit, control circuit and protection circuits.

Comparison with previous generation



$I_{O(RMS)} = 3$ A, $V_{DC} = 325$ V, $f_O = 60$ Hz, $f_c = 5$ kHz, $\lambda = 1.0$, 3 ph-mod, $T_c = 100$ °C

Estimated loss of a 10 hp PAC at intermediate load 650V / 50 A rating



$V_{CE(sat)}$ — E_{off} trade-off

Vice President of Corporate Marketing and Channel Strategy

Vicor Corporation announced the appointment of David Krakauer as Vice President of Corporate Marketing and Channel Strategy. Mr. Krakauer will oversee all marketing activities including corporate branding, promotion, and communications, as well as channel marketing and sales enablement.

Prior to joining Vicor, Mr. Krakauer was responsible for corporate marketing and customer experience at Analog Devices where he also held prior roles managing successful product lines. Mr. Krakauer has a BSEE and MSEE from the Massachusetts Institute of Technology as well as an MBA from the MIT Sloan School of Management.

Vicor Senior Vice President of Global Sales and Marketing, Phil Davies commented, "David brings extensive experience in driving profitable revenue growth through novel marketing strategies and practices. We are pleased to bring David on board as Vicor continues to build its brand in high-growth markets as the high-performance power module company."

www.vicorpower.com

SiC-Power Modules for Electric Vehicle Fast Charging and Solar Markets

Cree announced the launch of its Wolfspeed WolfPACK™ power modules, extending its range of solutions and ushering in a new era of performance for a diverse range of industrial power markets, including electric vehicle fast charging, renewable energy and energy storage, and industrial power applications. Using 1200V Wolfspeed® MOSFET technology, the modules deliver maximum efficiency in easy-to-use packages that allow designers to significantly increase efficiency and performance with smaller, more scalable power systems. Compared to silicon, the use of silicon carbide-based power solutions enable faster, smaller, lighter and more powerful electrical systems for a wide range of industrial applications. The silicon carbide modules maximize power density while simplifying designs in a standard form factor to significantly accelerate the production and rollout of next-generation technology for a wide range of rapidly growing industrial markets, including off-board charging and solar energy solutions. The offering bridges the gap between single die discrete components and high-ampacity module solutions, giving today's design engineers a wide breadth of portfolio options for design requirements using Wolfspeed silicon carbide.

"The introduction of the Wolfspeed WolfPACK™ power modules extends our power portfolio to cover the broad spectrum of high voltage power applications, which will help an array of high-growth industries transform as the global transition from silicon to silicon carbide

continues to accelerate," said Jay Cameron, senior vice president and general manager, Wolfspeed Power. "Maximizing power density while minimizing design complexity is essential for engineers working in the mid-power range, and the new modules simplify layouts to help accelerate production of EV fast charging and solar infrastructures."

www.cree.com

EMEA Distribution Award in the Category of Volume Partners

TTI has been awarded with the Distributor of the Year Award by Bourns. The annual awards celebrate Bourns' best performing distribution partners in the EMEA region. TTI was named winner in the Volume Partners category by Al Yost, COO and President of Bourns. In addition, Marc Opitz, Senior Manager Strategic Product Marketing at TTI, became the first person to receive a new award; the Bourns MVP award. This new category was created to recognise individuals who have gone the extra mile to achieve exceptional levels of sales for Bourns.

"We are pleased to receive this prestigious award for the fifth time in Europe. Despite challenging market conditions, we have grown our business together by investing in broad and deep inventory, new project development activities and new product introductions", said Felix Corbett, Director Supplier Marketing at TTI in Europe. "Our long-term partnership with Bourns and its investment in high quality products and service continues to enable us to support our customers across the full portfolio of passive and discrete technologies, helping us to meet customer needs on time and with the most reliable quality."

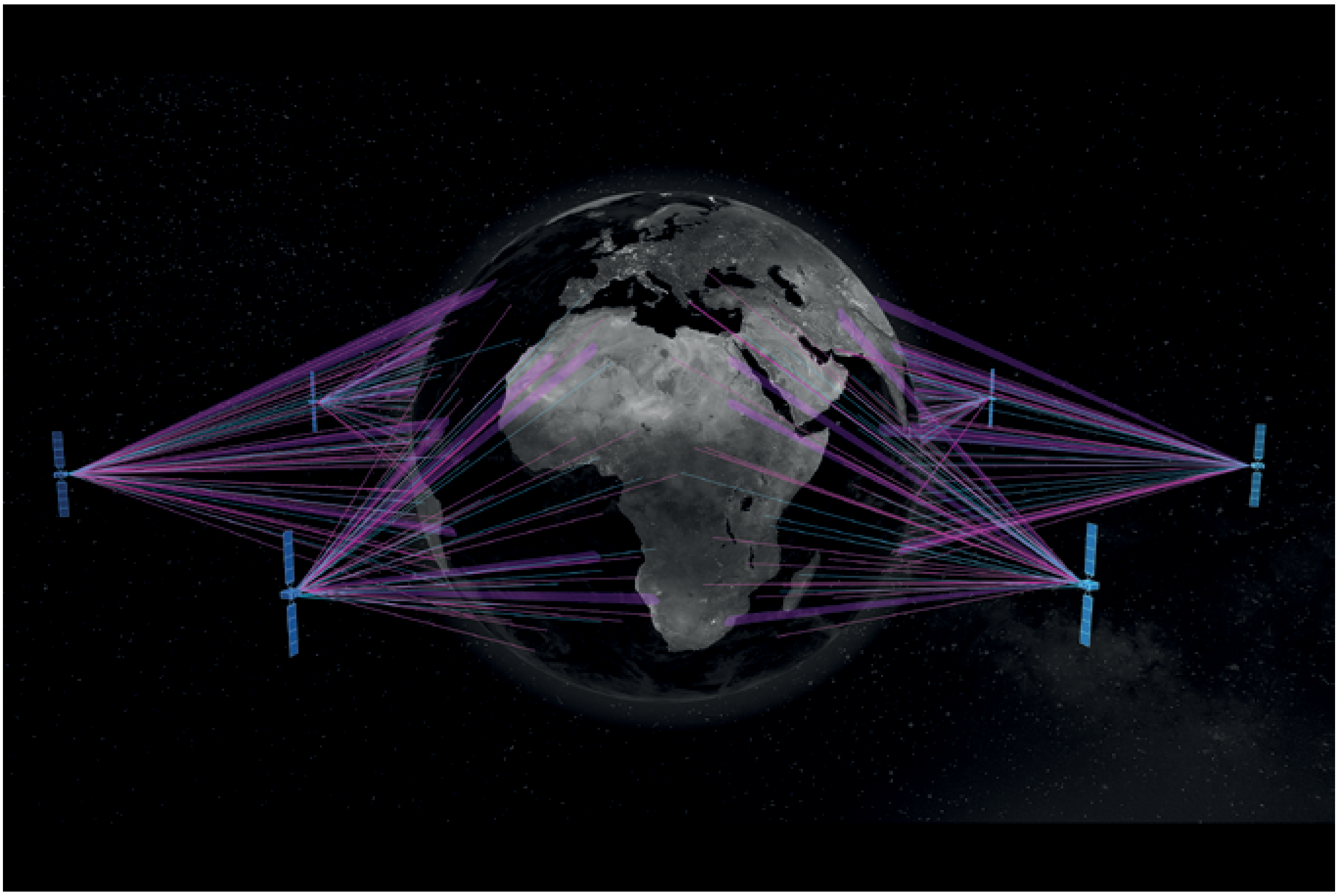
"Bourns is delighted to announce TTI Europe has won the "Distributor of the year award" for 2019, in the category of Bourns Volume Partners EMEA. Following a buoyant 2018, 2019 was challenging

with corrections in the market, but TTI continued to provide excellent customer service. This was instrumental in TTI increasing its customer count and achieving the highest customer count among our volume distributors," commented Ferdinand Leicher, Vice President Sales EMEA at Bourns.

www.ttiieurope.com

Boeing Satellites Use Radiation-Tolerant Power Modules

Tested and proven resiliency to 50 kilorad of total ionizing dose and immune to single-event upsets



Boeing is using Vicor in the O3b programme

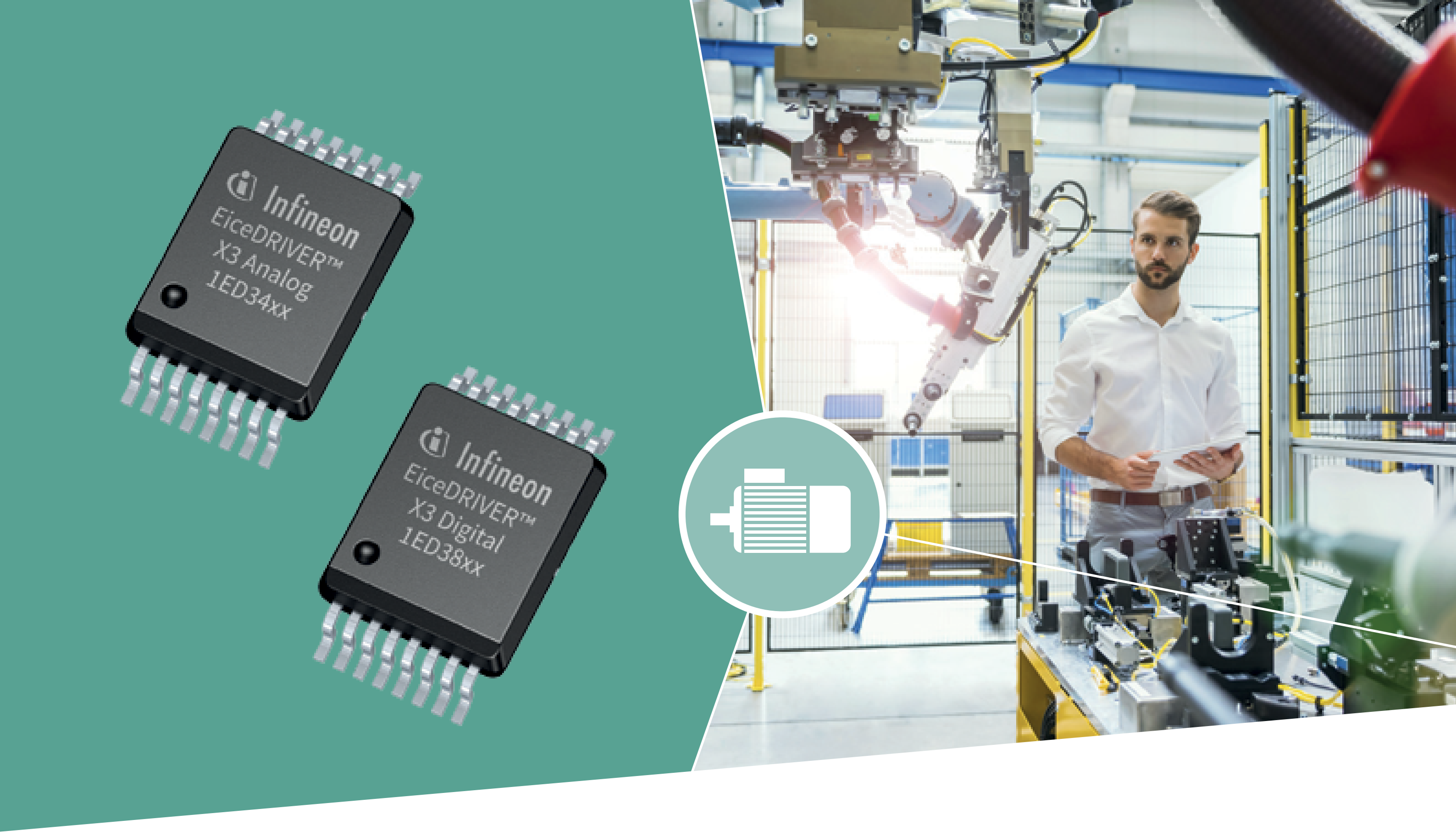
Vicor launched radiation-fault-tolerant DC-DC converter power modules, housed in the Vicor plated SM-ChiP™ package. Capable of powering low-voltage ASICs of up to 300 watts from a 100V nominal power source, the ChiPs were tested by Boeing to be resilient to 50krad of total ionizing dose and immune to single-event upsets. Immunity to single-event upsets is achieved using a redundant architecture, where two identical and parallel powertrains with fault-tolerant control ICs are housed in a single high-density SM-ChiP package.

Advanced communication satellites require high power density and low noise. Vicor soft-switching, high-frequency ZCS/ZVS power stages within metal-shielded ChiPs, reduce the power system noise floor, enabling signal integrity and total system performance with the requisite high level of reliability.

The complete power-source-to-point-of-load solution consists of four SM-ChiPs: the BCM3423, a 100V nominal, 300 watt K = 1/3 bus converter in a 34 x 23mm package; the PRM2919, a 33V nominal 200W regulator in a 29 x 19mm package; and two VTM2919 current multipliers, a K = 1/32 with an output of 0.8V at 150A and a K = 1/8 with an output of 3.4V at 25 amps. The solution powers the ASIC directly from the 100V power source with minimal external components and low-noise operation.

All of the modules are available in the Vicor high-density SM-ChiP package with BGA (ball grid array) connections and optional solder mask for the top and bottom surfaces. Operating temperature for the ChiPs is –30 to 125°C.

www.vicorpower.com



Predictive maintenance with Infineon's isolated gate driver solutions

EiceDRIVER™ X3 Analog (1ED34xx) and X3 Digital (1ED38xx) are two highly flexible families of isolated gate drivers that offer a wide range of configurable features and monitoring options. This reduces hardware complexity and evaluation time, also enabling novel use cases such as predictive maintenance.

Features

- High output current up to 9 A and high output supply voltage range up to 40 V
- Reliable and precise short-circuit protection and Miller Clamp function (especially for SiC MOSFET and IGBT7 power switches)
- Compliance with the highest isolation standards according to UL 1577 and VDE 0884-11
- Configurability of various features, such as short-circuit protection, soft-off, UVLO levels and much more
- 30 ns max. part-to-part skew in small DSO-16 fine pitch package with 8 mm creepage

Benefits

- Enables fast design cycles due to low number of external components, yet offers adjustable short-circuit detection with soft-off functionality
- Best-in-class DESAT accuracy: perfect for all applications requiring reliable short-circuit protection (including SiC MOSFET and IGBT7)
- Enables predictive maintenance and rapid prototyping
- Exceptional CMTI robustness > 200 kV/µs for noisy environments
- Designed for drive, solar, EV charging, UPS, commercial air conditioning and other industrial applications

www.infineon.com/gdenhanced

DC-Meter for Fair and Smart EV Fast Charge Billing

The innovative technology of electric vehicles (EVs) is leading to a reinvention of mobility habits, while their deployment on a mass scale is bringing up new technological obstacles. Charging stations are a key example. The challenge for the next five years is to build global networks to ensure drivers do not have 'range anxiety' and can perform a quick "refill" at any charging station along their route. Major charging networks are spreading across Europe, supported by and integrated into all economic recovery plans.

By Alexis Rigaud, Clément Saudet, Sébastien Auray, Florent Balboni, Mathieu Béguin, LEM

A DC meter for harmonization of costs for fast charging
Today's public charging infrastructure mostly supplies alternating current (AC). This leads to a long charging time of eight hours on average, due to a low power capability of around 44 kW. To reduce this charging time to only a few minutes, charger manufacturers convert the AC into direct current (DC) outside the car, bypassing the On-Board-Charger (OBC) and supplying the battery pack of the electric vehicle directly. Although this method boosts charging power up to 400 kW, this conversion stage generates power losses, which should not be billed to the EV owner. Thus, an electric meter is placed after the conversion stage to monitor and bill the exact energy transferred to the electric vehicle, rather than the charge duration.

To meet this need, LEM is launching today its DC Billing Meter (DCBM). This new DC meter solution is smart, extremely compact, and fully compliant with the German "Eichrecht" regulations, which enforces billing based on precise energy measurement. Standards are being established not only at the European level but also internationally.

Figure 1: LEM DCBM

The LEM DCBM has been developed to meet market demands for inter-operability and data security, for easy and fast retrofitting of charging stations already deployed, and for high power measurements, up to 600A/1000V.

A gateway from electrotechnical systems to the Cloud
The LEM DCBM is integrated into a global charging station architecture. When a charge is requested by the EV owner, a chain of requests is triggered, going through the charge point operator, the charge controller, and up to the DCBM. The latter starts measuring energy over the whole duration of the charging session. When charging is complete, the measurement data are gathered and stored in long-term memory in the DCBM, together with several identifiers carried by the successive requests, and secured by a signature. During the charging session, the DCBM can provide the controller with data on the currently transferred energy, as well as live current, voltage and temperature measurements.

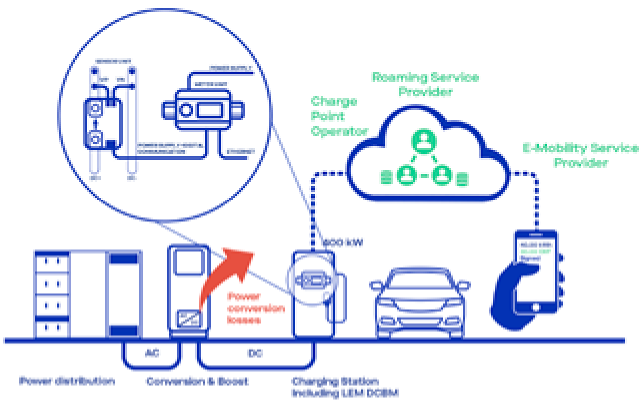


Figure 2: Global charging station architecture

Future-oriented communication
Offering Ethernet communication, the DCBM is Plug&Play. Instant network integration is assured through the global TCP/IP standard, with optional DHCP for automatic addressing. The product offers HTTPS/REST interfacing for easy, secure integration with data systems. The measurement data are also signed, providing proof of authenticity. Following the S.A.F.E initiative, the DCBM supports the OCMF format, offering the best inter-operability for cloud service operators.

HTTP/REST

HTTP is the data exchange protocol used by every web browser, making it compatible with any software. HTTP/REST is a subset of the protocol that allows simple data formatting. The format chosen for the DCBM is JSON, giving the device human-readable, IoT-ready data sets. Using the main HTTP methods (GET / POST / PUT), the DCBM can easily be requested to start, stop and retrieve charging sessions. Moreover, in-session readings provide a live display to the driver, offering a gas-station-like experience and ensuring an easy evolution to the mass use of electric vehicles.

OCMF

The OCMF (Open Charge Metering Format) is an open-source standard developed by the S.A.F.E initiative. Designed to achieve system independence, it addresses a wide variety of existing EV charging standards that govern the final billing of the meter. Moreover, the standard was designed to support extra fields to address the rapidly changing billing processes of EV charging sessions. The S.A.F.E alliance provides a certified transparency software for OCMF to verify the authenticity of the charging session and results.

Signed billing data

The DCBM supports its own format of data along with the OCMF format. Both formats are digitally signed with standard ECDSA methods, allowing verification of authenticity and integrity of the billing data. Each DCBM has its own public key that shall be registered onto a PKI (Public Key Infrastructure) institution, thus protecting the end user.

Figure 3: Example data set for a DCBM charging session

Conclusion

With its new DCBM, LEM opens up the field of electricity billing, which can include applications such as data centers, photovoltaic applications and DC grids, allowing a sustainable, ecological transition.

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Thermal Management of Chip-Scale GaN Devices

Wide bandgap (WBG) power semiconductors are being adopted into mainstream designs due to order-of-magnitude improvements in electrical figures-of-merit (FOMs). The huge performance improvements require revisiting many design assumptions, including thermal management [1].

By John Glaser, Director of Applications Engineering, Muskan Sharma, Senior CAD Engineer, Michael de Rooij, Vice President of Applications Engineering, and Alex Lidow, CEO and Co-founder, Efficient Power Conversion

This article discusses the challenges that thermal management raises due to increased power density, especially with chip-scale-packaging (CSP). What is sometimes overlooked, however, is that CSP eGaN® power FETs and integrated circuits have excellent thermal performance when mounted on standard printed circuit boards (PCBs) with simple methods for attaching heat sinks.

For example, a CSP GaN FET with a 4 mm^2 footprint on a standard 4-layer PCB can achieve junction-to-heat sink thermal resistance values of less than 4 K/W with low-cost assembly and heat sink materials and techniques. Analysis, simulation, and experimental verification are provided in this article. In addition, pathways to further thermal improvement are discussed.

As an example, consider the case of a surface mount buck converter synchronous rectifier, where the dominant loss is conduction loss. A CSP eGaN FET, the EPC2059, occupies 3.92 mm^2 of PCB area for a 170V, 9 mΩ FET, whereas a state-of-the-art 150V, 16.5 mΩ double-side cooled Si MOSFET occupies nearly eight times the board PCB area at 30.9 mm^2.

If footprint area were the dominant factor determining temperature rise, the larger Si MOSFET would have a temperature rise about 23% of that of a GaN for a given current, even though the eGaN FET has much lower on-resistance ($R_{DS(on)}$). In practice, however, the thermal performance of CSP eGaN FETs appear to be on par with, or better than, larger Si MOSFETs. This seemingly counter-intuitive result, and the reasons for it, are not obvious, hence some in-depth investigation is required.

Several publications demonstrate that chip-scale eGaN FETs have excellent absolute thermal performance despite their much smaller area compared to equivalent $R_{DS(on)}$ MOSFETs, and that practical heat sink mounting methods exist [2, 3] as illustrated in Figure 1 that shows a simple method for attaching a heat sink to CSP eGaN FETs. Unfortunately, most publications provide little detail on heat flow and the thermal models, when present. The articles are simplistic and have little rigorous justification.

Since the maximum rated junction temperature, $T_{j,max}$, is often the main limiting factor in designs, it is crucial for power systems designers to understand how and why high thermal performance can be achieved. Such understanding provides confidence in design; thus, shortening design cycles, reducing the amount and severity of required testing, increasing reliability, and reducing overall cost.

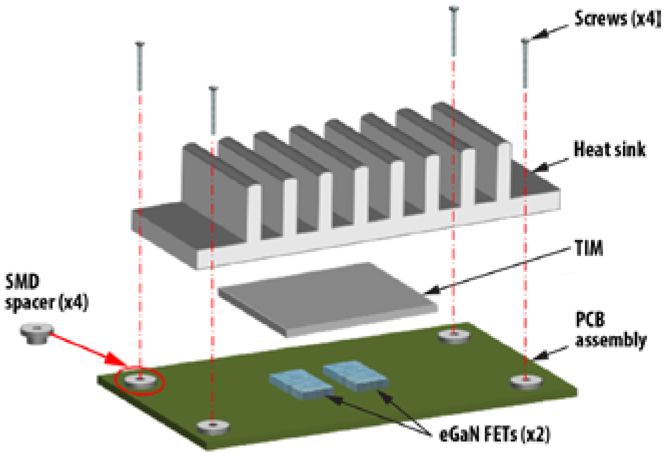

Figure 1: Attaching a heat sink to CSP eGaN FETs using SMD spacers and thermal interface material

In many designs using surface mount power semiconductors, the PCB and the transistor-to-heat sink interface form the first bottleneck to heat flow [4]. In cases where a heat sink is used, the PCB's role in heat dissipation is frequently neglected, but is, in fact, a significant path for heat flow. The PCB's contribution to extracting heat is significant even for very small CSP eGaN FETs where, in practical designs, such FETs can achieve thermal performance from junction-to-ambient on par with, or even better than, much larger Si MOSFETs.

When combined with the superior electrical performance of eGaN FETs, size can be reduced, power levels increased, and operating temperatures lowered. This can be shown using detailed 3D finite element simulations of typical PCB layouts in conjunction with experimental verification.

For high power applications, or those that operate in environments with a high ambient temperature, heat sinks are used to transfer the heat energy to the ambient environment. A typical thermal management approach for a CSP eGaN FET involves the application of an electrically insulating thermal interface material (TIM) to the top surface of the mounted FET, and mechanically attaching a heat sink atop it. In this configuration, spacers are often used to ensure that the heat sink has sufficient distance from the FET's top surface to the facing surface of the heat sink in order to meet both voltage standoff requirements and absorb mechanical variations, as shown in Figure 1.

Mechanical tolerances call for compliant TIMs, and these are generally available as sheet material, putty, or gel. In a high-volume manufacturing process, the putty or gel TIM is dispensed to the top of the eGaN FET/s, after which the heat sink is attached to the PCB. The TIM is compressed by the heat sink and flows around the FET, forming a cylinder of material surrounding the FET and filling the space between the PCB and heat sink. Spacers are used to set the minimum spacing between the FET/s and heat sink.

Figure 2 shows the various heat flow paths for the thermal assembly previously described. Intuitively, it appears that heat flow from the top and sides of the chip-scale FET dominates due to the short path through the TIM, whereas, in fact, the heat flow following the PCB-TIM-heat sink path is also a large contributor to heat removal.

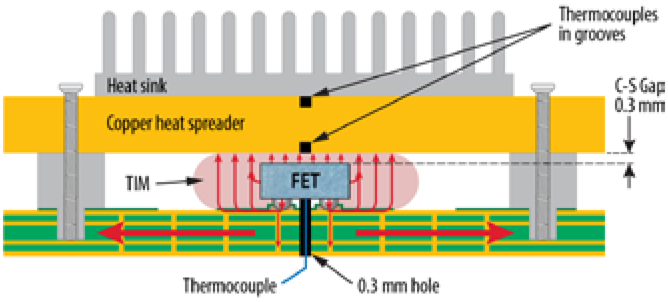

Figure 2: Cross-sectional view of the thermal solution showing the GaN FET, heat paths, and sensor locations for characterization

Due to the solder metallic bond, the FET has an excellent thermal connection with the copper on the PCB. The PCB effectively spreads the heat since the thermal conductivity of the copper is approximately two orders of magnitude higher than the TIM. Though the heat from the PCB to the heat sink must flow through a TIM thickness 2-5 times larger than the path from the FET to the heat sink, the effective cross-section of TIM in this path may be greater than 10 times the exposed surface area of the FET, since its area is proportional to the square of the radius of the cylinder formed by the application of the thermal interface material. Hence, the contribution of the PCB-to-heat sink thermal path must be taken into account when analyzing this thermal management approach.

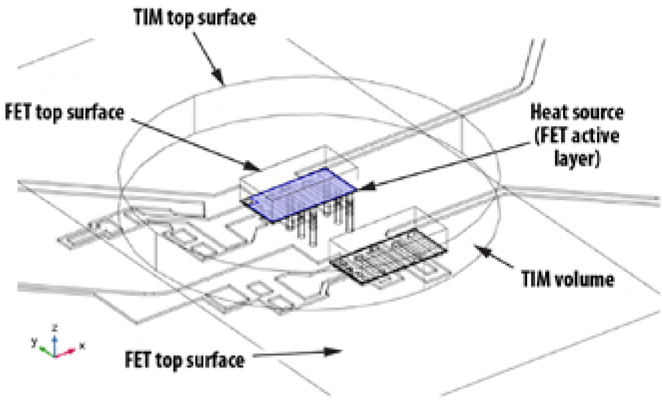

Figure 3: Wireframe illustration of a typical PCB layout with two GaN FETs showing the copper traces contacting the FETs and TIM cylinder. Heat would attach directly above the cylinder and is sink not shown for clarity.

The above analysis can be accomplished using 3D finite element method (FEM) tools. A half-bridge PCB for eGaN FETs forms the baseline case. This PCB has a layout optimized for best electrical performance [5] and uses 4-layer construction of 70 mm copper foil, FR408 dielectric, and has a total thickness of 1.6 mm (62 mils). A volume of thermally conductive putty is placed on the mounted FETs and immediate vicinity as shown in Figure 3. A heat sink is placed over the FETs with a gap between the top side of the FET and facing heat sink surface. The board has copper pours with insulating gaps and a subset of vias that would be used in a typical design. A key point is that the best electrical performance drives the designer to put as much copper in the immediate vicinity of the FET, which also benefits the thermal performance.

Simulation Results

For the thermal investigation discussed in this article, a series of 3D FEM analyses were implemented using COMSOL [6] Multiphysics® simulation software. Many simulations were executed, while varying parameters such as the radius of the TIM cylinder, the TIM thermal conductivity, single or dual FETs heat source cases, and the influence of additional components and boundary conditions. Figure 4 presents the results for a single FET heat source case, where the die size and thermal conductivity of the gel were varied. The distance between the heat sink and the die was kept at a conservative 0.3 mm. A comparison between two of the data points and actual measurements is shown in the next section in Table I.

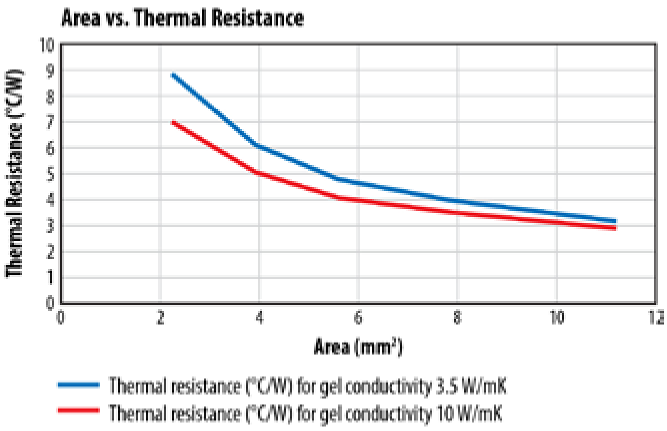

Figure 4: Thermal FEA simulation results for various die area and two kinds of thermal gel, 3.5 W/mK (blue) and 10 W/mK (red).

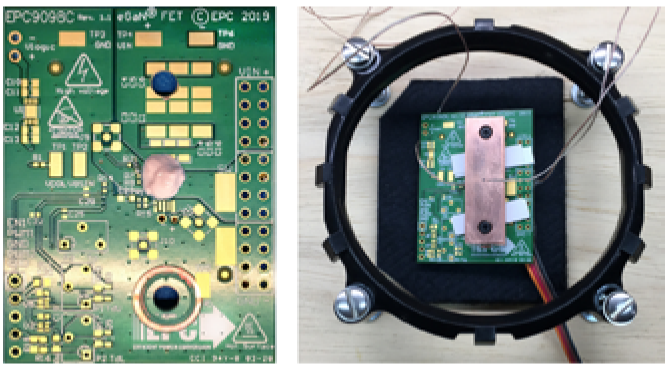

Figure 5: Experimental PCB of the thermal case study showing the application of the TIM (left) and with the heat-spreader attached (right)

Experimental Results

A series of physical experiments were conducted to verify these simulations and to further understand the practical effects on the FET, such as thermal contact impedance. Good agreement among the empirical results and the simulations was obtained, which supported confidence in the simulations.

TIM part number	Thermal conductivity [W/m/K]	Power [W]	ΔT [K] (FET to spreader)	Measured R_θ [K/W]	Simulated R_θ [K/W]
65-00-GEL30-0010	3.5	1.06	6.62	6.2	6.1
TG-PP10-50G	10	5.06	25.6	5.1	5.1

Table I: Thermal Interface Materials (TIM) Used in Experiments Reported in This Article

A cost analysis was done with the more expensive 10 W/m/K (TG-PP10-50G) material. A 10 mm diameter cylinder of material surrounding the FET has approximately 70 ml volume. For moderate production rates, the per-FET TIM cost is less than $0.01 US.

Summary

Small chip-scale eGaN FETs have excellent thermal performance when mounted on a PCB that is designed for best electrical performance. This performance is obtained with simple, manufacturable, and cost-effective thermal solutions.

Simulations, supported by experimental verification, examine the effect of various parameters and heat flow paths to provide guidance on designing for performance versus cost. Even lower thermal resistance can be achieved by increasing the number and diameter of the thermal vias, or by placing thermally conductive elements such as resistors, capacitors, or other transistors inside the TIM gel cylinder. In all cases chip-scale eGaN FETs outperform their larger MOSFET ancestors by a wide margin.

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www.epc-co.com

Saving Energy and Reducing Costs with the Use of Buffers

Pilot Project: Capacitor Cabinets from Mersen Enable High Power Pulses in Induction Heating

High power pulses such as those that occur in short-time tempering or spot welding cause tremendous costs: This is because the power companies calculate the costs on the basis of the maximum power, even if it is needed for only a few seconds. It therefore makes sense to supply the power for such applications independently of the mains – for example by means of capacitors that are designed for high power peaks.

By Jens Heitmann, Account Manager/Marketing Manager, FTCAP GmbH

IDEA GmbH is testing such a concept in a pilot project. The main role is played by custom capacitor cabinets from Mersen. IDEA develops high-efficiency products and solutions for induction heating applications, such as tempering, soldering and shrinking. "Our expertise also includes induction tempering applications", explains Andreas Häußler, Managing Director of IDEA GmbH. "Our induction heating systems are in use worldwide for the efficient tempering of diverse workpieces with extreme precision." The systems of the company based in Baden-Württemberg feature a flexible adaptation and frequency range, to enable optimal design of the custom heating process.

Figure 1: The control cabinets from IDEA are equipped with threaded aluminium electrolytic capacitors of the GM series from FTCAP Photo: Mersen

Saving energy and costs with capacitor cabinets

To be able to offer customers state-of-the-art technology at all times, IDEA continues to research new processes and methods. Currently the experts are analysing whether special capacitor cabinets can save energy and reduce costs in short-time tempering applications. "Induction heating and welding systems often require high power for a very short time, in the range of milliseconds", explains Andreas Häußler. This is especially the case in spot-welding systems for automotive construction. But applications with requirements for precise contours in the tempering of gear wheels also require a high power pulse for a short time in order to quickly heat the surfaces of the components before they are quenched. "In the past, this process was implemented without capacitors, which means the high power pulses are drawn from the regular mains network."

However, that puts a load on the mains and results in substantial energy costs, which are calculated on the basis of the maximum power draw. "Even if the application requires heat for only one second at 1 MW, you have to pay the power company the flat rate for the maximum power of 1 MW", explains Andreas Häußler. "It then makes no difference how long the breaks are between the heating phases." The mains elements must also be designed for high power outputs, which also causes additional costs. The problem could be alleviated by capacitor banks used as energy buffers between the mains connection and the application. "By buffering with capacitors and supplying a continuous charge of 100 kW, one has to pay only for the reduced power", explains Andreas Häußler. "The upstream elements can likewise be designed for lower power to reduce costs." Systems such as these, however, do not yet exist – although IDEA will soon start a pilot project to analyse the potentials.

High standards for the capacitors

The first step was to procure suitable capacitors. Of course, the experts at IDEA again placed their confidence in Mersen, a time-proven supplier with which the company has a long-standing business relationship. The standards were high: IDEA required capacitor cabinets that provide a very high capacity in a very small design. "The systems must allow several million charge and discharge cycles at ambient temperatures up to 55 °C, without the occurrence of defects or significant capacity losses", explains Andreas Häußler. "Maximum efficiency also requires very low internal impedance and low self-discharge." In terms of performance, the buffers must be capable of a power output of several hundred kilowatts for about one second. The process design then requires a break of several seconds.

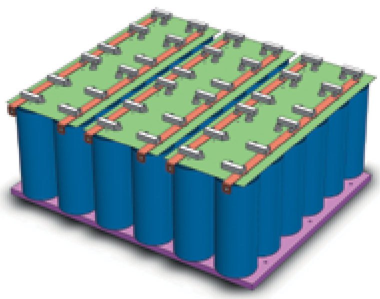

Figure 2: Mersen developed a concept for IDEA in which numerous capacitors are installed in each cabinet; Photo: Mersen

Mersen developed a concept for IDEA in which numerous capacitors are installed in each cabinet. “For the pilot project we will initially deliver two cabinets, which are being built and equipped at our own facilities”, says André Tausche, Managing Director of FTCAP (part of the Mersen Group). “In addition to the capacitors, we are also supplying the required telescoping rails, cross braces and symmetrical resistors. We also provide professional installation of the rails and capacitors on the panels.” The entire production process for the assembly is carried out by IDEA.

Figure 3: IDEA GmbH develops high-efficiency products and solutions for induction heating applications, such as tempering, soldering and shrinking; Photo: IDEA GmbH

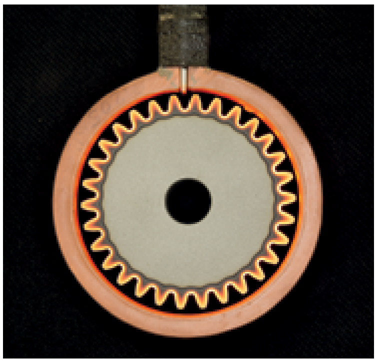

Figure 4: Applications with requirements for precise contours in the tempering of gear wheels require a high power pulse for a short time in order to quickly heat the surfaces of the components Photo: IDEA GmbH

High capacities and a long life

The control cabinets from IDEA are equipped with aluminium electrolytic capacitors with a threaded connection of the GM series from FTCAP. Even at high operating temperatures of up to 85 °C, each of the capacitors has a very long life of about 8,000 hours. In addition, these aluminium electrolytic capacitors, in which all internal contacts are welded, can be used in a broad voltage range from 16 V – 450 V, and they also feature very low inductance.

“Capacitors with a threaded connection are generally suitable for all applications requiring very close integration of the components with their environment”, explains André Tausche. “That is the case not only in the current project, but also in medical and railway technology, for example.” The GMX Long Life series is designed for a long life, which makes it ideal for use in medical technology. The GW series was developed for the even harsher conditions of railway technology. These aluminium electrolytic capacitors are insensitive to high ripple currents and also feature very low inductance. FTCAP developed the GF series especially for environments with stringent safety requirements. These aluminium electrolytic capacitors consist of a self-extinguishing electrolyte and are used for example in industrial welding machines.

Figure 5: Currently IDEA is analysing whether special capacitor cabinets can save energy and reduce costs in short-time tempering applications; Photo: IDEA GmbH

Andreas Häußler is satisfied with the choice of capacitors: “The very high-volume power density, long life and low inductance of GM series capacitors from FTCAP make them ideal for our pilot project”, emphasises the managing director of IDEA. The first tests of the two capacitor cabinets are scheduled to start soon. If the concept proves to be viable, Mersen will be involved in the long term: “Mersen is an established, reliable and flexible supplier of IDEA GmbH. We are pleased to have a strong partner at our side who can also implement small-series custom solutions that are optimised for the particular application”, says Andreas Häußler in conclusion.

www.ftcap.de

www.idea-induction.de

Unleashing GaN with High-Performance Gate Driving

GaN technology is a true enabler for power stages, today providing performance that was unthinkable in the previous decade. The maximum performance and benefits from GaN are obtained only when the gate driver matches the same degree of performance and innovation as the transistors. After many years of research and development, MinDCet has overcome the pitfalls in GaN gate driving by introducing the MDC901 gate driver.

By Mike Wens, CEO, Managing Director, MinDCet NV

Introduction

Since the introduction of the first gallium nitride (GaN) transistors over ten years ago, their advantages in power electronics over silicon MOSFETs have become well-known. Indeed, the material properties of GaN offer lower parasitic capacitances for a given on-resistance, inherent fast switching transients, lack of reverse recovery and high temperature operation capability. These excellent properties are seemingly the perfect combination for high performing power converters.

However, two important aspects must be considered to achieve GaN's performance potential. Firstly, it is a common conception that GaN's fast transient switching capability will directly lead to significantly higher switching frequencies and resultantly, higher efficiencies. When GaN is switched at optimal speed it will indeed show lower switching losses compared to MOSFET technology, for a given frequency. The primary reason for the comparatively lower GaN switching losses is the decreased time during the switching transient, the time when voltage and current are simultaneously present over and through the switch. The Joule losses caused by this switching loss increase linearly with frequency. Eventually, when operating GaN at increasingly higher switching frequencies, the resulting GaN efficiency may become equal or potentially lower than a MOSFET-based converter. Although there are diminishing efficiency benefits of GaN at higher switching frequencies, the GaN-based converters additionally benefit from the use of smaller storage passives, equating to a higher power density.

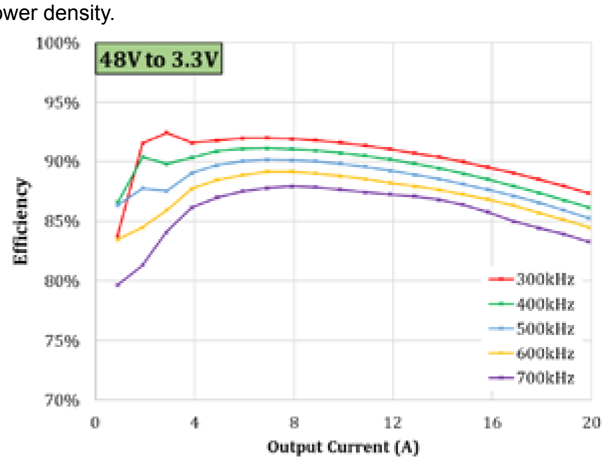

Figure 1: The measured efficiency as a function of the output current for a 48V to 3.3V GaN-based buck converter, at different switching frequencies.

This effect is demonstrated with a 48V to 3.3V step-down buck converter, built around the MinDCet MDC901 gate driver, a GaN Systems GS61008P half-bridge and a WE-HCF 1.4uH/31.5A power inductor, as depicted in Figure 5. The low converter duty cycle benefits from the fast switching transient speeds, resulting in a 10 to 15 percent efficiency increase over an equivalent MOSFET-based converter at the same switching frequency. The buck converter measurement in Figure 1 exemplifies that despite GaN's capabilities, the conversion efficiency decreases as switching frequency increases. Already at moderate switching frequencies of 300 kHz, a clear decrease of nearly 1 percent efficiency per additional 100 kHz in switching frequency can be observed over the measured frequencies from 300 to 700 kHz.

For a 48V to 12V buck converter this trade-off changes. Examining Figure 2, the GaN converter efficiency benefits from a higher switching frequency at low- to moderate loads (up to about 10A) over the 300 to 700 kHz range. To be noted is that the selected inductor has an impact on converter efficiency. Care must be taken in making the right trade-offs in the GaN-based converter design.

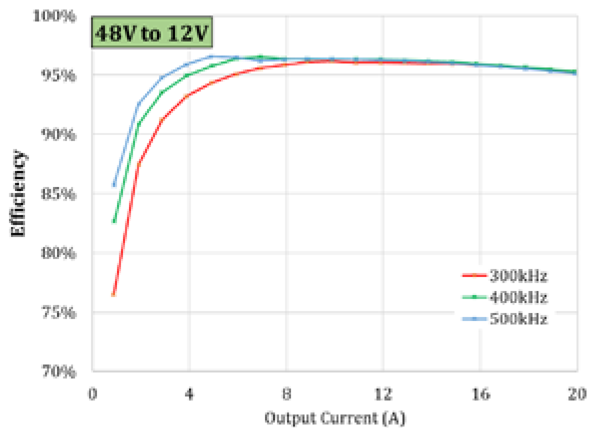

Figure 2: The measured efficiency as a function of the output current for a 48V to 12V GaN-based buck converter, at different switching frequencies.

Secondly, to enable the true intrinsic benefits of GaN, it is necessary to switch at high transient speeds. Values from 10V/ns up to 100V/ns and beyond are possible. The main component responsible for transient speed is the gate driver. Naturally, proper circuit design, specifically power routing, gate-loop routing and decoupling, needs to be implemented to enable the gate-driver and GaN to do their work optimally. In general, a standard MOSFET gate driver may in

unique cases be able to drive GaN, but optimal performance will not be reached. As a consequence the benefits of using GaN are partly lost. A gate driver that switches GaN at high transient speeds must fulfill specific requirements while simultaneously being subjected to significant stresses. These stringent requirements can only be met by a gate driver carefully developed to work with GaN.

Pitfalls for GaN Gate-Driving

GaN transistors in power applications have a lot of potential : higher power efficiency, higher power density, potential heat-sink/fan-less design,... However getting the maximal benefit from a GaN stage requires careful driving, avoiding the pitfalls along the road.

High Slew Rates

Driving GaN transistors is very ambiguous. These devices are chosen for their inherently large voltage slew rates (in excess of 100V/ns), which leads to very low switching losses (losses incurred when Vds and Ids are not zero). The quick switchover between low and high-side transistors causes the load current to alternate very quickly between load and input voltage (e.g. buck converter applications). This poses hard constraints to the bus voltage decoupling, as PCB tracks to the half-bridge cause overshoot, highly defined by the bus loop inductance. Additionally, the high slew rates inject large peak currents into the gate driving path through the drain source capacitance of the off-state transistor.

Parasitic Turn-On

In a half-bridge configuration, parasitic turn-on can occur to the transistor that is turned off, when its drain-source voltage is suddenly increasing to the bus voltage, either actively by the opposing transistor or inductively through the load current. This current will be converted to a non-zero gate voltage both by the gate driver pull-down impedance and the gate-source loop inductance. If this voltage is higher than the threshold voltage, a cross current will occur between the high-side and low-side switches of the half-bridge. Low gate loop inductance is only possible in monolithic co-integration of the power-stage and gate-driver, where a separate pull-down and pull-up path for each GaN transistor is very desirable.

Dead-Time

Dead-time in a half-bridge is the time between the turn-off event of one transistor and the turn-on event of the complementary bridge transistor. Granular control of the dead-time is essential. Too short of a dead-time will cause excess losses as the GaN drain-source capacitance is discharged by the complementary GaN. Zero voltage switching occurs at larger dead-times, allowing the drain-source

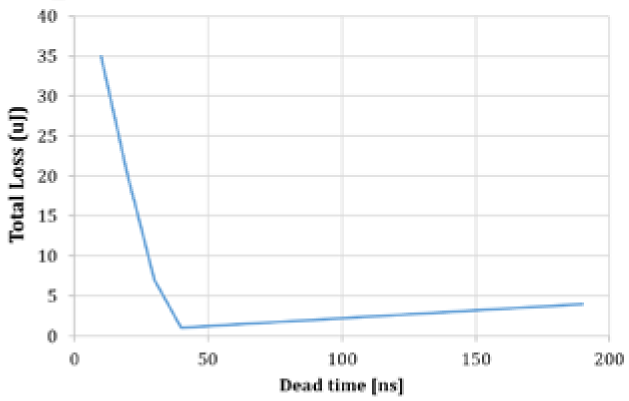

Figure 3: The energy loss as a function of the dead-time in a GaN-based buck converter. Note that the lowest loss does not coincide with the smallest dead-time.

capacitance to be discharged by the inductor (in a buck converter). Consequently, this energy is not dissipated. Too long dead-times will introduce larger losses as the reverse conduction of a GaN with zero Vgs is subject to a larger voltage drop (of a few volts) compared to a diode. Fixed dead-times lead to a suboptimal efficiency and must be tuned to the proper dead-time for minimal loss, which is highly application dependent.

Gate Overcharging

In non-isolated gate-drive applications, the gate driver is often supplied through bootstrapping of the low voltage supply. This technique will charge the high-side gate driver supply decoupling capacitor through a fast high-voltage diode. This generates a floating voltage that is used to supply all floating circuitry used to drive the high-side predriver. As explained before, the non-zero deadtime will cause the drain-source voltage of the low-side GaN transistor - depending on the current magnitude direction of the load - to go below zero. This effectively causes the bootstrap capacitor to charge beyond the input supply. A GaN gate is known to be notoriously sensitive to gate overvoltages, therefore the gate needs protection against overcharging to ensure reliability of the converter. In practice this is reduced through the use of clamping structures, at the cost of increased gate driver power consumption and PCB real estate with its effectiveness limited by PCB parasitics.

Negative Output Voltage Operation

The negative swing of the output driver voltage depends on the parasitic source inductance and the load conditions of the power converter, which can be poorly predicted. For predictable operation, a guarantee that the converter bridge can always be controlled is required, even when going negative in voltage compared to the supply grounds. In a DC coupled level-shifter, special precautions must be taken to allow operation below supply ground.

High duty cycle operation

Bootstrapped operation of a gate driver is a simple and effective means to provide charge to control the high-side transistor, for example, in a half-bridge. Unavoidably, there is temperature dependent leakage and bias for supporting circuitry needed in the predriver system - which causes the bootstrap voltage to leak away. If the bootstrap voltage decreases below a certain minimal voltage (often monitored through on-board undervoltage detection circuit), the predriver circuit may act erroneously and in the worst case detrimental to the converter. For a given bootstrap capacitance and power converter application, this sets a maximum on the duty cycle that can be maintained or limits the modulation depth that can be used.

The MinDCet Answer: The MDC901

High-end, high-power density and fast switching applications call for a GaN powerstage - where a specific driver is needed to ensure reliable driving and protect the valuable GaN stage.

To tackle the pitfalls previously described and provide the performance GaN demands, MinDCet introduced the MDC901 GaN gate driver. The depicted block diagram in Figure 4 provides an overview of the key functionality, solving the major pitfalls described in the previous sections.

Separate pull-up and pull-down paths allow for tuning of the turn-on speed and consequently the slew-rate of the output stage while maintaining a low impedance pulldown path for the GaN transistor. This keeps the gate-source voltage under control in off-state avoiding parasitic turn-on, even under high drain-gate capacitive currents.

The dead-time for turn-on and turn-off can be set through a series of digital inputs. This allows static tuning of the dead-time for a given application or in conjunction with a controller, this could be performed dynamically for optimal efficiency. Additionally, dead-time can be set in automatic mode. A closed loop senses the GaN gate voltages and the gate is only turned on when the complementary GaN gate is off. This is a fail-safe operation mode.

The risk of gate-overcharging during negative voltage operation is solved by placing fully floating regulators both in the high-side and low-side domain after the bootstrap diode. This results in a well defined and robustly protected gate driver voltage.

Negative output voltage operation is guaranteed down to -4V, allowing accurate gate control even under high inductive currents. This has been accommodated by a specifically designed level shifter and floating supply generation.

For high-duty cycle applications (e.g. motor drivers and class-D amplifiers), it is mandatory to maintain a high-side on-state for longer periods of time. This functionality was implemented by an integrated charge pump, compensating for DC bias under 100% duty cycle conditions.

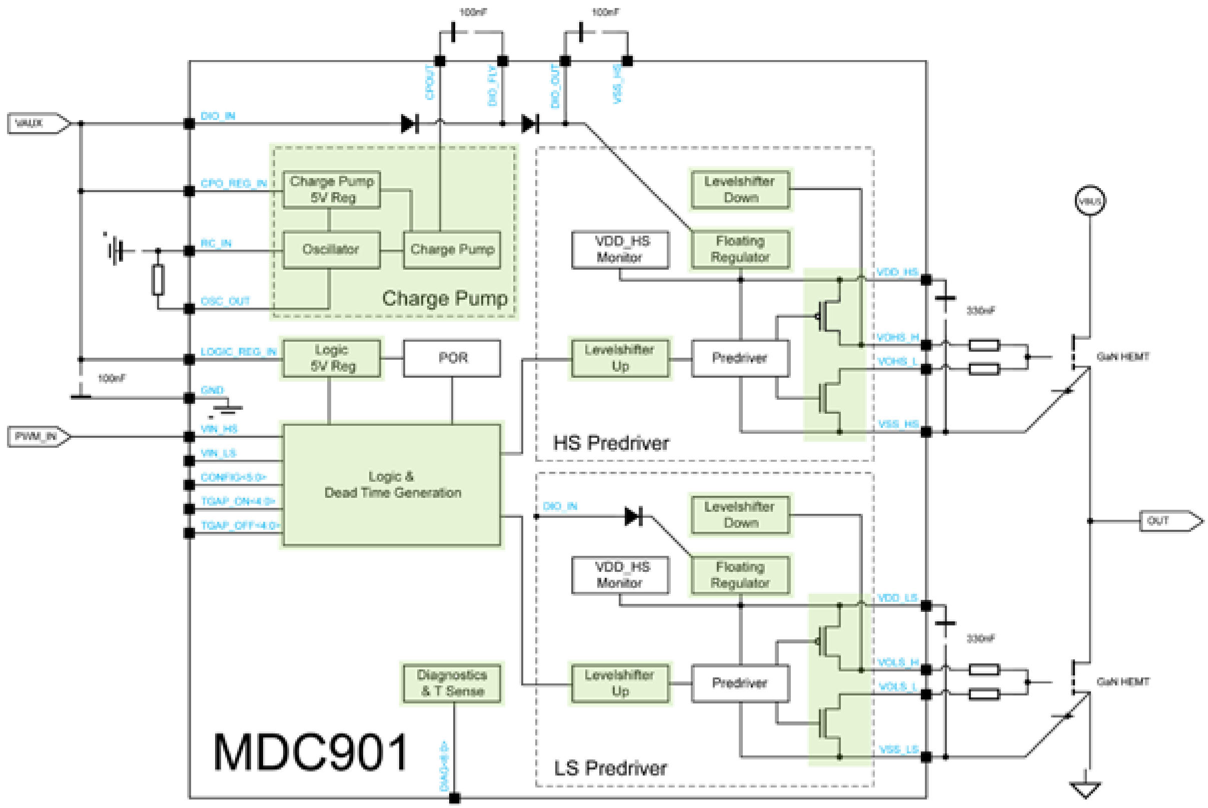

Figure 4: The block diagram of the MDC901 GaN gate driver.

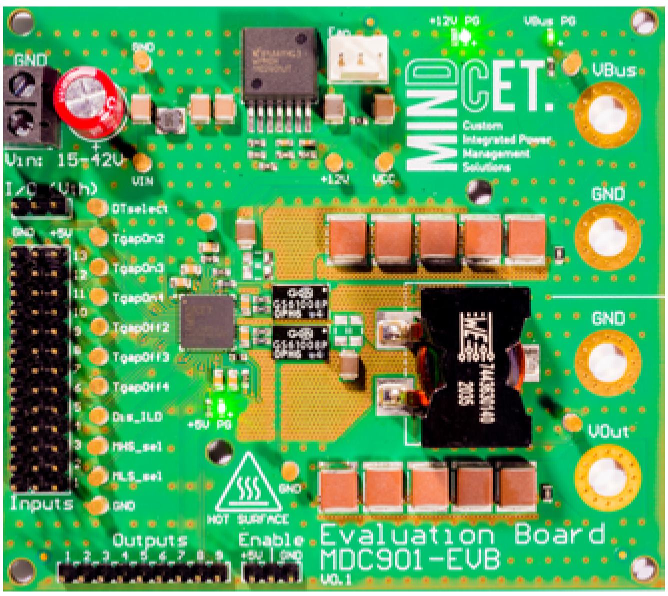

Figure 5: The MDC901 100V half-bridge evaluation board.

The MDC901 provides a high-end and feature-rich solution to driving GaN transistors in a reliable way for maximizing performance in the given application. The driver was developed for DC-DC solutions, but can be used for all other GaN driving applications like LIDAR, motor drivers, and electronic fuse applications requiring true 200V capability. To enable easy and fast design-in of the MDC901 gate driver in a variety of applications, a 100V half-bridge evaluation board in a buck-converter topology, as displayed in Figure 5, was developed for assisting power electronics designers.

Conclusions

Enabling the true benefits of GaN power stages requires implementing an optimized gate-driver that is designed specifically to work with GaN transistors. Resultantly, the GaN can be pushed to the limits, yielding the highest possible performance, which provides for a maximum return on the technological and monetary investment. A discrete gate-driver such as the MDC901 provides the user with the flexibility, diagnostics and an expanded feature set for choosing the best-suited GaN transistors for the given application.

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Paving the Way for Seamless Characterization, Simulation and Development

In recent years, the demand for power electronic systems has been steadily growing. At the same time, manufacturers have been faced with an increasing need to customize power semiconductor devices for specific applications. Currently, selecting the right semiconductor is challenging, as gaps in characterization standards impede the comparability of components, especially for fast power semiconductors.

By Uwe Jansen, Infineon Technologies AG,
Anna-Lena Heller, Kevin Hermanns, PE-Systems GmbH,
Florian Schilling, Ying Su, Physikalisch-Technische Bundesanstalt,
Dominik Koch, Julian Weimer, Philipp Ziegler, University of Stuttgart,
Alexandra Fabricius, DKE German Commission for Electrical,
Electronic & Information Technologies of DIN and VDE

Characterization methods and environments for semiconductors are defined in the IEC 60747 series [1] on semiconductor devices. However, the application of these standards is limited when it comes to new technologies like SiC and GaN. And even for the established technologies, the traceability of measurements is lacking.

Furthermore, setting up a simulation during the selection process is often laborious on the customer side. Semiconductor manufacturers have to decide which of the many available simulation tools they want to model. If their customers use a different tool from the ones they have selected, then parametrization will require considerable effort or the device won't be considered.

The German, publicly-funded project MessLeha addresses this issue by defining a machine-readable data sheet to support the setup of simulation models. The project will also develop a measurement method and environment for measuring fast power semiconductors.

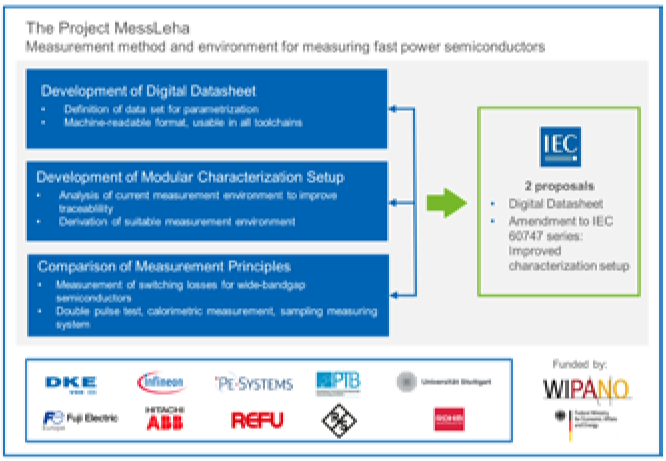

Figure 1: Overview of the project MessLeha

Development of a Digital Datasheet

In order to meet the requirements for a power converter, individual components must interact optimally in a complex system. For the power semiconductor, an initial selection is based on data sheet values. At a later stage, further criteria such as deliverability are added. Some power semiconductor manufacturers offer models for certain toolchains, or are in the process of preparing this step. At this point, the question arises whether this is the right way. Should a manufacturer of a component supply a model only for a specific toolchain? Are there other models to be created and maintained in the medium term? What about customers/users who have a different solution in use? What about market access for novel simulation tools if manufacturers offer models for one or maybe two specific toolchains? Does this perhaps even slow down technical innovation?

Neither semiconductor manufacturers, developers and manufacturers of power electronic systems nor manufacturers of simulation tools can have an interest in this scenario. It creates dependencies and generates unnecessary effort. The introduction of a machine-readable data sheet could be helpful at this point. The manufacturers of power semiconductors would store characteristic values as in the current PDF data sheet. Manufacturers of simulation tools would very quickly develop a solution for importing and automatically parametrizing component models, if they had such a coordinated data set. After the introduction of the machine-readable data sheet, developers would be able to evaluate the behavior of a specific component very quickly. Depending on the willingness of the manufacturers of power semiconductors to provide more data than usual in a current PDF datasheet, it would even be conceivable to provide reliability data or daily updated statements about deliverability. This would allow power electronics designers to further streamline the development process. A faster and more intense interaction between device vendors and their customers becomes conceivable.

It is highly likely that the aforementioned stakeholders will have a vested interest in the content of a machine-readable data sheet. The declared goal of the project is to explore this interest and bring their contribution together in an agreed standard.

designing a proper characterization setup has become more challenging due to the high switching speed of these devices. Parasitic elements, inductive as well as capacitive, will have more impact when switching faster. Main challenges in the setup are minimizing the stray inductance of DC

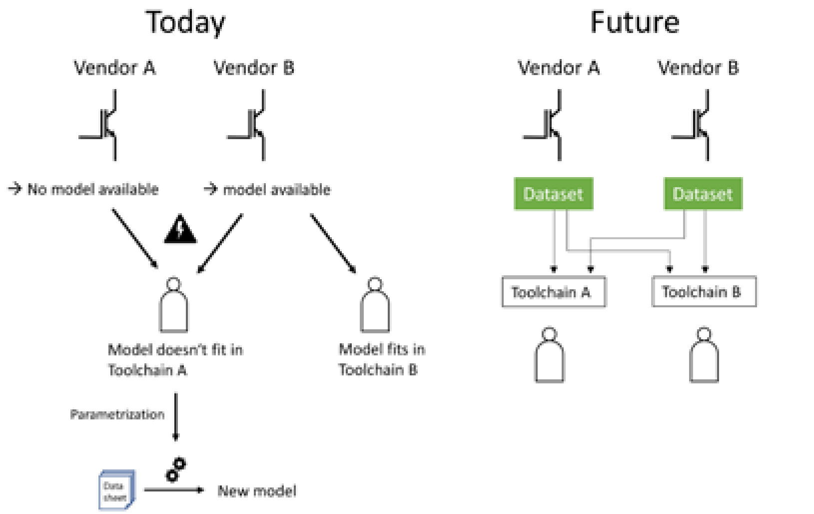

Figure 2: Today (left), only customers with appropriate toolchains are able to use provided models, while the aim of future datasets (right) is to provide a defined interface suitable for all toolchains.

Development of a Modular Characterization Setup

Double Pulse Testing (DPT) is an important method for power device characterization and comparison. Characterization usually is done at the power device manufacturer's to create data sheets and simulation models. Comparative device evaluation is performed by power device customers preparing strategic decisions between device and packaging technologies. For both cases, the devices need to be tested in a characterization setup that minimizes external impact on device performance as far as possible to attain consistent and comparable results. With the emergence of new Wide-Bandgap (WBG) semiconductors like SiC MOSFETs, link and current sensor, reducing parasitic capacitances, a fast and strong driver close to the device, and sufficient bandwidth for voltage measurement as well as for current measurement. For low-power applications, it is quite common to place the complete DPT setup including the DUT on a single PCB. However, at higher power, and for a larger product portfolio as common in the power module business, this approach tends to become cumbersome. Hence, a modular approach separating the complete setup into two main parts is advantageous. A device board, carrying only the device itself and an optional driver, is designed individually for the best fit of the specific module. As a counterpart, there is a DC link board contain-

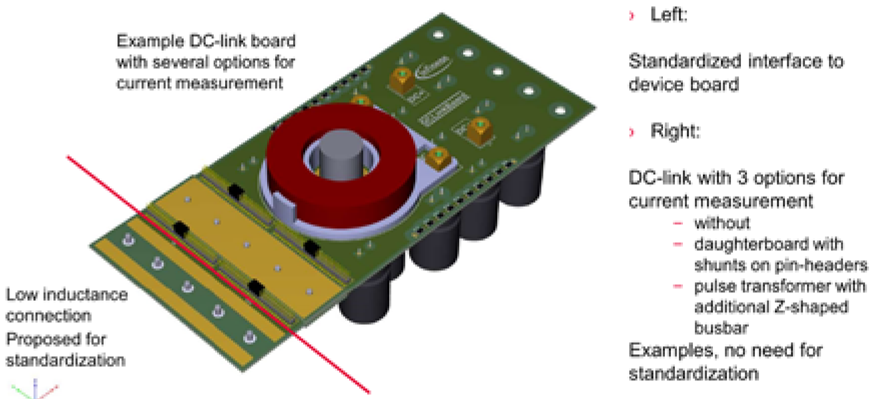

Figure 3: DC-link board with low-inductance interface

ing a low-inductance DC link as well as a low-inductance current measurement. Of course, these two boards need to be connected by a unified low-inductance connection. Fig. 3 shows a proposal for such a board offering a simple low-inductance connection on the left and a DC link with several, optional current sensors on the right. This board is intended to house either a pulse current transformer, a planar shunt arrangement or a Rogowski coil.

Comparison of Measurement Principles

Due to the fast switching times of Wide-Bandgap semiconductors, like SiC and GaN, the requirements of the equipment for the switching loss measurements are rapidly increasing in comparison to silicon devices.

The University of Stuttgart with its Institutes for Power Electronics and Electrical Drives (ILEA) and Robust Power Semiconductor Systems (ILH) is therefore working on improving and characterizing measurement setups for Wide-Bandgap switching loss determination. For this purpose, the existing state-of-the-art Double Pulse Test has been improved by new current sensors and high-accuracy characterization of current and voltage probes with regard to frequency behavior, i.e. bandwidth. Furthermore, the influence of the parasitics in the setup, like stray inductance, will be taken into account. The results are verified with the help of highly accurate calorimetric measurements, utilizing the heat-up phase for fast switching loss results at several points of operation.

In parallel, the National Metrology Institute of Germany (PTB) is developing a method for measuring the switching losses with a sampling measuring system. With this method, the voltage and the current will be recorded precisely during the switching time. For this purpose, the voltage divider and the shunt first need to be characterized. Another challenge is the time correction between the two recorded signals. These two factors ensure the accuracy of the calculated switching losses.

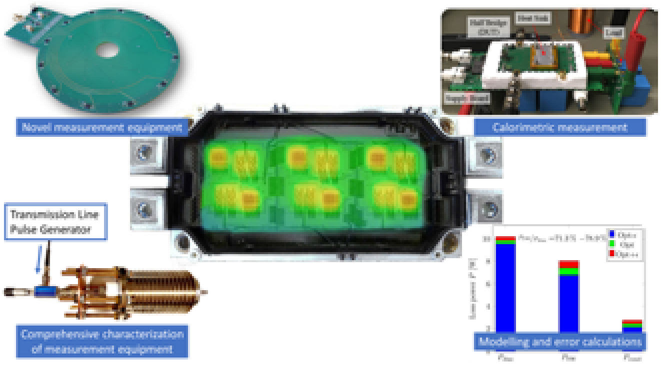

Figure 4: Power module as DUT and the different facets of switching loss characterization in this project (middle). Novel current sensor based on the HOKA principle for precise current measurement [2] (top left). Calorimetric measurement setup for Wide-Bandgap discrete power semiconductors [3] (top right). Bandwidth characterization for a shunt with a transmission line pulse generator (PTB) (bottom left). Precise modelling and error calculation of calorimetric and electrical measurements for level of trust calculation [4] (bottom left).

After the development phase of the three methods, a comparison will be performed between all methods. The measurement uncertainty of the systems will also be determined.

Standardization in IEC – and How to Participate

The project MessLeha aims to develop a standardized measurement environment and machine-readable data sheet to support a smoother development of power electronic systems. This can only be achieved if the solution is extensively updated. At the end of the project in December 2021, two drafts will be proposed to DKE, the German Commission for Electrical, Electronic & Information Technologies in DIN and VDE. Upon approval, these drafts will then be proposed to the Technical Committee TC 47 “Semiconductor devices” of the International Electrotechnical Commission IEC.

A proposal for an amendment to the IEC 60747 series will address the current lack of traceability of measurements. It will furthermore make sure that the Double Pulse Test will be applicable to the new SiC and GaN semiconductors as well. The second proposal will define the machine-readable data sheet.

On March 4, 2021, the project MessLeha will hold an online workshop to collect feedback from stakeholders. During two dedicated breakout sessions, the project partners will discuss with the participants their requirements for device model parametrization and simulations as well as for the measurement environment.

The input gathered during these sessions will be included in the ongoing work and the resulting standardization proposals. If you are interested in participating, you can learn more about the workshop content and registration on the website provided at the end of this article.

Website Link: www.dke.de/messleha-en#register

References:

[1] Relevant are the following standards of the IEC 60747 series:
IEC 60747-8 Semiconductor devices - Discrete devices - Part 8: Field-effect transistors
IEC 60747-9 Semiconductor devices - Part 9: Discrete devices - Insulated-gate bipolar transistors (IGBTs)
IEC 60747-15 Semiconductor devices - Discrete devices - Part 15: Isolated power semiconductor devices

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Automatic Magnetic Simulation Generation for Inductive Components Design

The current trends in power electronics tend towards higher frequencies to reduce the weight and volume of passive components. This is impulsed by the development of semiconductors in GaN and SiC technologies which permit to obtain the most efficient converters in the smallest size. Nevertheless, a higher switching frequency brings new problematics for the magnetic components design.

By Patrick Fouassier, Principal Engineer, R&D Manager, and Benoît Battail, R&D Engineer, PREMO FRANCE

Additional losses due to skin-depth reduction, proximity effect between conductors or fringing flux effect can become very important to be fully considered. Of course, it exists some analytical models to estimate their level, but they remain quite complex or require many hypotheses for an easy and accurate application in the Industry. Another way to estimate their amount can be the use of Finite Elements Analysis simulation (FEA). However, from an industrial point of view, the cost of such software and the time spent to build each mechanical model remain a limitation. To answer to this concern, a new fast and cheap automatic design method, based on a coupling between analytical model approach and FEA simulation, will be presented.

The main interest of the presented method is to estimate easily and cheaply in an automatic way the additional losses in a magnetic component. Building the model with an automatic generation also permits to reduce the risk of human errors in the geometric construction or in the input data.
Globally, the problem is introduced on a Mathcad® [1] page with all the requirements about the operation (buck/boost/filter choke, flyback/bridge transformer…) and its related electrical values as well as with the first estimated set of dimensions, turns and conductors to calculate the DC resistance, RMS current and flux density values... Analytically, the DC copper and core losses can be already estimated from well-known models [2,3] by robust analytical calculations.

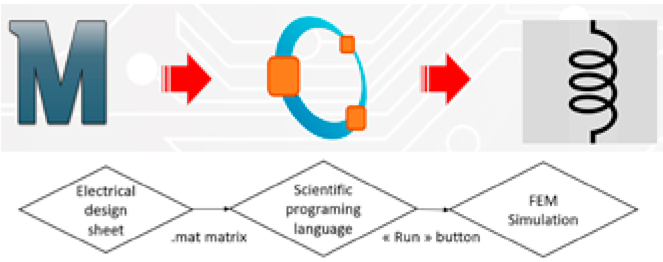


Figure 1: Flow chart of the method.

With the switching frequency increase in converters, the phenomena causing additional copper loss in windings are well identified [4,5,6,7], but their impact is difficult to solve analytically for real components without using important hypotheses or time-consuming 3D model introduction in FEA software at first.

To be quick and with no license fees, the FEMM® [8] software has been selected to quickly solve the Maxwell's equations in 2D and show the impact of frequency effects in conductors. Its postprocessor is used to calculate the AC losses according the ripple of current at the specified frequency.
The GNU-Octave® [9] scientific programming language (to define the script and parametrize the simulation) is used to operate the coupling between analytical calculations and FEA approaches (Figure1). The parameters are passed through a matrix (*.mat*). The script can also launch postprocessing calculation and pre-defined strategies like harmonics study to be more accurate in the results.

Filtering Coil Example

Firstly, the method has been implemented for a filtering choke with a 3-turn flat wire coil and core with gap.

1. Mathcad calculations

The method begins in a home-made Mathcad routine with equations related to the component operation. Several modules have been de-

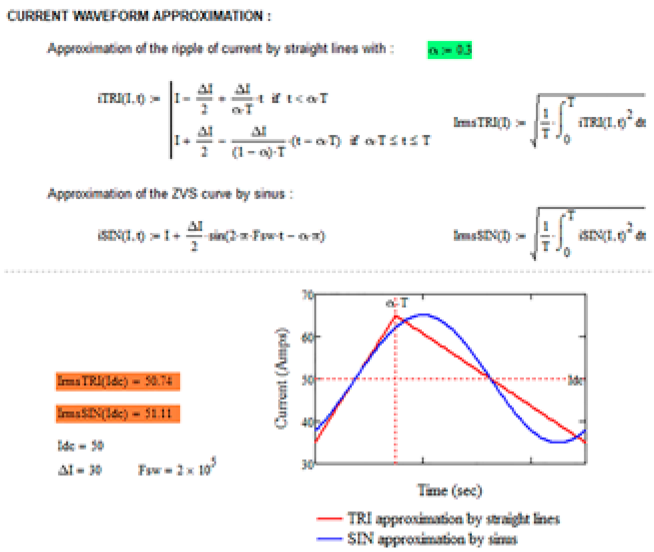


Figure 2: Part of the Mathcad routine (current waveform to calculate Irms and Bpk).

veloped yet for chokes with gap, flyback or bridge transformers... The electrical behavior is translated into voltage and current waveforms by pieces of straight lines to be able to calculate the RMS current values (*Irms*) in windings and the maximum flux density (*Bpk*) in the selected core format and copper turns (Figure 2).

Frequency, temperature, input voltage range, current level… are all set as variables for automatic calculation on the Mathcad sheet. From it, the DC copper and core losses can be already computed as well as the possible gap length estimation. At the end of the file, the needed information for FEA simulation are transmitted to Octave thanks to a matrix (Figure 3).

MTL	"Mean turn length""
N	"Number of turns"
Wt	"Wire thickness"
Ww	"Wire width"
Wc	"Core width"
Hcout	"Outer height"
Hcin	"Window height"
Lcout	"outer length"
Lin	"Window length"
δwind_core	"Space between winding and bottom core"
ΔI	"Current ripple"
μr	"Initial permeability"
Top	"Operating temperature"
Ae	"Magnetic cross section"
Dcleg	"Core central leg diameter"
T	"Switching period"
lg	"gap length"
Hcoil	"Coil height in the window"

Figure 3: Matrix of parameters used for Mathcad-Octave coupling.

2. Octave script

An existing Octave [7] package provides functions which can be used to control FEMM and parametrize a simulation from a script file. The developed script opens FEMM and generates the simulation (2D axisymmetric or planar type) according to the data available in the matrix generated by Mathcad (geometry construction, assign physical properties, set boundary conditions).

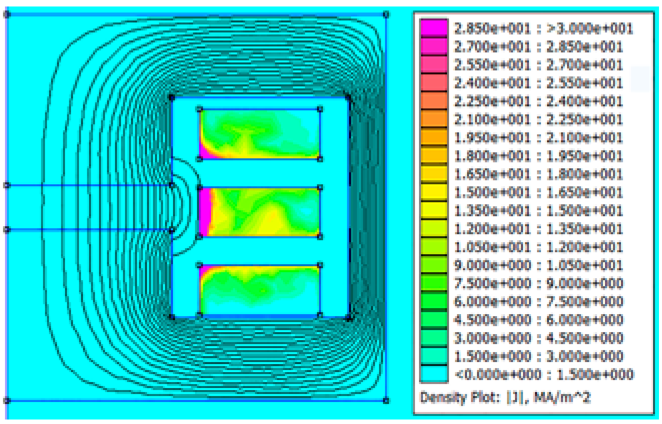


Figure 4: Current density in conductors generating extra AC losses.

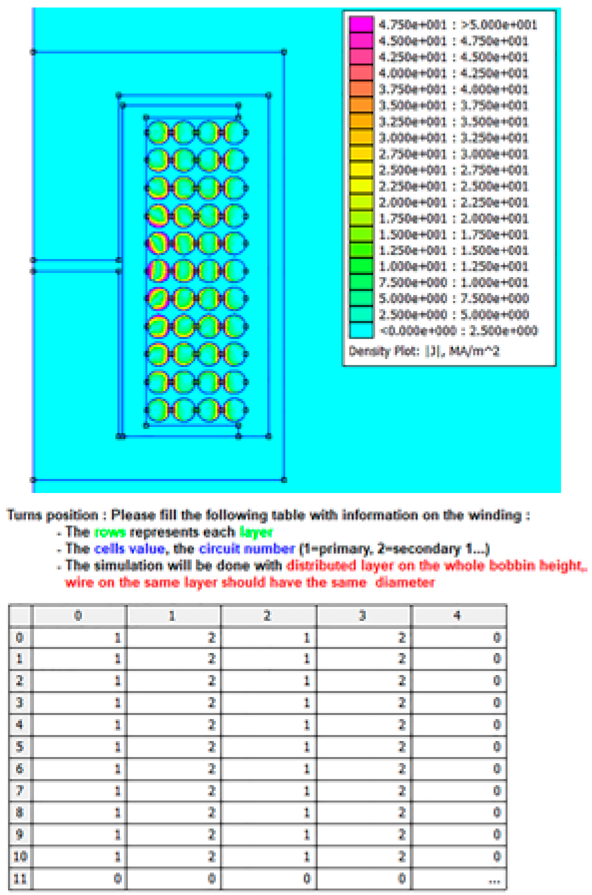
3. FEMM processing

After automatic generation (in a few seconds only) of the result on figure 4 where the influence of the fringing flux out of the gap and proximity effect between turns can be clearly seen, the AC copper losses from the first harmonic are computed here at 1.7W (100°C) that is of the same amount as the DC copper losses! The postprocessor can also be used to check the inductance value or the magnetic field inside the core…

Transformer Case

Another Mathcad file and Octave script have been created to extend the method to multi-winding transformers. The geometrical data (Figure 5a) of the core and bobbin are defined in a Mathcad file and sent to Octave with also the electrical parameters for the simulation. The windings are defined in a matrix (Figure 5b) which represents the circuit numbers (in line) per layers (in column); the value in the cell gives a number to the circuit to which the current level will be assigned. The real part of the currents I_i is defined to respect the equation (1) and the imaginary part at the primary is creating the flux in the core (N_i is the number of turns in each circuit). FEMM Litz wire integrated model [10] can be directly used if conductors are of this type.

$$\Sigma N_i \, Re\,(I_i) = 0 \qquad (1)$$



	0	1	2	3	4
0	1	2	1	2	0
1	1	2	1	2	0
2	1	2	1	2	0
3	1	2	1	2	0
4	1	2	1	2	0
5	1	2	1	2	0
6	1	2	1	2	0
7	1	2	1	2	0
8	1	2	1	2	0
9	1	2	1	2	0
10	1	2	1	2	0
11	0	0	0	0	...

Figure 5: Transformer geometry (a) and winding matrix (b).

Conclusions and Future Work

A method for automatic generation in a 2D FEA software is presented for a quick estimation of the complementary AC copper losses in windings due to frequency effects. It combines Mathcad-Octave-FEMM software at almost no cost with a very fast computation and no manual geometry introduction. Linked to analytical models, it enables a more realistic estimation of the total loss in magnetic components.

Further to the axisymmetric examples presented here for a filtering coil and a 2-winding transformer, 2D planar types will be introduced to consider other geometries like ring cores or low-profile magnetic circuits. Moreover, the automatic generation and programmed control of post-processor will be used to introduce pre-defined Fourier analysis. The purpose of this analysis is to get the AC losses contribution for all the possible harmonics of the current. Eventually the link with thermal simulation in a similar way will be studied to get the temperature map.

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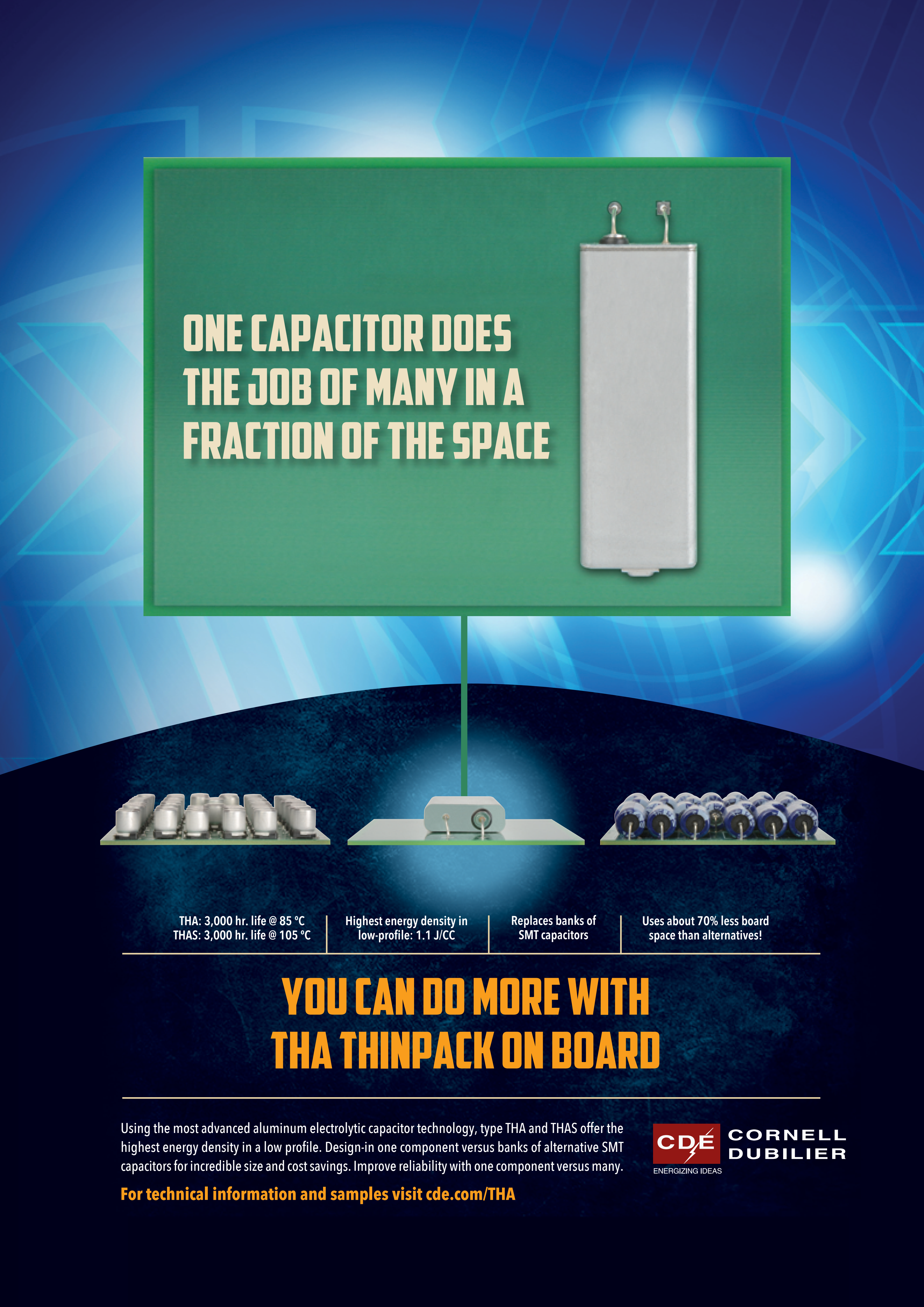
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THA: 3,000 hr. life @ 85 °C
THAS: 3,000 hr. life @ 105 °C
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Reduce Power Supply Requirements for Ceramic Capacitors with a High Efficiency, High Frequency, Low EMI DC-to-DC Converter

The price of the multilayer ceramic capacitors (MLCCs) has risen sharply over the past several years, tracking the expansion in the number of power supplies used in automotive, industry, data center, and telecommunications industries. Ceramic capacitors are used in power supplies on the output to lower output ripple, and to control output voltage overshot and undershot due to high slew rate load transients. The input side requires ceramic capacitors for decoupling and to filter EMI due to their low ESR and low ESL in high frequency.

By Zhongming Ye, Senior Applications Engineer, Analog Devices

The quest to increase the performance of industrial and automotive systems calls for increases in data processing speed of several orders of magnitude, with an increasing number of power-hungry devices squeezed into microprocessors, CPUs, system on chips (SoCs), ASICs, and FPGAs. Each of these complex device types requires a number of regulated voltage rails: typically, 0.8 V for cores, 1.2 V and 1.1 V for DDR3 and LPDDR4, respectively, and 5 V, 3.3 V, and 1.8 V for peripheral and auxiliary components. Buck (step-down) converters are widely used to produce the regulated power supplies from a battery or a dc bus.

For instance, the proliferation of the advanced driver assistance systems (ADAS) in automobiles has dramatically increased ceramic capacitor usage rates. With the rise of 5G technology in telecommunications, where high performance power supplies are required, ceramic capacitor usages will also significantly increase. Core supply currents have increased from several amps to tens of amps, with very tight control of supply ripple, load transient overshot/undershot, and electromagnetic interference (EMI)—features that require additional capacitance.

In many cases, traditional power supply approaches can't keep up with the pace of change. Overall solution size is too big, efficiency is too low, circuit design is too complicated, and the bill of materials (BOM) is too costly. For example, to meet the tight voltage regulation specifications for a fast load transient, a large number of ceramic capacitors are required at the output to store and source significant currents arising from load transients. The total cost of the output ceramic capacitors can reach several times that of the power IC.

Higher power supply operating (switching) frequencies can reduce the effect of transients on output voltage and reduce the capacitance requirements and overall solution size, but higher switching frequencies usually result in increased switching losses, reducing overall efficiency. Is it possible to avoid this trade-off and meet transient requirements at the very high current levels demanded by advanced microprocessors, CPUs, SoCs, ASICs, and FPGAs?

Analog Devices' Power by Linear™ monolithic Silent Switcher® 2 buck regulator family enables compact solution size, high current capability, high efficiency, and, more importantly, superior EMI performance. The LTC7151S monolithic buck regulator uses a Silent Switcher 2 architecture to simplify EMI filter design. Valley current mode reduces the output capacitance requirement. Let's look at a 20 V input to 1 V at 15 A output solution for an SoC.

15 A Solution from 20 V Input for an SoC

Figure 1 shows a 1 MHz, 1.0 V, 15 A solution for SoC and CPU power applications where the input is typically 12 V or 5 V and can vary from 3.1 V to 20 V. Only input and output capacitors, an inductor, and several small resistors and capacitors are necessary to complete a power supply. This circuit can be easily modified to produce other output voltages, such as 1.8 V, 1.1 V, and 0.85 V, down to 0.6 V. The negative return (to the V– pin) of the output rail enables remote feedback sensing of the output voltage close to the load, minimizing feedback errors caused by voltage drops across board traces.

The solution in Figure 1 uses an LTC7151S Silent Switcher 2 regulator, which features high performance integrated MOSFETs in a 28-lead, thermally enhanced 4 mm × 5 mm × 0.74 mm LQFN package. Control is via valley current mode. Protection functions are built-in to minimize the number of external protection components.

The minimum on time of the top switch is only 20 ns (typical), enabling direct step-down to core voltages at a very high frequency. Thermal management features enable reliable and continuous deliv-

ery current up to 15 A from input voltage up to 20 V without heatsink or airflow, making it a popular choice for SOCs, FPGAs, DSPs, GPUs, and microprocessors in telecom, industry, transportation, and automotive ap-plications.

The wide input range of the LTC7151S enables use as a first-stage intermediate converter, supporting up to 15 A at 5 V or 3.3 V to multiple downstream point-of-load or LDO regulators.

Meet Tight Transient Specifications with a Minimum Output Capacitor

Typically, an output capacitor is scaled to meet requirements for loop stability and load transient response. These specifications are particularly tight for power supplies that serve processor core voltages, where load tran-sient overshoot and undershoot must be well controlled. For instance, during a load step, the output capacitor must step in, instan-taneously supplying current to support the load, until the feedback loop brings up the switch current enough to take over. Typically, overshoot and undershoot are suppressed by installing a significant number of multi-layer ceramic capacitors at the output side, fulfilling charge storage requirements during fast load transients.

Additionally, or alternatively, pushing the switching frequency higher can improve fast loop response, but at the price of increased switching losses.

There is a third option: regulators with val-ley current-mode control can dynamically change the regulator's switch TON and TOFF times to almost instantaneously meet the demands of load transients. This allows for significantly reduced out-put capacitance to meet fast response times. Figure 2 shows the results of the LTC7151S Silent Switcher regulator immediately responding to a load step from 4 A to 12 A with 8 A/µs slew rate. The controlled on-time (COT) valley current-mode architecture of the LTC7151S allows the switch node pulses to compress during the 4 A to 12 A load step transition. About 1 µs after the start of the rising edge, the out-put voltage starts its recovery, with overshoot and undershoot limited to 46 mV peak-to-peak. The three 100 µF ceramic capacitors shown in Figure 2a are sufficient to meet typical transient specifications, as shown in Figure 2b. Figure 2c shows typical switch waveforms during a load step.

High Efficiency Step-Down at 3 MHz Fits Tight Spaces

In the 4 mm × 5 mm × 0.74 mm package of the LTC7151S are integrated MOSFETs, drivers, and hot-loop capacitors. By keeping these components close, parasitic effects are reduced, allowing for fast turn on/off of the switches with very narrow deadtime. The conduction loss of the antiparallel diode of the switches is greatly reduced. The integrated hot-loop decoupling capacitor and built-in compensation circuit also eliminate design complexity, minimizing the total solu-tion size.

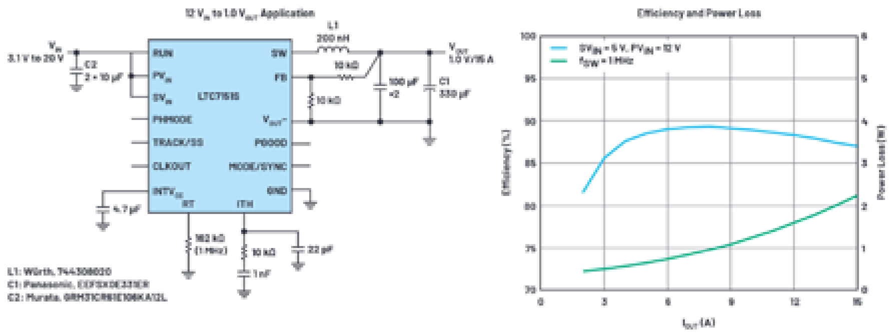


Figure 1: Schematic and efficiency of a 1 MHz, 15 A buck regulator for SoCs and CPUs.

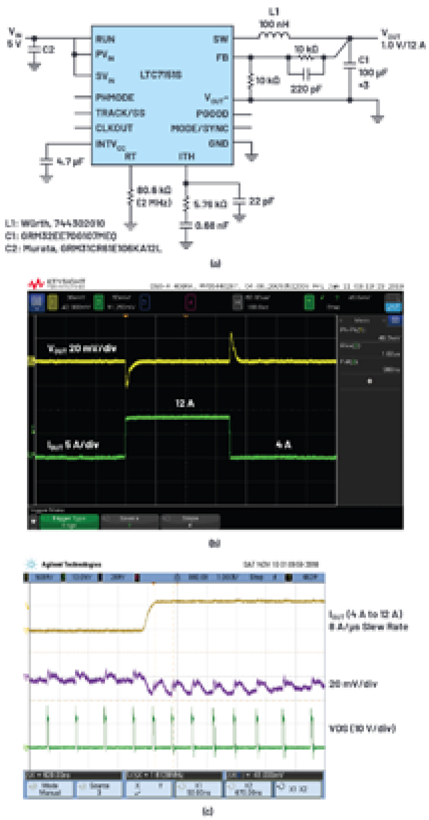


Figure 2: (a) This 5 V input to 1 V output application runs at 2 MHz, requiring minimal capacitance at the output to quickly and cleanly react to (b) load steps, along with (c) switching waveforms during the load step.

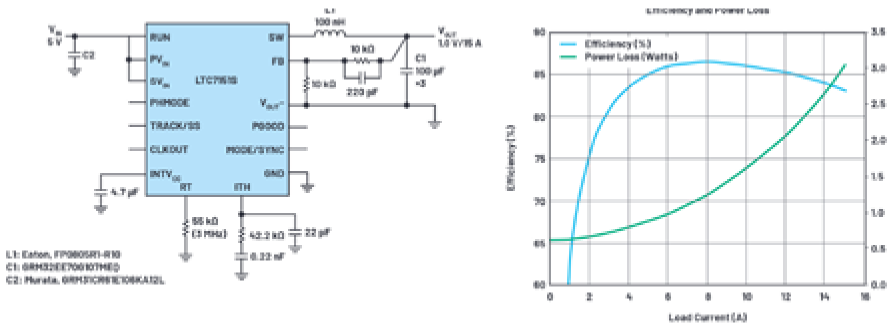


Figure 3: Schematic and efficiency for 5 V input to 1 V/15 A with fSW = 3 MHz.

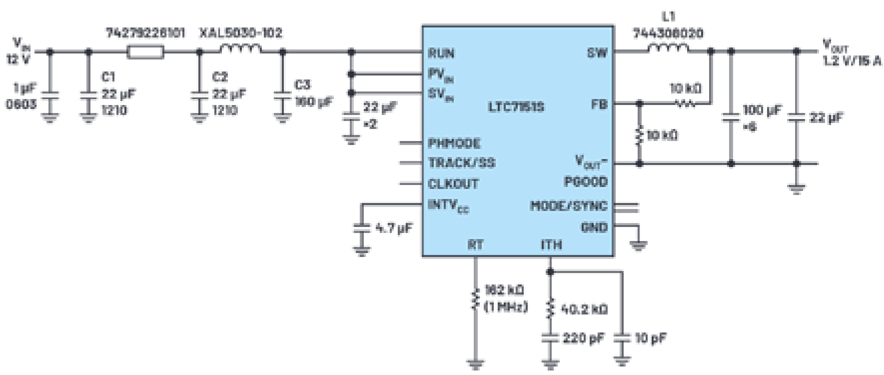


Figure 4: Schematic of a 1.2 V regulator with 1 MHz switching frequency.

As previously mentioned, the 20 ns (typical) minimum on the top switch allows for very low duty ratio conversion at high frequency, enabling the designer to take advantage of very high frequency operation (such as 3 MHz) to reduce the size and value of the inductor, input capacitor, and output capacitor. Extremely compact solutions are possible for limited space applications, such as portable devices or instruments in automotive and medical applications. Bulky thermal mitigation components such as fans and heatsinks are not necessary when using the LTC7151S, thanks to its high performance power conversion, even at very high frequencies.

Figure 3 shows a 5 V to 1 V solution operating at a 3 MHz switching frequency. A small size 100 nH inductor from Eaton together with three 100 µF/1210 ceramic capacitors delivers a very low profile compact solution for FPGA and microprocessor applications. The efficiency curve is shown in Figure 3b. The temperature rise at room temperature is about 15°C at full load.

Silent Switcher 2 Technology Results in Excellent EMI Performance

Meeting published EMI specifications—such as CISPR 22/CISPR 32 conducted and radiated EMI peak limits—with a 15 A application could mean a number of iterative board spins, involving numerous trade-offs of solution size, total efficiency, reliability, and complexity. Traditional approaches control the EMI by slowing down switching edges and/or lowering the switching frequency. Both have undesired effects, such as reduced efficiency, increased minimum on and off times, and a larger solution size. Brute force EMI mitigation—such as complicated and bulky EMI filters or metal shielding—add significant costs in required board space, components, and assembly, while complicating thermal management and testing.

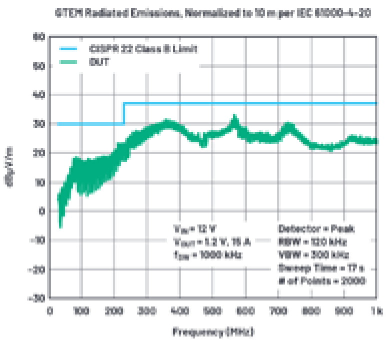


Figure 5: Radiated EMI in GTEM passes the CISPR 22 Class B limit.

The Analog Devices' proprietary Silent Switcher 2 architecture uses a number of EMI reduction technologies, including integrated hot-loop capacitors, to minimize noisy antenna size. The LTC7151S keeps EMI low by incorporating high performance MOSFETs and drivers, which allows the IC designer to produce a device with built-in minimized switch-node ringing. The result is that the associated energy stored in the hot loop is highly controlled, even when switching edges have high slew rates, enabling exceptional EMI performance while minimizing the ac switching losses at high operating frequencies.

The LTC7151S has been tested in an EMI testing chamber and passed the CISPR 22/CISPR 32 conducted and radiated EMI peak limit with a simple EMI filter in front. Figure 4 shows the schematic of a 1 MHz, 1.2 V/15 A circuit, and Figure 5 shows the radiated EMI CISPR 22 test result in gigahertz transverse electromagnetic (GTEM) cell.

Conclusion

The proliferation of intelligent electronics, automation, and sensors in industry and automotive environments has driven up the required number and performance requirements of power supplies. Low EMI, in particular, has increased in priority as a key power supply parametric consideration, along with the usual demands for small solution size, high efficiency, thermal proficiency, robustness, and ease of use.

The LTC7151S meets stringent EMI demands in a very compact size using Silent Switcher 2 techniques from the Power by Linear division of Analog Devices. Thanks to the valley current-mode control and high frequency operation, the LTC7151S dynamically changes the TON and TOFF times to actively support load transients nearly instantaneously, allowing for much smaller output capacitance and fast response. Its integrated MOSFETs and thermal management enable robust and reliable delivery of current up to 15 A continuously from input ranges up to 20 V.

About the Author

Zhongming Ye is a senior applications engineer for power products at Analog Devices in Santa Clara, California. He has been working at Linear Technology (now part of Analog Devices) since 2009 to provide application support to various products including buck, boost, flyback, and forward converters. His interests in power management include high performance power converters and regulators of high efficiency, high power density, and low EMI for automotive, medical, and industrial applications. Prior to joining Linear Technology, he worked at Intersil for three years on PWM controllers for isolated power products. He obtained a Ph.D. degree in electrical engineering from Queen's University, Kingston, Canada. Zhongming was a senior member of the IEEE Power Electronics Society.

www.analog.com

Active Motor Simulator for Testing Automotive Inverters

Simulation of Electrical Machines for Inverter Lifetime-, EOL- and System-Tests.

One of the central components of electrical or hybrid vehicles is the inverter – the device that converts DC voltage from the battery into AC currents for the electrical motor. Thus, testing inverters requires basically a battery simulation and a motor simulation. Battery simulations are available on the market. Depending on the parameters, either standard power supplies with or without grid feedback or specific powerful battery simulations may be applied.

By Michael Rost, IRS Systementwicklung GmbH

To simulate the motor there are usually two options: simple passive load or a full-size motor simulator.
The passive coil solution is very common in all fields of test in production, validation, and laboratory equipment. It is cost-efficient, simple, but with the drawbacks mentioned in the table below. Low DC current has the advantage, that relatively small power supplies can be applied, but the DC-path of the inverter is not tested under real conditions.

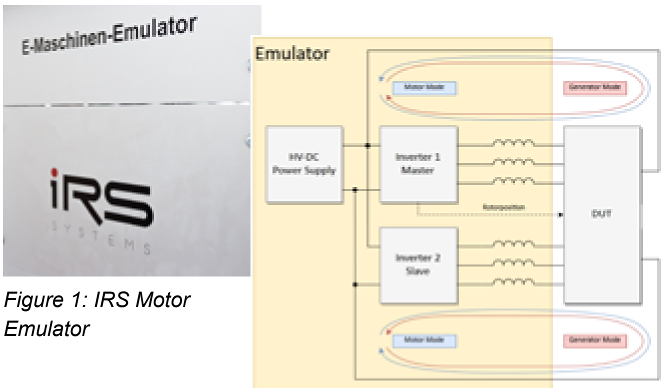


Figure 1: IRS Motor Emulator

Passive coil	Active motor simulator – full size	Active motor simulator - IRS
+ Very cost-efficient	- Very high price	+/- Cost efficient
+ Small setup	- Space consuming setup	+ Small setup
+ Full phase current	+ Full phase current	+ Full phase current
- Only reactive phase current	+ Simulation of real phase currents	+ Simulation of real phase currents
- No recuperation	+ Recuperation possible	+ Recuperation possible
+/- Low DC currents	+/- Real DC current from battery	+ Real DC current, but low power

For Electronic motor simulations, the assortment is much more limited. For high power inverters with more than 100kW, highly sophisticated motor simulators are available from only few companies at prices well over 500.000 EUR. For many applications, the functionality of these simulators is oversized, e.g. in production lines or lifetime tests. In the latter, several inverters must be tested in parallel, resulting in the need of many motor simulations. Thus, in lifetime tests usually the simple coil solution is applied. IRS provides a cost-efficient motor simulation, where real currents are simulated including realistic battery current and where recuperation is possible. But still the current drawn from the battery simulator has only to cover the losses of the system.

The motor simulator is applied in several lifetime testers, EOL testers and LV124/GS95024 validation systems. The system is designed and produced by IRS. As in many other projects, the components for handling high currents and high voltages are provided by GvA, the partner of IRS for high power.

Key Facts

- Cost-efficient motor simulator for motors in the range of 10kW to 400kW
- Wide voltage range 30V to 1000V DC for BEV, PHEV or MHEV inverters
- Realistic currents both on motor and battery connections of the inverter
- Motor and recuperation operation
- Low current consumption from the battery simulator
- 6-phase motor simulation available

Use Cases

Technical Description
Following picture shows the basic setup of the IRS electrical motor emulator for a three-phase-inverter as device under test (DUT):
The concept is based on the idea to directly run two inverters against each other - both three phases and the DC-Link are directly coupled.

NEW WAYS TO BOOST PERFORMANCE

Vincotech

SOLAR

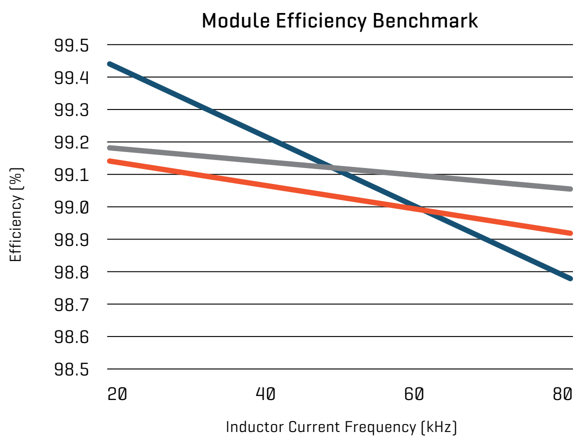
*flow*BOOST S3 triple boosters – a real alternative for 1500 V solar inverters

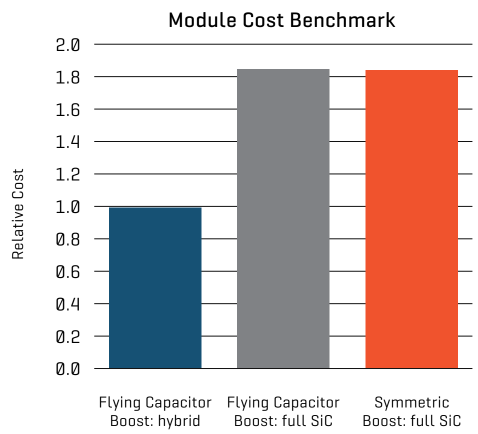
Designers seeking to strike the right balance between cost and performance need real alternatives. That's what Vincotech's new *flow*BOOST S3 triple boosters are here to do. Featuring high efficiency flying capacitor topology, these new boosters enable engineers to find the right design balance.

Available in a low-inductance *flow* S3 housing and tailored for 1500 V solar inverters, these boosters outperform their conventional counterparts and provide even greater power density for more compact, lighter systems.

Main benefits:

- Multi-sourced components to minimize supply chain risk
- Solder or Press-fit pins and pre-applied TIM to help reduce production cost
- Optimized hybrid Si/SiC-based solutions with a common footprint for greater design flexibility and leading cost/performance metrics





www.vincotech.com/flying-cap

EMPOWERING **YOUR IDEAS**

As battery simulator a standard power supply may be used. With appropriate control of the motor simulator, the phase current flows from DUT to simulator via the phase coils and back to the DUT via the DC-Link, and vice versa. Thus, the DC-Link is stressed with a realistic current, but since the energy is flowing between the two inverters, the battery simulation has only to provide the energy for the losses of the entire system. This is one of the most important benefits: a relatively small power supply without energy feedback to the grid can be used. With a power supply of only 20kW, motors of about 250kW can be simulated.

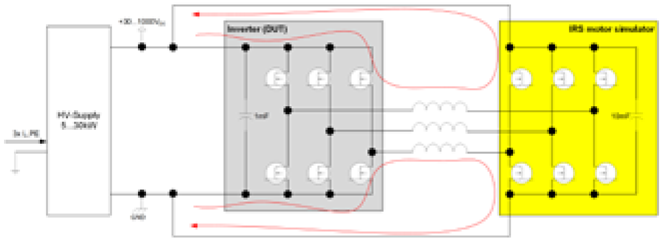


Figure 2: Active motor simulator concept

In most setups, the simulator generates the induced voltage of the motor and the DUT is in current control mode, defining the applied torque to the motor.

Since the setup is symmetrical, either the DUT operates as generator and the simulator as motor load, or vice versa. Thus, both standard motor operation and recuperation can be simulated. Three phase currents and the negative DC-current of the DUT are shown in the figure. In this case, negative current means recuperation.

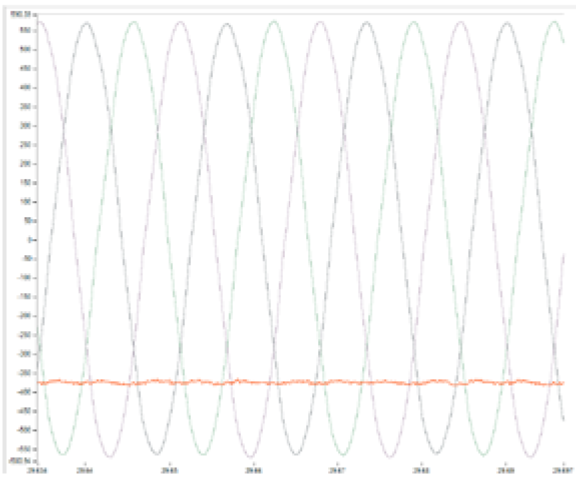


Figure 3: Typical phase currents and HV-DC current

Advantages and constraints

Compared to the highly sophisticated motor simulators, where usually huge multi-level-inverters are applied, this setup uses a compact two-level inverter. This saves both space and cost to a great extent. Furthermore, the relatively small power supply benefits to low cost and size immensely.

Of course, there are constraints. The direct coupling needs good synchronization between the two inverters. The system runs best at fixed frequencies in the range of 5…10kHz. This chopping frequency also defines the maximum speed to simulate with a two-level-inverter. Furthermore, harmonics must be compensated with this direct coupling. A typical maximum frequency of phase current is in the range of 200Hz – at a 3-pole-motor leading to 4000RPM.

The focus of IRS motor simulator are applications, where fixed operating points are selected, rather than simulation of a full non-linear motor model. Linear motor models can be implemented.

But many applications do not need to simulate the full speed range or mechanical behavior of the motor. Thus, IRS motor simulator is the best choice in applications where speed and motor harmonics are not crucial, but space and cost determine the best fitting simulator system. Please note, that both cost and space savings – compared to highly sophisticated simulators - exceed the factor of 10 by far!

On the other hand, the simulator only needs about twice as much space compared to a simple passive coil solution

Position sensor simulation

To test an inverter, not only the load for the motor phases has to be simulated. The inverter needs to know the exact motor position to apply the appropriate current on the respective phases. IRS provides two versions of position sensors:

- AMR/GMR position sensor (for e.g. Infineon TLE5309)
- Resolver-simulation.

Both variants are integrated in the motor emulator. Furthermore, they are also available as Compact-RIO or stand-alone module IRS Sens-Sim or IRS Resolversimulation, when a simple inductive coil solution is applied.

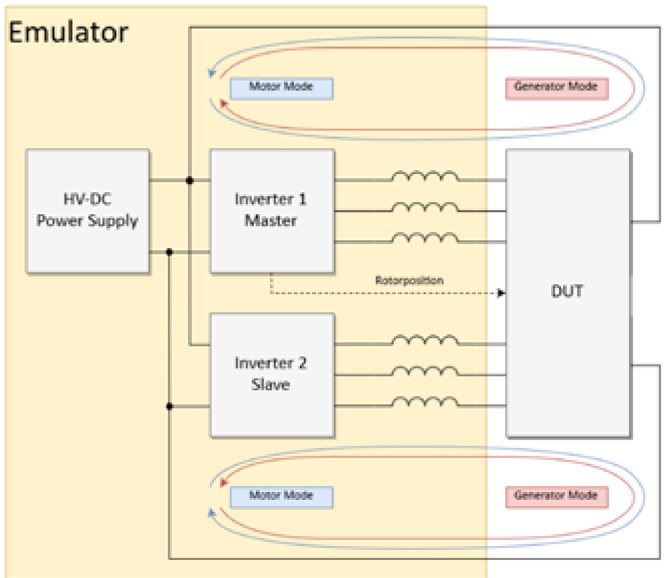


Figure 4: 6-Phase motor simulation

6-Phase motor simulation

Powerful electrical vehicles may apply 6-Phase motors in the future. This means twice the power and the motor may continue working even with a phase failure. Two IRS motor simulator can be combined and synchronized to simulate a 6-phase motor. This setup already proofs its reliability in several test stations at the customer.

Independent DUT voltage

When the DUT HV voltage should be flexible and independent from the Emulator, Both DUT and Emulator may be supplied with separate power supplies. This can be useful e.g. for LV123 tests, where different HV-voltages must be applied at the DUT, while the motor simulator performs at the same setpoint. This setup is feasible with IRS motor simulator, but of course, will require larger power supplies, including grid feedback.

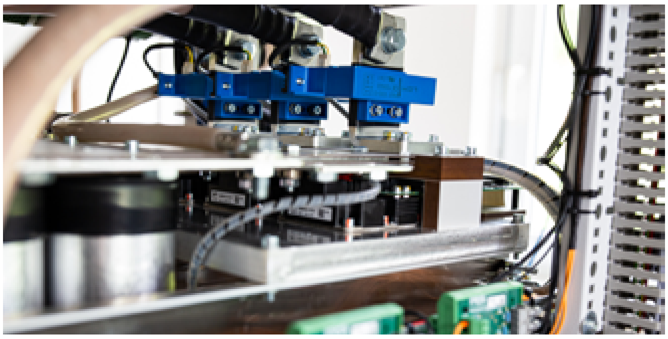


Figure 5: Power devices from GvA

Technical Data

	Min	Typ	Max	Unit
HV-DC voltage range	30		1000	V
Phase Current (Typ=continuous / max=for 60 seconds)		500	700	A_{RMS}
Peak phase current (overcurrent protection)	-1000		1000	A_{pk}
Phase inductance (may be modified application specific)		85		µH
Phase current frequency	0		200	Hz
Inverter chopping frequency	4	8	14	kHz

www.irs.systems

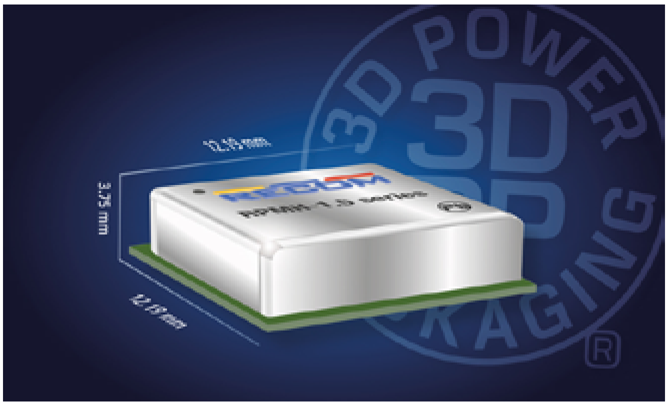
Small Footprint Gate Driver for Fast Design-ins

Infineon Technologies adds a generation to its most versatile and simple to use EiceDRIVER™ 1ED Compact isolated gate driver family: the X3 Compact (1ED31xx) family. This gate driver provides separate output options together with active shutdown and short circuit clamping in DSO-8 300 mil package. The active Miller clamp option is best suited for silicon carbide (SiC) MOSFET 0 V turn off. The X3 Compact offers a benchmark CMTI of 200 kV/µs, and typical 5, 10, and 14 A output current. It is aiming at industrial drives, solar systems , EV charging, uninterruptible power supplies, commercial air conditioning as well as other applications. The EiceDRIVER X3 Compact is recognized under UL 1577 with an insulation test voltage of 5.7 kV RMS. Its 14 A high output current is well suited for high switching frequency applications as well as for IGBT 7, which requires a much higher gate driver output current compared to IGBT 4. With the same exceptional CMTI robustness as the X3 Enhanced of more than 200 kV/µs, the X3 Compact also avoids faulty switching patterns. The tight propagation delay matching of 7 ns (max.) leads to shorter deadtime. All variants integrate input filters, which reduces the need for external filters, provides accurate timing, and leads to lower BOM cost. The EiceDRIVER X3 Compact is the perfect driver for superjunction MOSFETs such as CoolMOS™, SiC MOSFETs such as CoolSiC™, and IGBT modules.

www.infineon.com

High Input Voltage Switching Regulator Range

RECOM has extended the current rating of its RPMH range of non-isolated switching regulators from 0.5A to 1.5A, with no increase in size, leveraging the company's expertise in 3D power packaging®. In a tiny 12.19 x 12.19 x 3.75mm package, the high-efficiency parts are available with trimmable outputs at nominal 3.3V, 5V, 12V, 15V,



and 24V. Inputs for each type can range up to 60VDC, and operating temperature is as high as 100°C with no derating, or higher still at reduced power. Features include on/off control, remote sensing, a power good signal, and comprehensive protection against output short-circuits, over-current, and over-voltage. The products meet EN55032 class B EMI limits with a simple external filter. The advance in power handling of the RPMH-1.5 is enabled by RECOM's 3D Power Packaging® techniques resulting in a 25-pad LGA package with six-sided shielding for optimal EMC and thermal performance. Evaluation boards are available which allow performance and all features to be tested.

"We have increased the current rating of our RPMH series by a factor of three", commented Matthew Dauterive, DC/DC Productmanager of RECOM. "This improvement opens up a much wider range of applications for the product. The wide input range, up to 60V, will be particularly attractive for 48V systems or applications such as automotive where high voltage surges can occur".

www.recom-power.com

Increase of Runtime with Solar Harvesting Solution

Designers of space-constrained designs can now significantly increase runtime with the MAX20361 single-/multi-cell solar harvester with maximum power point tracking (MPPT) from Maxim Integrated Products. The solar harvesting solution is ideal for space-constrained applications such as wearables and emerging internet of things (IoT) applications. Designers are often challenged with the tradeoff between small size and long runtime for wearable and IoT applications. By enabling solar charging in these highly space-constrained products, the MAX20361 can extend the runtime of those devices by providing a supplemental power source. This solar harvester reduces solution size by at least half compared to the closest competitor. In addition, the MAX20361 increases harvested energy with up to 5 percent better boost efficiency than the closest competitor, coupled with an adaptive MPPT approach which can improve the overall system level efficiency even further. "This device offers exciting possibilities for a new supplemental power source to continually charge the battery of a device," said Frank Dowling, director of the Industrial and Healthcare Business Unit at Maxim Integrated. "For example, if

you can harvest just 30mW of solar power per day on a 300mAHr battery system which typically runs for three weeks, you can as a result extend that runtime by over 50 percent."

www.maximintegrated.com

Design Enables a Secondary Side Microcontroller to Control Primary Power

In modern offline AC-DC power solutions, programmability and adaptive control offer the flexibility and intelligence needed by smart home devices to better interface with their power systems. In these systems, a secondary side microcontroller (MCU) is typically not capable of starting a system without the use of a separate bias power supply. The reference design from Microchip Technology solves this problem using the MCP1012 high voltage auxiliary AC-DC controller, demonstrating the ability to remove the independent bias power supply in many applications. The MCP1012 offline auxiliary device enables the system to transfer control of the power and duty cycle to a secondary MCU. The control between the system and the load can be more precise and purposefully coupled, through a design that can be simplified, reducing size and cost.

The reference design uses a patented isolation technique for isolated feedback. This patented isolation technique called Inde-Flux transformer technology is being licensed to Würth Elektronik eiSos. Inde-Flux technology is used in the Inde-Flux Transformer, the first transformer made by Würth Elektronik eiSos using this IP and sold as part of Microchip's 15W MCP1012 offline reference design. This transformer combines the signal power and signal communication into one device, eliminating the need for optical feedback or an independent signal transformer. The option is also available to use more traditional approaches with a planar pulse transformer on the reference design, as well as the ability of the design to work with more traditional optocouplers and signal transformers. The secondary-side control is then enabled through a combination of the transformer and Microchip's newly released MCP1012 AC-DC controller along with the SAM D20 series 32-bit MCU.

www.microchip.com

60W Wireless Power Receiver IC

Renesas Electronics Corporation introduced the world's first 60W wireless power receiver, the P9418, to deliver faster wireless charging experiences for smartphones, laptops and notebook devices in the industry's highest power density solution. Featuring Renesas' exclusive WattShare™ technology, the integrated P9418 wireless power receiver delivers up to 60W of power in a single chip. This enables quick and convenient charging on the go beyond smartphones, including device charging for a variety of portable computing devices. Based on Renesas' proprietary WattShare technology, the P9418 is an integrated single-chip wireless power transmitter/receiver IC (TRx) that can be configured to transmit or receive an AC power signal through magnetic induction. The P9418 builds on the proven P9415 wireless power receiver and provides an easy upgrade path for existing customers. The P9418 also delivers advanced telemetry and proprietary charging protocols required for high-power applications.Customers can also combine the P9418 wireless charging receiver with Renesas' power management portfolio, including its USB Type-C™ power delivery and battery charging solutions, to accelerate the development of their applications.

www.renesas.com

FET for USB-C Battery Chargers and Point-of-Load Converters

Efficient Power Conversion advances the performance capability of low voltage, off-the-shelf gallium nitride transistors with the introduction of the EPC2055 (3 mΩ, 40 V) eGaN FET. This device is ideal for applications with demanding requirements for performance in space-constrained form factors including USB-C batter chargers and ultra-thin point-of-load (POL) converters. Other low-voltage applications benefiting from the fast-switching speeds and ultra-high efficiency of the EPC2055 include LED lighting, 12 V – 24 V input motor drivers, and lidar systems for robotics, drones, and autonomous cars. According to Alex Lidow, EPC's co-founder and CEO, "The EPC2055 is a very good example of the rapid evolution of GaN FET technology. This 40 volt device offers both smaller size and reduced parasitics compared with previous-generation 40 V GaN FETs and at lower cost; thus, offering designers both improved performance and cost savings." The EPC90132 development board is a 40 V maximum device voltage, 25 A maximum output current, half bridge with onboard gate

drives, featuring the EPC2055 eGaN FETs. This 2" x 2" (50.8 mm x 50.8 mm) board is designed for optimal switching performance and contains all critical components for easy evaluation of the EPC2055.

www.epc-co.com

GaN Power Amplifier for C-Band Applications

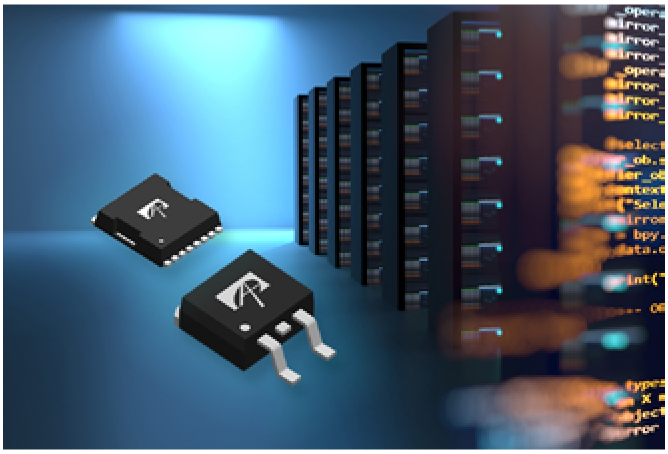
Qorvo introduced a GaN MMIC power amplifier (PA) that delivers up to 100 watts of saturated power in a small, 7 mm x 7 mm QFN package.

The PA is internally matched and requires no additional external RF components, enabling designers and system integrators to maximize design by reducing size and weight while offering better performance. The integrated Surface Mount Technology (SMT) package design enables customers to manufacture at a lower cost compared to die or bolt-down flange package alternatives. The Qorvo QPA2309, built on the company's patented QGaN25HV wafer process, operates between 5-6 GHz (C-band) and delivers an industry-best power added efficiency (PAE) of 52%. This GaN PA provides defense radar customers with two times higher saturated power, higher large signal gain and improved PAE in the same package size as the previous generation product. Qorvo also offers customers the option of a 50-watt version (QPA2310) in the same package configuration. Dean White, senior director of Qorvo's Defense and Aerospace business said, "The QPA2309 gives defense customers the ability to dramatically increase their power density output in the same design footprint, to increase radar range and sensitivity without adding size or weight."

www.qorvo.com

MOSFETs for 48V Hot Swap Telecom Applications

Alpha and Omega Semiconductor announced the release of, AOTL66518 and AOB66518L, a 150V MOSFET with low on-resistance and a high Safe Operating Area (SOA) capability designed for



demanding applications in Telcom Hot Swap. AOS designed these MOSFETs with a low on state resistance and a robust linear mode performance with a wide Safe Operating Area (SOA) to manage Telecom's demanding application where performance, reliability, and quality are essential. AOTL66518 and AOB66518L have a max junction temperature up to 175°C and protects the load by limiting high in rush currents in soft-start, eFuse, and Hot Swap application conditions. AOTL66518 delivers high robustness with a 150V MOSFET in a TOLL package. The TOLL package offers a 30% smaller footprint than a TO-263 (D2PAK) package and has a higher current capability due to clip technology. AOTL66518 has a very low thermal resistance from silicon junction to the bottom of the package case (Rthjc) compared to TO-263. These features enable Telecom designers to reduce the number of MOSFETs in parallel. "High reliability and robust linear mode performance are critical metrics in Telecommunications. AOTL66518 and AOB66518L have high SOA with low on-resistance to meet these demanding requirements," said Peter H. Wilson.

www.aosmd.com

High-Accuracy Battery Monitor and Balancer

Texas Instruments introduced an automotive battery monitor and balancer that reports high-accuracy voltage measurements in systems up to 800 V. In addition, the BQ79616-Q1 streamlines Automotive Safety Integrity Level (ASIL) D compliance in hybrid electric vehicles (HEVs) and electric vehicles (EVs). Filtering system-level noise to accurately measure battery-cell voltage and temperature and reliably reporting this information to the microcontroller (MCU) are key design challenges for automotive manufacturers. The device addresses both of these challenges to help engineers achieve battery safety goals and maximize distance per charge in wired and wireless battery management systems. The BQ79616-Q1 battery monitor and balancer is the industry's first to include a patented wake-up-at-fault feature. When paired with the BQ79600-Q1 SPI/UART communication interface, it enables total system shutdown when the vehicle is parked or turned off. This helps design engineers conserve battery power, improve cell balancing and support safety requirements.

It is the first in a next-generation family of TI battery monitors and balancers to support high-accuracy monitoring for a broad spectrum of battery chemistries, including lithium-iron phosphate (LiFePO4). This enables automotive manufacturers to more precisely measure battery state-of-charge and state-of-health, thereby reducing cost. The BQ79616-Q1's integrated digital low-pass filter and high-precision analog-to-digital converter optimize signal measurement accuracy, delivering cell-voltage measurements with less than 2 mV of error.

www.ti.com

High-Temperature Rated PPTC Overcurrent Protectors

Bourns announced the expansion of its line of Multifuse® high-temperature rated surface mount Polymer Positive Temperature Coefficient (PPTC) resettable fuse products. The MF-FSHT model family is designed to provide effective overcurrent protection in applications with higher ambient operating temperatures while also reducing the risk of generating nuisance tripping at elevated temperatures between 85°C and 125°C. These capabilities are particularly useful in applications that regularly experience elevated ambient temperatures, including, but not limited to, industrial equipment, outdoor security systems and computing/storage devices.

The Multifuse® MF-FSHT model family is available in a small EIA 0603 footprint, and further expands Bourns' leading line of high-temperature rated polymer PTCs that include the radial leaded MF-RHT model family and the surface mount MF-SMHT, MF-USHT, MF-NSHT and MF-PSHT model families.

"Our latest MF-FSHT series of surface mount polymer PTCs allows designers to more confidently specify robust overcurrent protection into their higher temperature applications where long-life operation is a must," said Lee Bourns, Product Line Manager for Overcurrent Protection at Bourns. "Furthermore, these new models also provide enhanced thermal derating performance at higher temperatures, thereby allowing designers to benefit from higher Ihold and Itrip current ratings at elevated temperatures while using one of the industry's smallest SMD footprints."

www.bourns.com

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